UNIVERSITY OF NEW ENGLAND

COLLGE OF PHARMACY

BID SET
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BOOK 2 OF 2

PORT ■ CITY
ARCHITECTURE

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PART 1 - GENERAL

1.1 REFERENCES

A. Refer to the GENERAL CONDITIONS, SUPPLEMENTARY CONDITIONS and applicable parts of DIVISION 1 for other general requirements.

1. GENERAL CONDITIONS, SUPPLEMENTARY CONDITIONS and DIVISION 1 paragraphs may be repeated in this Division for emphasis or for inclusion of more stringent/additional related requirements. Such repetition shall NOT be construed to reduce the requirements of those Divisions NOR to eliminate other requirements under those Divisions.

B. Refer to other Sections of this Division for detailed specifications on the work of this Division.

1.2 INTENT

A. It is the intent of the Contract Documents to require finished work, tested and ready for operation.

B. It is not intended that Contract Documents show every pipe, wire, conduit, fitting and appurtenance; however, such parts as may be necessary to complete the systems in accordance with best trade practice and Code requirements and to Architect's satisfaction shall be deemed to be included.

C. Drawings are diagrammatic and indicate the general arrangement of systems and work included in the Contract. DO NOT SCALE THE DRAWINGS.

1.3 EXAMINATION OF SITE AND CONTRACT DOCUMENTS

A. Before submitting prices or beginning work, thoroughly examine the site and the Contract Documents.

B. No claim for extra compensation will be recognized if difficulties are encountered, which would have been revealed by examination of site conditions and Contract Documents prior to executing Contract.

C. Where discrepancies occur within Contract Documents, notify Architect, in writing, of discrepancy and request clarification. Until notified of Architect's decision, include item or arrangement of better quality, greater quantity or higher cost in Contract price.

   1. For material, device and equipment identified on Contract Drawings by manufacturer and model: Check Specification for ancillary requirements such as pilot lights or alarms, and include same with furnished item. If Specifications require different model, notify Engineer of discrepancy and request clarification.

D. Notify Engineer, in writing, of materials and apparatus believed to be omitted, inadequate or unsuitable, or in violation of laws, ordinances, rules or regulations of authorities having jurisdiction. In absence of such written notice, it is mutually agreed that bid price for work under each Section has included the cost of items required for acceptable satisfactory functioning of entire system.

E. Prior to performing work required under Division 15, carefully inspect all existing conditions and the installed work of all other trades and verify that all conditions and all such work is complete to the point when the mechanical work may properly commence.

1.4 DEFINITIONS

A. Where more than one material, item or grade is listed in same paragraph, first one named is preferred choice.

B. The following terms are used in this Division and are defined as follows:

   1. "Indicated", "shown", "noted", "scheduled", "specified": These terms are a cross-reference to graphics, notes or schedules on the Drawings, to other paragraphs or schedules in the Specifications, and to similar means of recording requirements in Contract Documents. NO limitation of location is intended except as specifically noted.
   2. "Directed", "requested", "authorized", "selected", "required", "permitted": Where not otherwise explained, these terms mean "directed by the Engineer", "requested by the Engineer", etc. However, NO such implied meaning will be interpreted to extend the Engineer's responsibility into Contractor's area of construction supervision.
   3. "Provide": To furnish and install, ready for safe and regular operation the item, material or service indicated.
   4. "Furnish": To purchase, acquire and deliver to the site, complete with related accessories.
   5. "Install": To erect, mount and connect completely, by acceptable methods.
   6. "Work": Labor, materials, equipment, apparatus, controls and accessories required for proper and complete installation.
   7. "Concealed": Embedded in masonry or other construction; or installed in furred spaces, trenches or crawl spaces; or installed within double partitions or hung ceilings; or in enclosures.
   8. "Exposed": Visible to building occupants, excluding mechanical room and utility tunnel locations.
   9. "Acceptable Equivalent" or "Equal": Of weight, size, design, capacity and efficiency to meet requirements specified and shown, and of acceptable manufacture, as determined in the opinion of the Architect.

10. "Acceptable": Acceptable, as determined in the opinion of the Architect.
11. "Contractor": General Contractor.
12. "Motor Controllers": Manual or magnetic starter, individual pushbutton or Hand-Off-Automatic (HOA) switch controlling operation of equipment.
13. "Named" Product: Manufacturer's name for product, as recorded in published documents of latest issue as of date of Contract Documents. Obtain Architect's permission before using products of later or earlier model.

C. Standards, specifications and tests of following technical societies, organizations and governmental bodies, as referenced in Contract Documents, are hereby made part of Contract Documents.

1. AABC: Associated Air Balance Council
2. ACGIH: American Conference of Governmental Industrial Hygienists
3. ADC: Air Diffusion Council
4. AGA: American Gas Association
5. AIA: American Institute of Architects
6. AMCA: Air Movement and Control Association
7. ANSI: American National Standards Institute
8. API: American Petroleum Institute
9. ARI: Air Conditioning and Refrigeration Institute
10. ASA: American Standards Association.
11. ASCE: American Society of Civil Engineers
12. ASE: Association of Safety Engineers
13. ASHRAE: American Society of Heating, Refrigeration and Air Conditioning Engineers
14. ASME: American Society of Mechanical Engineers
15. ASPE: American Society of Plumbing Engineers
16. ASTM: American Society for Testing and Materials
17. AWS: American Welding Society
18. AWWA: American Water Works Association
19. CGA: Compressed Gas Association
20. CSA: Canadian Standards Association
21. CISPI: Cast Iron Soil Pipe Institute
22. EJMA: Expansion Joint Manufacturing Association
23. EPA: Environmental Protection Agency
24. FM: Factory Mutual Engineering Division
25. FSSC: Federal Specification
26. HIS: Hydraulic Institute Standards
27. IBR: Institute of Boiler and Radiator Manufacturers
28. IEEE: Institute of Electrical and Electronics Engineers
29. IRI: Industrial Risk Insurers
30. ISO: Insurance Services Office
31. MCAA: Mechanical Contractors Association of America
32. NBS: National Bureau of Standards
33. NEBB: National Environmental Balancing Bureau
34. NEC: National Electrical Code.
35. NEMA: National Electrical Manufacturers Association
36. NFPA: National Fire Protection Association
37. NOFI: National Oil Fuel Institute

38. NSC: National Safety Council
39. NSF: National Sanitation Foundation
40. OSHA: Occupational Safety and Health Administration
41. PDI: Plumbing and Drainage Institute
42. SBI: Steel Boiler Industry (Division of Hydronics Institute)
43. SMACNA: Sheet Metal and Air Conditioning Contractors National Association
44. STI: Steel Tank Institute
45. UL: Underwriter's Laboratories
46. CODE: Codes and regulations of the Federal, State and local governments and of utility companies having jurisdiction, as appropriate.

D. Use of singular or plural reference form in these Specifications shall not be construed to limit number of units required. Specifications are intended to define quality and performance characteristics; quantity of units supplied shall be as needed to meet requirements as specified and as shown on Contract Documents.

1.5 PERMITS, LAWS, ORDINANCES AND CODES

A. Contractor shall obtain and pay for permits, inspections, licenses and certificates required for work under this Division.

B. Contractor shall pay utility company back charges associated with his work.

C. Contractor shall comply with laws, ordinances, rules and regulations of Town of Hanover, State of New Hampshire and Federal authorities having jurisdiction; and shall comply with rules and regulations of National Board of Fire Underwriters, National Electrical Code and local utility companies.

D. Contract Documents shall govern whenever they are more stringent than Code requirements.

E. Install all systems of Division 15 sections in conformance with all applicable State of New Hampshire and Town of Hanover codes (Ordinance #15 dated September 1, 2001) as outlined in section 01000, in addition to all the specific codes and standards listed in the various Division 15 sections.

F. Codes include but are not limited to:

1. State of New Hampshire, "State Fire Code", current edition, including all applicable references.
2. ANSI/ASME Power Piping Code B31.1 – 1988.
3. The most recent applicable codes and standards.

1.6 SHOP DRAWING SUBMITTALS

A. Prepare and submit Shop Drawings through the Contractor to the Architect for review.

B. The selection and intention to use a product specified by name shall NOT excuse the need for timely submission of shop drawings for that product.

C. Prior to submitting shop drawings, submit for review preliminary list of intended or proposed manufacturers for all items for which shop drawings are required.

D. Submission of shop drawings of an unnamed manufacture or shop drawings at variance with the Contract Documents is NOT a proper request for substitution.

E. Samples that are submitted in lieu of shop drawings shall be clearly identified and shall be submitted in duplicate. Only one sample will be returned and that accepted sample shall be kept available at appropriate job site office. Accepted sample retained by Architect/Engineer will be kept available at Architect's/Engineer's home office.

F. Upon completion of shop drawing review, shop drawings will be returned, marked with one of the following notations: Furnish as Submitted; Furnish as Corrected; Revise and Resubmit; Rejected or Submit Specified Item. Only products whose shop drawings are marked "Furnish as Submitted" or "Furnish as Corrected" shall be used on the project.

G. Submittals shall include the following information:

1. Descriptive and product data necessary to verify compliance with Contract Documents.
2. Manufacturer's specifications including materials of construction, metal gauge, thickness and finish.
3. Certified dimensional drawings including clearances required for maintenance or access.
4. Performance data, ratings, operating characteristics and operating limits.
5. Electrical ratings and characteristics.
6. Wiring and control diagrams, where applicable.
7. Certifications requested, including UL label or listing.
8. List of accessories which are required but are NOT being provided by the product manufacturer or are NOT being furnished under this Section. Identify the Section(s) under which the accessories are being furnished.

H. In addition, submittals shall be clearly marked for the following:

1. Specification Section and Paragraph, or Drawing Schedule/Note/Detail/ etc., where equipment is specified.
2. Equipment or fixture identification corresponding to that used in Contract Documents.
3. Accessories and special or non-standard features and materials which are being furnished.

1.7 PRODUCT SELECTION

A. Contractor's options for selecting products are limited by Contract Document requirements and governing regulations and are NOT controlled by industry traditions or procedures experienced by Contractor on previous construction projects. Required procedures include, but are NOT necessarily limited to, the following various methods of specifying:

1. Single Product Manufacturer Named: provide product indicated.
2. Two or More Manufacturers' Products Named: Provide one of the named products, at Contractor's option, but excluding products which do NOT comply with requirements.
3. "Acceptable Equivalent" or "Or Equal": Where named products are accompanied by this term or words of similar effect, provide one of named products or propose substitute product according to paragraph 1.8, SUBSTITUTIONS.
4. Standards, Codes and Regulations: Where specification requires only compliance with a standard, code or regulation, the Contractor may select any product which complies with requirements of that standard, code or regulation.
5. Performance Requirements: Provide products which comply with specific performances indicated and which are recommended by manufacturer (in published product literature or by individual certification) for application intended. Overall performance of product is implied where product is specified with only certain specific performance requirements.
6. Prescriptive Requirements: Provide products which have been produced in accordance with prescriptive requirements using specified materials and components and complying with specified requirements for fabricating, finishing, testing and other manufacturing processes.
7. Visual Matching: Where matching with an established material is required, Architect's judgment of whether proposed product matches established material shall be final.

8. "Color as Selected by Architect": Unless otherwise noted, where specified product requirements include "color as selected by Architect" or words of similar effect, the selection of manufacturer and basic product complying with Contract Documents is Contractor's option and subsequent selection of color is Architect's option.

B. Inclusion by name, of more than one manufacturer or fabricator, does NOT necessarily imply acceptability of standard products of those named. All manufacturers, named or proposed, shall conform, with modification as necessary, to criteria established by Contract Documents for performance, efficiency, materials and special accessories.

1.8 SUBSTITUTIONS

A. Contractor shall pay Architect/Engineer for time spent reviewing substitution requests. Charges shall be $120/hour. Submittal of substitution request will be construed as evidence of Contractor's agreement to pay such charges, with no added cost to the Owner.

B. Contractor's request for substitution may be submitted only after award of Contract. Requests shall be in writing on Contractor's letterhead and shall include:

1. Contractor's detailed comparison of significant qualities between specified item and proposed substitution.

2. Statement of effect on construction time, coordination with other affected work, and cost information or proposal.
3. Contractor's statement to the effect that proposed substitution will result in overall work equal to, or better than, work originally intended.

C. Substitution requests will be considered: if extensive revisions to Contract Documents are NOT required; if changes are in keeping with general intent of Contract Documents; if submitted in timely and proper manner, fully documented; and if one or more of the following conditions is satisfied; all as judged by Architect:

1. Where request is directly related to "acceptable equivalent" clause, "or equal" clause or words of similar effect in Contract Documents.
2. Where specified product, material or method cannot be provided within Contract Time, but NOT as a result of Contractor's failure to pursue the work promptly or to coordinate various activities properly.
3. Where substantial advantage is offered Owner; in terms of cost, time, energy conservation or other valuable considerations; after deducting offsetting responsibilities that Owner may be required to bear, including additional compensation to Architect for redesign and evaluation services, increased cost of other work by Owner or separate Contractors, and similar considerations.

D. The burden is upon the Contractor, supplier and manufacturer to satisfy Architect that:

1. Proposed substitute is equal to, or superior to, the item specified.
2. Intent of the Contract Documents, including required performance, capacity, efficiency, quality, durability, safety, function, appearance, space clearances and delivery date, will be equaled or bettered.

E. Submission of shop drawings of unspecified manufacture or shop drawings at variance with the Contract Documents is NOT a proper request for substitution.

F. Changes in work of other trades, such as structural supports or wiring, which are required as a result of substitution and the associated costs for such changes shall be the complete responsibility of the Contractor proposing substitution. Except as noted in subparagraph 1.8.C.3 above, there shall be NO additional expense to the Owner.

1.9 SAMPLES

A. Submit samples as requested by the Architect.

1.10 RECORD DRAWINGS

A. Furnish, and keep on the job at all times, one complete and separate set of blueline prints of the mechanical work.

B. As work progresses, record changes, revisions and additions to Architectural and Mechanical work clearly, neatly, accurately and promptly. Items to be indicated include, but are not limited to, the following:

1. Dimensional change

2. Revision to Drawing detail
3. Location and depth of underground utility
4. Revision to pipe routing
5. Revision to conduit routing
6. Revision to electrical circuitry
7. Actual equipment location
8. Duct size and routing
9. Location of concealed internal utility
10. Changes made by Change Order
11. Details not on original Contract Drawing
12. Information on concealed elements which would be difficult to identify or measure later

C. Indicate daily progress on these prints by coloring in the various pipes, ducts, fixtures, apparatus and associated appurtenances as they are erected.

D. Approval of requisition for payment for work installed will NOT be given unless supported by record prints as required above.

E. At the conclusion of work, prepare record drawings and electronic drawing files. Submit record drawings and electronic drawings files for review by Architect and Engineer. Refer to DIVISION 1, GENERAL CONDITIONS and SUPPLEMENTARY CONDITIONS for further requirements.

1.11 OPERATING AND MAINTENANCE MANUALS

A. Submit, for review, Operating and Maintenance Manuals for each system or piece of equipment, at least two weeks prior to request for acceptance of same. Upon acceptance, furnish two copies of each manual (or greater quantity if otherwise specified under DIVISION 1) to Architect for transmittal to the Owner. Operating and Maintenance Manual shall include:

1. Description of Unit (System) and Component Parts, including function, normal operating characteristics and limiting conditions, performance curves, engineering data and tests and complete nomenclature and manufacturer's number for replaceable parts.
2. Operating Procedures, including start-up, break-in, routine and normal operating instructions; regulation, control, stopping, shutdown and emergency instructions; summer and winter operating instructions; and any special operating instructions.
3. Maintenance Procedures, including routine operations, guide to trouble-shooting; disassembly, repair and reassembly; alignment, adjusting and checking; servicing and lubrication schedule and list of lubricants; manufacturer's installation and maintenance bulletins and related information.
4. Sequence of Operation and Control Diagrams, corrected for as-built conditions.
5. Parts List, including illustrations, assembly drawings and diagrams required for maintenance, predicted life of parts subject to wear, and recommendations for stocking spare parts.
6. Valve Tag Charts, including number, location and function of each valve.
7. Copies of accepted shop drawings, charts and diagrams.
8. Names, addresses and telephone numbers of manufacturer's representative and service company.
9. Other data, as required under pertinent Sections of these Specifications.

10. Letters from each manufacturer certifying that his equipment was properly installed and is operating in accordance with manufacturer's intent.

1.12 VALVE CHARTS

A. For each piping system, furnish one valve chart framed under glass or in laminated plastic. Charts shall be typewritten and shall include:

1. System designation.
2. Valve numbers, in consecutive order, corresponding to numbers shown on Contract and Record Drawings.
3. Service and location of each valve.
4. Information on normal valve position and opening and closing sequence of interrelated valves.
5. Legend for piping identifications.

1.13 GUARANTEE

A. Furnish standard manufacturer's guarantees for work under this Division. Such guarantees shall be in addition to, and NOT in lieu of, other liabilities under the law or by other provisions of the Contract Documents.

B. Materials, equipment and workmanship shall carry the standard warranty against defects in material and workmanship. Failure which may develop due to defective or improper material, equipment, workmanship or design shall be made good, forthwith, by and at the expense of the Contractor, including damage done to areas, materials and other systems resulting from this failure.

C. Guarantee that all elements of the systems are of sufficient capacity to meet the specified performance requirements as set forth in Contract Documents.

D. Upon receipt of notice from Owner of a failure of system(s) or component(s) during the guarantee period, replace affected components within reasonable time period at no additional cost.

E. Guarantee period shall extend for one year from Date of Substantial Completion.

F. Before final request for payment, furnish written guarantee covering above requirements.

1.14 QUALITY ASSURANCE

A. Equipment and appurtenances shall be designed in conformity with ANSI, ASME, IEEE, NEMA, OSHA, AGMA and other generally accepted applicable standards.

B. All machinery and equipment shall be safeguarded in accordance with the safety codes of the ANSI, OSHA, and local industrial codes, including but not limited to, shaft guards on all rotating shafts, cages around exposed fan blades, etc.

C. All mechanical work shall be performed by mechanics who are qualified to do such work and who are normally engaged in this type of work.

PART 2 - PRODUCTS

2.1 GENERAL PRODUCT REQUIREMENTS

A. Products shall be undamaged and unused at time of installation and shall be complete with accessories, trim, finish, safety guards and other devices and details needed for complete installation and for intended use.

B. Where available, products shall be standard products of types, which have been produced and used previously and successfully on other projects and in similar applications.

C. Labels and stamps, which are required for observation after installation shall be located on accessible surfaces which, in occupied spaces, are NOT conspicuous. Other labels and stamps shall be located on concealed surfaces.

PART 3 - EXECUTION

3.1 ARRANGEMENT OF WORK

A. Consult Architectural Contract Drawings and Details for exact locations of fixtures and equipment. If exact location is not given, obtain information from Architect. Verify measurements in field. Base measurements on Architect's established benchmarks.

B. Install work as closely as possible to layouts shown on Contract Drawings. Modify work as necessary to:

1. Provide maximum possible headroom and space clearance on each side.
2. Provide adequate clearance and ready access to all parts of the work, for inspections, operation, safe maintenance and repair and code conformance.

3. Coordinate and arrange work to avoid conflicts with work of other trades, to avoid unnecessary cutting and patching, and as needed for satisfactory space conditions shown on coordination drawing submittals.
4. Where space appears inadequate, consult Architect before proceeding with installation.

C. Work shall present a neat coordinated appearance.

3.2 COORDINATION

A. It is the responsibility of the mechanical contractor to coordinate the work of his trade with all other trades prior to the commencement of construction. It is the responsibility of the contractors to provide, in his original bid, all necessary offsets, fittings, and transformations to provide a complete project. Any conflicts must be brought to the attention of the architect/engineer/owner. Any work requiring removal and reinstallation due to the lack of coordination shall be the responsibility of the contractors with no additional cost to the owner.

B. Prepare coordination drawings to a scale of 3/8"=1'-0" or larger; detailing major elements, components, and systems of mechanical equipment and materials in relationship with other systems, installations, and building components.

1. Indicate the proposed locations of piping, ductwork, equipment, and materials. Include the following:

   a. Clearances for servicing and maintaining equipment, including tube removal, filter removal, and space for equipment disassembly required for periodic maintenance.
   b. Equipment connections and support details.
   c. Clearance to access all electronic equipment such as VAV controllers.
   d. Fire-rated wall and floor penetrations.
   e. Sizes and location of required concrete pads and bases.
   f. Valve stem movement.
   g. Seismic bracing locations.

2. During coordination meetings discuss amongst the contractors scheduling, sequencing, movement, and positioning of large equipment into the building during construction.
3. Prepare reflected ceiling plans to coordinate and integrate installations, air outlets and inlets, light fixtures, communication systems components, sprinklers, and other ceiling-mounted items.
4. Refer to Section 230501 paragraph 1.4 Submittals for additional requirements.

C. Pipe appurtenances requiring service are not allowed in electric rooms.

3.3 INSPECTION

A. Prior to performing work required under Division 15, carefully inspect all existing conditions and the installed work of all other trades and verify that all conditions and all such work is complete to the point where the mechanical work may properly commence.

B. In the event of discrepancy, immediately notify Architect/Engineer/owner.

3.4 QUALITY ASSURANCE

A. Ample clearance shall be provided for repairs, inspection and adjustment. Protruding members such as joints, corners and gear covers shall be finished in appearance. All exposed welds shall be ground smooth and the corners of structural shapes shall be rounded or chamfered.

B. Secure and pay for all necessary fees, permits and approvals, as required for the work of this Section.

3.5 CUTTING AND PATCHING

A. Perform cutting, fitting, and patching of mechanical equipment and materials required to:

1. Uncover Work to provide for installation of ill-timed Work.
2. Remove and replace defective Work.
3. Remove and replace Work not conforming to requirements of the Contract Documents.
4. Remove samples of installed Work as specified for testing.
5. Install equipment and materials in existing structures.

B. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.

C. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.

D. Patch finished surfaces and building components using new materials specified for the original installation and experienced Installers.

3.6 PERFORMANCE

A. The project is to be commissioned, the contractor is required to work with the commissioning agent and related sub-contractors as required to fulfill the requirements of section 18000. The costs associated with this requirement shall be included in the contractor's base bid.

B. Perform all work that is essential in completing the intended installation in the proper manner.

C. Field verification of all dimensions is required.

D. Wherever obstructions are encountered in the path or course of the work that are not shown nor anticipated in the Contract Documents, do not proceed with the installation of the work before advising the Architect/engineer/owner and receiving detailed information or drawings or both.

3.7 INSTALLATION OF EQUIPMENT

A. All equipment shall be installed true, level and in the location shown on the Drawings. Precision gauges and levels shall be used in setting all equipment.

B. Furnish, install and protect all necessary guides, bearing plates, anchor and attachment bolts, and all other appurtenances required for the installation of equipment.

C. All equipment shall be installed in such a manner as to provide access for routine maintenance, including lubrication.

D. Structural steel supports and miscellaneous steel required for supporting and/or hanging equipment and piping furnished under this Division, shall be provided and installed.

E. All foundations, anchor pads, piers, thrust block, inertia blocks and structural steel supports shall be built to template and reinforced as required for loads imposed on them.

3.8 MECHANICAL ROOM SAFETY ISSUES

A. The FO&M project representative shall determine the normal walking paths within mechanical spaces. Projections of any objects in this walking space that are less than 6'-8" that create a safety hazard shall have rounded edges and be equipped with a protective covering. The protective may be 3/4" thick elastomeric insulation or other similar product approved by FO&M.

3.9 CLEANING

A. Protect equipment against mortar, dust, weather, etc., during construction and leave all equipment clean. Remove from the premises, all debris and unused material and leave premises in a clean and neat condition.

END OF SECTION 230500

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SECTION 230501 - BASIC MECHANICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Piping materials and installation instructions common to most piping systems.
2. Transition fittings.
3. Dielectric fittings.
4. Mechanical sleeve seals.
5. Sleeves.
6. Escutcheons.
7. Grout.
8. Mechanical demolition.
9. Equipment installation requirements common to equipment sections.
10. Painting and finishing.
11. Concrete bases.
12. Supports and anchorages.

1.3 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in duct shafts.

E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

F. The following are industry abbreviations for rubber materials:

1. EPDM: Ethylene-propylene-diene terpolymer rubber.
2. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

A. Product Data: For the following:

1. Transition fittings.
2. Dielectric fittings.
3. Mechanical sleeve seals.
4. Escutcheons.

B. Welding certificates.

C. Coordination Drawings

1. Before materials are purchased or work is begun, prepare Coordination Drawings showing size and location of mechanical pipes, ducts, equipment and appurtenances, relative to work of other trades.
2. Submit for review coordination drawings signed by following trades: sheet metal, plumbing, fire protection, electrical, and other HVAC trades. Drawings shall be composite construction floor plans, on mylar sepia transparencies.
3. Preliminary coordination drawings shall be prepared as follows:

    a. First: Sheet metal trade shall prepare drawings to be used as composite construction floor plans for coordination of trades. Drawings shall show duct layouts superimposed on floor plans; ceiling heights and duct heights above finished floors; duct sizes, including insulation; diffusers, registers and grilles; and light fixtures. Prepare drawings at the scale of 1/4" = 1'-0". In addition, where the coordination drawings require supplemental drawings to legibly show the work, prepare the supplemental drawings at the scale of 3/8" = 1'-0" or ½" = 1'-0".
    b. Second: As part of work of DIVISION 15, MECHANICAL, fire protection trade shall draw fire protection piping, etc., on coordination drawings prepared by sheet metal trade.
    c. Third: As part of DIVISION 16, ELECTRICAL WORK, electrical trade shall draw electrical distribution conduits, wires, panels, and other electrical work which must be coordinated with other trades; on coordination drawings which have been prepared by fire protection trade.
    d. Fourth: As part of work of DIVISION 15, MECHANICAL, plumbing trade shall draw waste piping, vent piping, water piping, risers and other plumbing work which must be coordinated with other trades; on coordination drawings which have been prepared by electrical trade.

e. Fifth: As part of work of DIVISION 15, MECHANICAL, HVAC trades shall draw HVAC piping work which must be coordinated with other trades; on coordination drawings which have been prepared by plumbing trade.

f. Each trade shall use a different color code.

4. Coordination Meeting and Drawing Revisions

a. Sixth: Contractor shall hold a coordination meeting with sheet metal, HVAC, fire protection, electrical and plumbing trades and shall resolve conflicts between trades. Coordination drawings are to assist in identifying trade conflicts.

b. Seventh: Sheet metal trade shall revise coordination drawings to reflect revisions to the various trade work (including sheet metal, HVAC, fire protection, electrical and plumbing trades), as determined by coordination meeting.

c. Eighth: Sheet metal, HVAC, fire protection, electrical and plumbing trades shall sign the revised coordination drawings as indication of their acceptance of the construction layout shown thereon.

5. Sheet metal trade shall submit the revised coordination drawings to Architect for review.

6. Coordination Drawings are for Contractor's and Engineer's use during construction and shall not be construed as replacing shop, "as-built" or record drawings required elsewhere in the Contract Documents.

1.5 QUALITY ASSURANCE

A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."

B. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."

2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is dated by the test agency within 12 months of the start of the work for the welder.

C. DEFINITIONS:

1. Welding Procedure Specification, WPS. It must have a specific procedure number, date written and identification of the person who wrote it.

2. Procedure Qualification Record, PQR. This is the record that indicates the procedure to be followed is a valid procedure.

3. Welding Operator Qualifications test, WPQ. This is a record, including bend test results or radiographic test results, for each welder. The WPQ is based on that company's procedure. It shall be certified and dated by the test agency within 12 months of the start of the work for the welder.

D. Welding and brazing procedure qualifications:

1. Contractor shall submit for review the Contractor's standard welding and brazing procedures (forms WPS or BPS). Procedure shall be submitted on PQR form as described

in the ASME Boiler and Pressure Vessel Code. The PQR shall be supported by the appropriate WPS and BPS.

2. All welders shall be certified to the WPS and BPS as listed on the Contractor's PQR. Certifications are to be performed by an independent testing laboratory within twelve months prior to the commencement of work. Each welder is to stamp the pipe adjacent to each weld performed by him/her. The Contractor is required to, via the submittal process, provide a list of each welder's name and the mark used by each welder.

E. Tack welding may be performed by non-certified welders. All tack welds, whether performed by certified or non-certified welders, must be ground out and removed.

1. Contractor option: In lieu of submitting the contractor's welding procedures, the contractor may adopt Dartmouth College's procedure #1.1.1.2 Rev. 0 and ASME/ANSI B3 1.1, latest edition. The welding procedure is available from DC Facilities Operation and Management.

F. No welding may take place until a satisfactory reviewed submittal is complete. It is the contractor's responsibility to provide a submittal in a timely fashion so as not to delay the project.

G. Soldering and brazing procedures for refrigeration piping shall conform to ANSI B9. 1 "Standard Safety Code for Mechanical Refrigeration."

H. Electrical Characteristics for Mechanical Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

I. Fire caulk: Fire caulk must bear the UL label and UL test number. A copy of the test as well as the installation instructions must be included in the submittal.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.7 COORDINATION

A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for mechanical installations.

B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

C. Coordinate requirements for access panels and doors for mechanical items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 8 Section "Access Doors and Frames."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.2 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 15 piping Sections for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

C. All piping and fittings shall be manufactured in USA or Canada.

2.3 JOINING MATERIALS

A. Refer to individual Division 15 piping Sections for special joining materials not listed below.

B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.

a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

2. AWWA C110, rubber, flat face, 1/8 inch thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

D. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

E. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

F. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.

G. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

H. Solvent Cements for Joining Plastic Piping:

1. ABS Piping: ASTM D 2235.
2. CPVC Piping: ASTM F 493.

3. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
4. PVC to ABS Piping Transition: ASTM D 3138.

I. Fiberglass Pipe Adhesive: As furnished or recommended by pipe manufacturer.

2.4 TRANSITION FITTINGS

A. AWWA Transition Couplings: Same size as, and with pressure rating at least equal to and with ends compatible with, piping to be joined.

1. Manufacturers:

a. Cascade Waterworks Mfg. Co.
b. Dresser Industries, Inc.; DMD Div.
c. Ford Meter Box Company, Incorporated (The); Pipe Products Div.
d. JCM Industries.
e. Smith-Blair, Inc.
f. Viking Johnson.

2. Underground Piping NPS 1-1/2 and Smaller: Manufactured fitting or coupling.
3. Underground Piping NPS 2 and Larger: AWWA C219, metal sleeve-type coupling.
4. Aboveground Pressure Piping: Pipe fitting.

B. Plastic-to-Metal Transition Fittings: CPVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.

1. Manufactures:

a. Eslon Thermoplastics.
b. Thompson Plastics, Inc.

2. Manufacturers:

a. NIBCO INC.
b. NIBCO, Inc.; Chemtrol Div.

3. Manufacturers:

a. Cascade Waterworks Mfg. Co.
b. Fernco, Inc.
c. Mission Rubber Company.
d. Plastic Oddities, Inc.

2.5 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.

1. Manufacturers:

a. Capitol Manufacturing Co.
b. Central Plastics Company.
c. Epco Sales, Inc.
d. Watts Industries, Inc.; Water Products Div.

D. Dielectric-Flange Kits: Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.

1. Manufacturers:

a. Advance Products & Systems, Inc.
b. Calpico, Inc.
c. Central Plastics Company.
d. Pipeline Seal and Insulator, Inc.

2. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig minimum working pressure where required to suit system pressures.

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

1. Manufacturers:

a. Calpico, Inc.
b. Lochinvar Corp.

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

1. Manufacturers:

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

2.6 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.

1. Manufacturers:

a. Advance Products & Systems, Inc.
b. Calpico, Inc.

c. Metraflex Co.
d. Pipeline Seal and Insulator, Inc.

2. Sealing Elements: EPDMinterlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
3. Pressure Plates: Plastic. Include two for each sealing element.
4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.7 SLEEVES

A. Galvanized-Steel Sheet: (.0359 light, .0598 heavy) thickness; round tube closed with welded or Pittsburgh lock longitudinal joint.

B. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.

C. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

D. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with set screws.

2.8 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.

C. One-Piece, Cast-Brass Type: With set screw.

1. Finish: Polished chrome-plated.

D. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.

1. Finish: Polished chrome-plated.

E. One-Piece, Stamped-Steel Type: With set screw or spring clips and chrome-plated finish.

F. Split-Plate, Stamped-Steel Type: With concealed hinge, set screw, and chrome-plated finish.

G. One-Piece, Floor-Plate Type: Cast-iron floor plate.

H. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

2.9 FIRE CAULK

A. Fire caulk, joint fillers, and other related materials compatible with each other and with joint substrates under conditions of service and application. All products shall be installed in the manner determined by the manufacturer as tested by an independent testing laboratory.

2.10 MOTOR SHEAVES

A. The mechanical contractor shall be responsible for furnishing and installing sheaves on motors and/or fans as required to achieve design performance.

2.11 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.

1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
2. Design Mix: 5000-psi, 28-day compressive strength.
3. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting installation and application of joint sealers and access panels. Do not proceed with installation until unsatisfactory conditions have been corrected.

B. Store and handle joint sealer materials in compliance with the manufacturers' recommendations to prevent their deterioration and damage.

3.2 PROJECT CONDITIONS

A. Conditions Affecting Selective Demolition: The following project conditions apply:

1. Protect adjacent materials indicated to remain. Install and maintain dust and noise barriers to keep dirt, dust, and noise from being transmitted to adjacent areas. Remove protection and barriers after demolition operations are complete.
2. Locate, identify, and protect mechanical services passing through demolition area and serving other areas outside the demolition limits. Maintain services to areas outside demolition limits. When services must be interrupted, contact FO&M to install temporary services for affected areas. Do not shut off or disconnect services without contacting FO&M.

B. Environmental Conditions: Apply joint sealers under temperature and humidity conditions within the limits permitted by the joint sealer manufacturer. Do not apply joint sealers to wet substrates.

3.3 SEQUENCE AND SCHEDULING

A. Coordinate the shut-off and disconnection of utility services with FO&M at least two business days in advance.

B. The contractors are not allowed to open or close existing building valves.

C. The contractor shall comply with the lock out / tag out procedures in accordance with the Dartmouth College policy. These procedures are intended to prevent injury to individuals and are strictly enforced.

D. When working in occupied buildings, the contractor shall coordinate with the building occupants to schedule noisy operations. Coordination shall take place via the DC Project Manager.

E. Perform demolition in phases as indicated.

3.4 MECHANICAL DEMOLITION

A. Refer to Division 1 Sections "Cutting and Patching" and "Selective Demolition" for general demolition requirements and procedures.

B. Major changes to existing building spaces have been shown on Contract Drawings; minor changes have NOT been shown. Contractor shall anticipate that there will be numerous minor changes including:

1. Relocation of control piping and control wiring.
2. Relocation of thermostats, due to architectural revisions.
3. Relocation of diffusers and registers.

C. Existing piping, ductwork, controls and mechanical system equipment which is located in areas designated for demolitions and which are not designated to remain shall be removed under other DIVISIONS (by the General Contractor). Material which is removed and is not designated for reuse shall, at the Owner's option, either:

1. Be delivered to Owner's storage location, OR
2. Become Contractor's property and be removed from the site.

D. Fused disconnect, demolish, and remove mechanical systems, equipment, and components indicated to be removed.

1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
2. Remove from the site and legally dispose of demolished materials and equipment not indicated to be salvaged, such as inactive and obsolete piping, fittings and specialties, hangers, equipment, ductwork, controls, fixtures, and insulation. Do not abandon inactive pipe & duct in place.
3. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.
4. Ducts to Be Abandoned in Place: Cap or plug ducts with same or compatible ductwork material.

5. Equipment to Be Removed: Fused disconnect and cap services and remove equipment.
6. Equipment to Be Removed and Reinstalled: Fused disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
7. Equipment to Be Removed and Salvaged: Fused disconnect and cap services and remove equipment and deliver to Owner.
8. Electrical connections to existing equipment which is to be removed or relocated, including motors, shall be disconnected under DIVISION 16, ELECTRICAL WORK.

E. If pipe, insulation, or equipment is damaged during construction in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality at no cost to the Owner.

3.5 RENOVATION AND ALTERATION WORK

A. Where existing piping systems are altered due to required service connections to existing campus infrastructure in part, work shall be compatible with existing construction and shall be done so as to leave work in safe condition that will not adversely affect operation of remaining portions of existing systems.

3.6 INSTALLATION OF SLEEVES

A. Applications:

1. Install light sheet metal sleeves for all pipes passing through non-fire rated dry wall partitions and walls.
2. Install heavy sheet metal sleeves for all ducts passing through floors and smoke rated walls and in walls constructed of concrete or masonry.
3. Install steel pipe sleeves for all pipes passing through fire and/or smoke rated walls, and in walls constructed of masonry or concrete.
4. Sleeves may be eliminated in walls when holes are cleanly cored or saw cut through solid concrete or masonry.
5. Penetrations through exterior walls shall be heavy sheet metal or steel pipe.

B. The interstitial space between the sleeve and the (insulated) pipe/duct passing through the sleeve shall be ≥1/2" and ≤1".

C. Sleeves poured in place shall have anchors welded to the outside of the sleeve to insure embedment in the concrete. All steel shall be painted one coat of a rust inhibitive paint.

D. Sleeves shall be installed flush with the face of finished walls and ceilings; extend one inch above the level of finished floors.

E. Sleeves may be eliminated where pipes and ducts pass through fire separations providing the UL tested assembly requires the elimination of a sleeve. Refer to DC Standards 07841, THROUGH PENETRATION FIRESTOP SYSTEMS.

3.7 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 15 Sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

D. 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.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

I. Install fittings for changes in direction and branch connections.

J. Install piping to allow application of insulation.

K. Select system components with pressure rating equal to or greater than system operating pressure.

L. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:

1. New Piping:

a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
b. Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.
c. Insulated Piping: One-piece, stamped-steel type with spring clips.
d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece , cast-brass type with polished chrome-plated finish.
f. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type and set screw.
g. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with rough-brass finish.
h. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type with exposed-riveting and set screw.
i. Bare Piping in Equipment Rooms: One-piece, cast-brass type.
j. Bare Piping in Equipment Rooms: One-piece, stamped-steel type with set screw.
k. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.

M. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Install steel pipe for sleeves smaller than 6 inches in diameter.
2. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter.
3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

N. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

O. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 7 Section "Through-Penetration Firestop Systems" for materials.

P. Verify final equipment locations for roughing-in.

Q. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.8 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 15 Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

I. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
2. ABS Piping: Join according to ASTM D 2235 and ASTM D 2661 Appendixes.
3. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
4. PVC Pressure Piping: Join schedule number ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.
5. PVC Nonpressure Piping: Join according to ASTM D 2855.
6. PVC to ABS Nonpressure Transition Fittings: Join according to ASTM D 3138 Appendix.

J. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D 3139.

K. Plastic Nonpressure Piping Gasketed Joints: Join according to ASTM D 3212.

L. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.

1. Plain-End Pipe and Fittings: Use butt fusion.
2. Plain-End Pipe and Socket Fittings: Use socket fusion.

M. Fiberglass Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.

3.9 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:

1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.
3. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.
4. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

3.10 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

C. Install mechanical equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

D. Install equipment to allow right of way for piping installed at required slope.

3.11 PAINTING

A. Painting of mechanical systems, equipment, and components is specified in Division 9 Section ."

B. The mechanical contractor shall clean and paint to match original finish, all items scratched or otherwise damaged.

C. Paint with one coat of rust inhibitive primer and one coat of finish black rust inhibitive paint all steel brackets, supports, stands, hangers, etc., furnished and installed by this contractor.

3.12 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.

1. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
7. Use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Division 3 Section ."

3.13 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 5 Section "Metal Fabrications" for structural steel.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor mechanical materials and equipment.

C. Field Welding: Comply with AWS D1.1.

3.14 GROUTING

A. Mix and install grout for mechanical equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

3.15 INSTALLATION OF FILTERS

A. All air equipment with filters shall be supplied with two sets of filters except as noted below.

1. Active carbon filters.
2. Final filters.

B. Contractor shall install the first set of filters in air moving equipment to protect the air handler from the construction environment.

C. Units with provisions for both pre-filters and final filters shall initially have the same quality filter installed in the final filter location as the pre-filter.

D. Coordinate with the FO&M representative regarding the timing for installing active carbon filters.

E. The contractor shall install the second set, the owner's set, of filters just prior to the balancing contractor starting their work.

END OF SECTION 230501

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SECTION 230512 – CAST IRON BOILERS

SECTION 230512 - CAST-IRON BOILERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes packaged, factory-fabricated, gas fired, cast-iron boilers, trim, and accessories for generating hot water.

1.3 SUBMITTALS

A. Product Data: Include performance data, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: For boilers, boiler trim, and accessories. Include plans, elevations, sections, details, and attachments to other Work.

1. For installed products indicated to comply with design loads, include structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
2. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
3. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.
4. Wiring Diagrams: Detail power, signal, and control wiring.

C. Manufacturer Seismic Qualification Certification: Submit certification that cast-iron boiler, accessories, and components will withstand seismic forces defined in Division 23 Section "Mechanical Vibration and Seismic Controls" when anchored to a concrete base. Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
    a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Source quality-control test reports.

E. Startup service reports.

F. Operation and Maintenance Data: For cast-iron boilers to include in emergency, operation, and maintenance manuals.

G. Warranties: Special warranties specified in this Section.

1.4 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of cast-iron boilers and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."

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

C. ASME Compliance: Fabricate and label cast-iron boilers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

D. ASHRAE/IESNA 90.1 Compliance: Cast-iron boilers shall have minimum efficiency according to Table 10-8.

E. DOE Compliance: Minimum efficiency shall comply with 10 CFR 430, Appendix N, "Uniform Test Method for Measuring the Energy Consumption of Furnaces and Boilers."

F. I=B=R Compliance: Cast-iron boilers shall be tested and rated according to HI's "Testing and Rating Standard for Heating Boilers," with I=B=R emblem on a nameplate affixed to boiler.

G. UL Compliance: Test cast-iron boilers to comply with UL 726, "Oil-Fired Boiler Assemblies."

H. UL Compliance: Test cast-iron boilers to comply with UL 795, "Commercial-Industrial Gas Heating Equipment."

1.5 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace controls and heat exchangers of cast-iron boilers that fail in materials or workmanship within specified warranty period.

B. Warranty Period for Controls: Two years from date of Substantial Completion.

C. Warranty Period for Heat Exchangers: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Smith Cast Iron Boilers.
2. Burnham Corporation.
3. Slant/Fin Corporation.
4. Weil-McLain; a United Dominion Company.

2.2 PACKAGED CAST-IRON BOILERS

A. Description: Factory-fabricated, -assembled, and -tested cast-iron boiler with cast-iron sections sealed pressure-tight, set on an insulated steel base, and held together with tie rods; including insulated jacket and flue-gas vent connection.

B. Maximum Pressure Rating: Water, 80 psig .

C. Fabricate base and attachment to pressure vessel with reinforcement strong enough to resist boiler movement during a seismic event when boiler base is anchored to building structure.

2.3 COMPONENTS

A. Cast-Iron Section Design: Wet base, single pass, joined using high-temperature sealant to seal flue-gas passages not in contact with heating medium, tapered cast-iron push nipples, and held together with tie rods. Drain and blowdown tappings.

1. Return injection tube to equalize water flow to all sections.
2. Crown inspection tappings with brass plugs.

B. Combustion Chamber: Equipped with ceramic-fiber target wall and flame observation ports, front and back. Seal flue-gas passages between cast-iron sections with fiber rope and high-temperature sealant.

1. Combustion Chamber Access: Refractory lined, hinged, front.

C. Casing:

1. Jacket: Sheet metal, with snap-in or interlocking closures and baked-enamel protective finish.
2. Insulation: Minimum 1-inch thick fiberglass insulation surrounding the heat exchanger.
3. Access: For cleaning between cast-iron sections.
4. Draft Hood: Flue canopy and flue connection shall be constructed of aluminized steel containing integral adjustable outlet damper assembly.
5. Insulated base constructed of aluminized steel to permit boiler to be installed on combustible floor.
6. Steel rails to mount boiler on concrete base.
7. Mounting base to secure boiler to concrete base.

D. Draft Diverter: Steel assembly integral with boiler casing.

2.4 FORCED-DRAFT GAS BURNER

A. Burner: Welded construction with multivane, stainless-steel, flame-retention diffuser for natural gas.

B. Blower: Forward-curved, centrifugal fan integral to burner, directly driven by motor; with adjustable, dual-blade damper assembly and locking quadrant to set air-fuel ratio.

1. Refer to Division 23 Section "Motors" for general requirements.
2. RPM: 3450.

C. Gas Train: Control devices and modulating control sequence shall comply with requirements in IRI and UL. Burner shall be provided with factory piped gas train complete with main gas cock, pilot shut off cock, auxiliary motorized gas valve with union, combination main automatic gas valve and gas pressure regulator and leakage test gas cock.

D. Pilot: Intermittent-electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.

2.5 HOT-WATER BOILER TRIM

A. Include devices sized to comply with ANSI B31.9, "Building Services Piping."

B. Aquastat Controllers: Operating, firing rate, and high limit.

C. Safety Relief Valve: ASME rated. 40 psig.

D. Altitude and Temperature Gage: Minimum 3-1/2-inch diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges so normal operating range is at approximately 50 percent of full range.

E. Boiler Air Vent: Manual.

F. Drain Valve: Minimum NPS 3/4 hose-end gate valve.

2.6 BURNER OPERATING CONTROLS

A. Description: To maintain safe operating conditions, burner safety controls limit the operation of burner.

1. High Cutoff: Manual reset stops burner if operating conditions rise above maximum boiler design pressure.
2. Low-Water Cutoff Switch: Float and electronic probe shall prevent burner operation on low water. Cutoff switch shall be manual-reset type.
3. Blocked Vent Safety Switch: Manual-reset switch factory mounted on draft diverter.
4. Rollout Safety Switch: Factory mounted on boiler combustion chamber.
5. Alarm Bell: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.

2.7 BOILER OPERATING CONTROLS

A. Boiler operating controls shall include the following devices and features:

1. Control Transformer: 115 V.
2. Operating Pressure Control: Factory wired and mounted to cycle burner.
3. Low-Water Cutoff and Pump Control:
4. Sequence of Operation: Electric, factory-fabricated, and field-installed panel to control burner firing rate to reset supply-water temperature inversely with outside-air temperature. At -6 deg F outside-air temperature, set supply-water temperature at 160 deg F ; at 60 deg F outside-air temperature, set supply-water temperature at 120 deg F.

   a. Include automatic, alternating-firing sequence for multiple boilers.

2.8 SOURCE QUALITY CONTROL

A. Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code: Section IV.

B. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.

C. Allow Owner access to source quality-control testing of cast-iron boilers. Notify Architect 14 days in advance of testing.

PART 3 - EXECUTION

3.1 EXAMINATION

A. 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.

1. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

B. Examine mechanical spaces for suitable conditions where boilers will be installed. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 BOILER INSTALLATION

A. Install boilers level on concrete base. Concrete base is specified in Division 23 Section "Basic Mechanical Materials and Methods," and concrete materials and installation requirements are specified in Division 3.

B. Concrete Bases: Anchor boilers to concrete base.

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.
5. Cast-in-place concrete materials and placement requirements are specified in Division 3.

C. Vibration Isolation: Rubber pads with a minimum static deflection of 0.25 inch. Vibration isolation devices and installation requirements are specified in Division 23 Section "Mechanical Vibration and Seismic Controls."

D. Install gas-fired boilers according to NFPA 54.

E. Assemble and install boiler trim.

F. Install electrical devices furnished with boiler but not specified to be factory mounted.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect gas piping full size to boiler gas-train inlet with union.

C. Extend full size gas train vents through roof to atmosphere with appropriate terminations. Individual vents where applicable may be combined maintaining required free area of vent.

D. Connect hot-water piping to supply- and return-boiler tappings with shutoff valve and union or flange at each connection.

E. Install piping from safety relief valves to nearest floor drain.

F. Connect breeching full size to boiler outlet. Refer to Division 23 Section "Breechings, Chimneys, and Stacks" for venting materials.

G. Install piping adjacent to boiler to allow service and maintenance.

H. Ground equipment according to Division 26 Section "Grounding and Bonding."

I. Connect wiring according to Division 26 Section "Conductors and Cables."

J. 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 UL 486B.

3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to test, inspect, and adjust boiler components and equipment installation and to perform startup service.

B. Perform installation and startup checks according to manufacturer's written instructions.

C. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.

D. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.

E. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

F. Burner Test: Adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen, and carbon monoxide in flue gas and to achieve combustion efficiency.

G. Adjust initial temperature set points.

H. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

I. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to site outside normal occupancy hours for this purpose, without additional cost.

J. Prepare written report that documents testing procedures and results.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain cast-iron boilers. Refer to Division 1 Section "Closeout Procedures."

END OF SECTION 230512

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SECTION 230513 - MOTORS

SECTION 230513 - MOTORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes basic requirements for factory- and field-installed motors.

1.3 DEFINITIONS

A. Factory-Installed Motor: A motor installed by motorized-equipment manufacturer as a component of equipment.

B. Field-Installed Motor: A motor installed at Project site and not factory installed as an integral component of motorized equipment.

1.4 SUBMITTALS

A. Product Data for Field-Installed Motors: For each type and size of motor, provide nameplate data and ratings; shipping, installed, and operating weights; enclosure type and mounting arrangements; size, type, and location of winding terminations; conduit entry and ground lug locations; and information on coatings or finishes.

B. Shop Drawings for Field-Installed Motors: Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Include the following:

1. Each installed unit's type and details.
2. Nameplate legends.
3. Diagrams of power, signal, and control wiring. Provide schematic wiring diagram for each type of motor and for each control scheme.

C. Coordination Drawings: Floor plans showing dimensioned layout, required working clearances, and required area above and around field-installed motors. Show motor layout, mechanical power transfer link, driven load, and relationship between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.

D. Manufacturer Seismic Qualification Certification: Where seismic restraint is required by Code, submit certification that motors, accessories, and components will withstand seismic forces defined in Division 15 Section "Mechanical Vibration and Seismic Controls. Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

    a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Qualification Data: For testing agency.

F. Field quality-control test reports.

G. Operation and Maintenance Data: For field-installed motors to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

B. Source Limitations: Obtain field-installed motors through one source from a single manufacturer.

C. Product Options for Field-Installed Motors: Drawings indicate size, profiles, and dimensional requirements of motors and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."

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

E. Electrical components and materials shall be UL labeled.

F. NEMA Standards MG 1: Motors and Generators

G. NEMA Standards ICS 2: Industrial Control Devices, Controllers, and Assemblies.

H. NEMA Standard 250: Enclosures for Electrical Equipment

I. NEMA Standard KS 1: Enclosed Switches

J. NEMA Standard E: Energy efficient motors.

K. Comply with National Electrical Code (NFPA 70).

1.6 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices and features that comply with the following:

1. Compatible with the following:

    a. Magnetic controllers.
    b. Reduced-voltage controllers.

2. Designed and labeled for use with variable frequency controllers, and suitable for use throughout speed range without overheating.
3. Matched to torque and horsepower requirements of the load.
4. Matched to ratings and characteristics of supply circuit and required control sequence.

B. Coordinate motor support with requirements for driven load; access for maintenance and motor replacement; installation of accessories, belts, belt guards; and adjustment of sliding rails for belt tensioning.

C. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

PART 2 - PRODUCTS

2.1 MOTOR REQUIREMENTS

A. Motor requirements apply to factory- and field-installed motors.

2.2 MOTOR CHARACTERISTICS

A. Motors ¾ HP and Larger: Three phase.

B. Motors Smaller Than or equal to ½ HP: Single phase.

C. Frequency Rating: 60 Hz.

D. Voltage Rating: NEMA standard voltage selected to operate on nominal circuit voltage to which motor is connected.

E. Service Factor: 1.15 for open drip proof motors; 1.0 for totally enclosed motors.

F. Duty: Continuous duty at ambient temperature of 105 deg F and at altitude of 3300 feet above sea level.

G. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

H. Enclosure: Open drip proof.

I. All motors shall be rated for VFD duty whether or not originally intended for such use.

J. All motors 1hp and larger shall have a minimum of 85% power factor rating.

2.3 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Premium efficiency with minimum motor efficiency per following schedule:

OPEN DRIP PROOF MOTORS (ODP)			
HP	1200 RPM	1800 RPM	3600 RPM
1	82.5%	85.5%	77.0%
1.5	86.5%	86.5%	84.0%
2	87.5%	86.5%	85.5%
3	88.5%	89.5%	85.5%
5	89.5%	89.5%	86.5%
7.5	90.2%	91.0%	88.5%
10	91.7%	91.7%	89.5%
15	91.7%	93.0%	90.2%
20	92.4%	93.0%	91.0%
25	93.0%	93.6%	91.7%
30	93.6%	94.1%	91.7%
40	94.1%	94.1%	92.4%
50	94.1%	94.5%	93.0%
60	94.5%	95.0%	93.6%
75	94.5%	95.0%	93.6%
100	95.0%	95.4%	93.6%
125	95.0%	95.4%	94.1%
150	95.4%	95.8%	94.1%
200	95.4%	95.8%	95.0%

TOTALLY ENCLOSED FAN COOLED EXPLOSION PROOF MOTORS (TEFC)			
HP	1200 RPM	1800 RPM	3600 RPM
1	82.5%	85.5%	77.0%
1.5	87.5%	86.5%	84.0%
2	88.5%	86.5%	85.5%
3	89.5%	89.5%	86.5%
5	89.5%	89.5%	88.5%
7.5	91.0%	91.7%	89.5%
10	91.0%	91.7%	90.2%
15	91.7%	92.4%	91.0%
20	91.7%	93.0%	91.0%
25	93.0%	93.6%	91.7%
30	93.0%	93.6%	91.7%
40	94.1%	94.1%	92.4%
50	94.1%	94.5%	93.0%
60	94.5%	95.0%	93.6%
75	94.5%	95.4%	93.6%
100	95.0%	95.4%	94.1%
125	95.0%	95.4%	95.0%
150	95.8%	95.8%	95.0%
200	95.8%	96.2%	95.4%

C. Motors shall NOT be installed in Hazardous (Classified) locations, unless permitted by NEC Articles 500 through 517.

D. Stator: Copper windings, unless otherwise indicated.

1. Multispeed motors shall have separate winding for each speed.

E. Rotor: Squirrel cage, unless otherwise indicated.

F. Bearings: Double-shielded, prelubricated ball bearings suitable for radial and thrust loading.

G. Temperature Rise: Match insulation rating, unless otherwise indicated.

H. Insulation: Class F, unless otherwise indicated.

I. Code Letter Designation:

1. Motors 5 HP and Larger: NEMA starting Code F.
2. Motors Smaller Than 5 HP: Manufacturer's standard starting characteristic.

J. Enclosure: Cast iron for motors 7.5 hp and larger; rolled steel for motors smaller than 7.5 hp.

1. Finish: Gray enamel.

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

A. Motors Used with Reduced-Inrush Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.

1. Designed with critical vibration frequencies outside operating range of controller output.
2. Temperature Rise: Matched to rating for Class B insulation.
3. Insulation: Class H.
4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

C. Rugged-Duty Motors: Totally enclosed, with 1.25 minimum service factor, greased bearings, integral condensate drains, and capped relief vents. Windings insulated with non-hygroscopic material.

1. Finish: Chemical-resistant paint over corrosion-resistant primer.

D. Source Quality Control for Field-Installed Motors: Perform the following tests on each motor according to NEMA MG 1:

1. Measure winding resistance.
2. Read no-load current and speed at rated voltage and frequency.
3. Measure locked rotor current at rated frequency.
4. Perform high-potential test.

2.5 SINGLE-PHASE MOTORS

A. Type: One of the following, to suit starting torque and requirements of specific motor application:

1. Permanent-split capacitor.
2. Split-phase start, capacitor run.
3. Capacitor start, capacitor run.

B. Shaded-Pole Motors: For motors 1/20 hp and smaller only.

C. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

D. Bearings: Ball type for belt-connected motors and other motors with high radial forces on motor shaft; sealed, prelubricated-sleeve type for other single-phase motors.

E. Source Quality Control for Field-Installed Motors: Perform the following tests on each motor according to NEMA MG 1:

1. Measure winding resistance.
2. Read no-load current and speed at rated voltage and frequency.
3. Measure locked rotor current at rated frequency.
4. Perform high-potential test.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive field-installed motors for compliance with requirements, installation tolerances, and other conditions affecting performance.

B. Examine roughing-in for conduit systems to verify actual locations of conduit connections before motor installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FIELD-INSTALLED MOTOR INSTALLATION

A. Anchor each motor assembly to base, adjustable rails, or other support, arranged and sized according to manufacturer's written instructions. Attach by bolting. Level and align with load transfer link.

B. Install motors on concrete bases complying with Division 3.

C. Comply with mounting and anchoring requirements specified in Division 15 Section "Mechanical Vibration and Seismic Controls."

3.3 FIELD QUALITY CONTROL FOR FIELD-INSTALLED MOTORS

A. Prepare for acceptance tests.

1. Align motors, bases, shafts, pulleys, and belts. Tension belts according to manufacturer's written instructions.
2. Verify bearing lubrication.
3. Run each motor with its controller. Demonstrate correct rotation, alignment, and speed at motor design load.
4. Test interlocks and control and safety features for proper operation.
5. Verify that current and voltage for each phase comply with nameplate rating and NEMA MG 1 tolerances.

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

C. Perform the following field tests and inspections and prepare test reports:

1. Perform electrical tests and visual and mechanical inspections except optional tests and inspections stated in NETA ATS on field -installed motors. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3.4 FIELD-INSTALLED MOTOR DEMONSTRATION

A. Refer to Division 1 Section "Closeout Procedures."

3.5 CLEANING

A. After completing equipment installation, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

B. Clean motors, on completion of installation, according to manufacturer's written instructions.

END OF SECTION 230513

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SECTION 230516 – PIPE EXPANSION FITTINGS AND LOOPS

SECTION 230516 - PIPE EXPANSION FITTINGS AND LOOPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following pipe expansion joints and expansion compensation devices for mechanical piping systems:

1. Metal-bellows expansion joints.
2. Expansion compensators.
3. Rubber expansion joints.
4. Flexible-hose expansion joints.
5. Packed slip expansion joints.
6. Pipe bends and loops.
7. Alignment guides and anchors.

1.3 DEFINITIONS

A. BR: Butyl rubber.

B. Buna-N: Nitrile rubber.

C. CR: Chlorosulfonated polyethylene synthetic rubber.

D. CSM: Chlorosulfonyl-polyethylene rubber.

E. EPDM: Ethylene-propylene-diene terpolymer rubber.

F. NR: Natural rubber.

G. PTFE: Polytetrafluoroethylene plastic.

1.4 PERFORMANCE REQUIREMENTS

A. Compatibility: Products shall be suitable for piping system fluids, materials, working pressures, and temperatures.

B. Capability: Products shall absorb 200 percent of maximum axial movement between anchors.

1.5 SUBMITTALS

A. Product Data: For each type of pipe expansion joint and alignment guide indicated.

B. Shop Drawings: Signed and sealed by a qualified professional engineer.

1. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and bends.
2. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
3. Alignment Guide Details: Detail field assembly and attachment to building structure.
4. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.

C. Product Certificates: For each type of pipe expansion joint, signed by product manufacturer.

D. Welding certificates.

E. Operation and Maintenance Data: For pipe expansion joints to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to the following:

1. Steel Shapes and Plates: AWS D1.1, "Structural Welding Code - Steel."
2. Welding to Piping: ASME Boiler and Pressure Vessel Code: Section IX.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 EXPANSION JOINTS

A. Externally pressurized bellows type expansion joints. Bellows shall be made of a minimum 3 ply multi-layer 304 stainless steel. Bellows shall be welded to the internal guide ring and housing. Expansion joint shall be preset for ambient conditions on the construction site and shall have a minimum 3/4” compensation for contraction.

1. Expansion joints shall be flanged whenever possible and shall be equipped with a drain port. Housing shall be made of carbon steel piping matching the installation.
2. Approved manufacturers are HySpan series 3500 and Pathway X-Press.

B. Expansion Compensators: Double-ply corrugated steel, stainless steel, or copper-alloy bellows in a housing with internal guides, antitorque device, and removable end clip for positioning.

1. Manufacturers:

    a. Hyspan Precision Products, Inc.
    b. Senior Flexonics, Inc.; Pathway Division.

2. Minimum Pressure Rating: 300 psig, unless otherwise indicated.
3. Configuration for Copper Piping: Two-ply phosphor-bronze or stainless-steel bellows and bronze or stainless-steel shroud.
4. Configuration for Steel Piping: Two-ply stainless-steel bellows and carbon-steel shroud.
5. End Connections for Copper Tubing NPS 2 and Smaller: Threaded.
6. End Connections for Copper Tubing NPS 2-1/2 to NPS 4: Threaded.
7. End Connections for Steel Pipe NPS 2 and Smaller: Threaded.
8. End Connections for Steel Pipe NPS 2-1/2 to NPS 4: Flanged.

C. Rubber Expansion Joints: ASTM F 1123, fabric-reinforced rubber with external control rods and complying with FSA's "Technical Handbook: Non-Metallic Expansion Joints and Flexible Pipe Connectors."

1. Manufacturers:

    a. Flex-Hose Co., Inc.
    b. Flexicraft Industries.
    c. Flex-Weld, Inc.
    d. Garlock Sealing Technologies.
    e. General Rubber Corp.
    f. Mason Industries, Inc.; Mercer Rubber Co.
    g. Metraflex, Inc.
    h. MG Piping Products Co.
    i. Proco Products, Inc.
    j. Red Valve Company, Inc.
    k. Senior Flexonics, Inc.; Pathway Division.
    l. Tozen America Corp.
    m. Unaflex Inc.
    n. Vibration Mountings & Controls, Inc.
    o. Keflex

2. Arch Type: Multiple arches.
3. Spherical Type: Multiple spheres.

    a. Minimum Pressure and Temperature Ratings for NPS 1-1/2 to NPS 4: 150 psig at 220 deg F
    b. Minimum Pressure and Temperature Ratings for NPS 5 and NPS 6: 140 psig at 200 deg F.
    c. Minimum Pressure and Temperature Ratings for NPS 8 to NPS 12: 140 psig at 180 deg F.

4. Material: EPDM.
5. End Connections: Full-faced, integral, steel flanges with steel retaining rings.

D. Flexible-Hose Expansion Joints: Manufactured assembly with two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose; with inlet and outlet elbow fittings, corrugated-metal inner hoses, and braided outer sheaths.

1. Manufacturers:

a. Flex-Hose Co., Inc.
b. Flexicraft Industries.
c. Flex-Pression, Ltd.
d. Metraflex, Inc.

2. Flexible-Hose Expansion Joints for Copper Piping: Copper-alloy fittings with solder-joint end connections.

a. NPS 2 and Smaller: Bronze hoses and single-braid bronze sheaths with 450 psig at 70 deg F and 340 psig at 450 deg F ratings.
b. NPS 2-1/2 to NPS 4: Stainless steel hoses and single-braid, stainless steel sheaths with 300 psig at 70 deg F and 225 psig at 450 deg F ratings.

3. Flexible-Hose Expansion Joints for Steel Piping: Carbon-steel fittings with threaded end connections for NPS 2 and smaller and weld end connections for NPS 2-1/2 and larger.

a. NPS 2 and Smaller: Stainless steel hoses and single-braid, stainless steel sheaths with 450 psig at 70 deg F and 325 psig at 600 deg F ratings.
b. NPS 2-1/2 to NPS 6: Stainless steel hoses and single-braid, stainless steel sheaths with 200 psig at 70 deg F and 145 psig at 600 deg F ratings.
c. NPS 8 to NPS 12: Stainless steel hoses and single-braid, stainless steel sheaths with 125 psig at 70 deg F and 90 psig at 600 deg F ratings.

E. Packed Slip Expansion Joints: ASTM F 1007, carbon-steel, packing type designed for repacking under pressure and pressure rated for 250 psig at 400 deg F minimum. Include asbestos-free PTFE packing, compound limit stops, and drip connection if used for steam piping.

1. Manufacturers:

a. Adsco Manufacturing, LLC.
b. Advanced Thermal Systems, Inc.
c. Hyspan Precision Products, Inc.

2. Configuration: Single- and double-joint class with base, unless otherwise indicated.
3. End Connections: Flanged or weld ends to match piping system.

2.3 ALIGNMENT GUIDES

A. Description: Steel, factory fabricated, with bolted two-section outer cylinder and base for alignment of piping and two-section guiding spider for bolting to pipe.

1. Manufacturers:

    a. Adsco Manufacturing, LLC.
    b. Advanced Thermal Systems, Inc.
    c. Flex-Hose Co., Inc.
    d. Flexicraft Industries.
    e. Flex-Weld, Inc.
    f. Hyspan Precision Products, Inc.
    g. Metraflex, Inc.
    h. Piping Technology & Products, Inc.
    i. Senior Flexonics, Inc.; Pathway Division.

2.4 MATERIALS FOR ANCHORS

A. Steel Shapes and Plates: ASTM A 36/A 36M.

B. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel, hex head.

C. Washers: ASTM F 844, steel, plain, flat washers.

D. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, and tension and shear capacities appropriate for application.

1. Stud: Threaded, zinc-coated carbon steel.
2. Expansion Plug: Zinc-coated steel.
3. Washer and Nut: Zinc-coated steel.

E. Chemical Fasteners: Insert-type-stud bonding system anchor for use with hardened portland cement concrete, and tension and shear capacities appropriate for application.

1. Bonding Material: ASTM C 881, Type IV, Grade 3, 2-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
2. Stud: ASTM A 307, zinc-coated carbon steel with continuous thread on stud, unless otherwise indicated.
3. Washer and Nut: Zinc-coated steel.

F. Concrete: Portland cement mix, 3000 psi minimum. Refer to Division 3 Section "Cast-in-Place Concrete" for formwork, reinforcement, and concrete.

G. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink, nonmetallic grout, suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 EXPANSION-JOINT INSTALLATION

A. Install manufactured, nonmetallic expansion joints according to FSA's "Technical Handbook: Non-Metallic Expansion Joints and Flexible Pipe Connectors."

B. Install expansion joints of sizes matching size of piping in which they are installed.

C. Install alignment guides to allow expansion and to avoid end-loading and torsional stress.

3.2 SWING CONNECTIONS

A. Connect risers and branch connections to mains with at least five pipe fittings, including tee in main.

B. Connect risers and branch connections to terminal units with at least four pipe fittings, including tee in riser.

C. Connect mains and branch connections to terminal units with at least four pipe fittings, including tee in main.

3.3 ALIGNMENT-GUIDE INSTALLATION

A. Install guides on piping adjoining pipe expansion joints and bends and loops.

B. Attach guides to pipe and secure to building structure.

3.4 ANCHOR INSTALLATION

A. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

B. Fabricate and install steel anchors by welding steel shapes, plates, and bars to piping and to structure. Comply with ASME B31.9 and AWS D1.1.

C. Construct concrete anchors of poured-in-place concrete of dimensions indicated and include embedded fasteners.

D. Install pipe anchors according to expansion-joint manufacturer's written instructions if expansion joints or compensators are indicated.

E. Use grout to form flat bearing surfaces for expansion fittings, guides, and anchors installed on or in concrete.

END OF SECTION 230516

TABLE OF CONTENTS
SECTION 230518 – FIRE-TUBE BOILERS

SECTION 230518 – VERTICAL TUBELESS STEAM BOILERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes packaged, factory-fabricated and -assembled, gas-fired, vertical tubeless boilers, trim, condensate return/feed water system, blow-off separator, make-up water softener system and accessories for generating steam.

1.3 SUBMITTALS

A. Product Data: Include performance data, operating characteristics, furnished specialties, and accessories.
   1. Wiring Diagrams: Detail power, signal, and control wiring.

B. Manufacturer Seismic Qualification Certification: Submit certification that boiler, accessories, and components will withstand seismic forces defined in Division 23 Section "Mechanical Vibration and Seismic Controls" when anchored to a concrete base. Include the following:

   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

      a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Source quality-control test reports.

D. ASME Stamp Certification and Report: Submit "A," "S," or "PP" stamp certificate of authorization, as required by authorities having jurisdiction, and document hydrostatic testing of piping external to boiler.

E. Startup service reports.

F. Operation and Maintenance Data: For boilers to include in emergency, operation, and maintenance manuals.

G. Warranties: Special warranties specified in this Section.

1.4 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of boilers and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."

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

C. ASME Compliance: Fabricate and label boilers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

D. ASHRAE/IESNA 90.1 Compliance: Boilers shall have minimum efficiency according to Table 10-8.

E. UL Compliance: Test fire-tube boilers to comply with UL 795, "Commercial-Industrial Gas Heating Equipment."

1.5 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Fulton, or approved equivalent.

2.2 STEAM BOILERS

A. General

1. The steam boiler(s) shall be of the vertical tubeless type or vertical multi port and shall be constructed in accordance with the ASME section I Power Boiler Code for 15 or 150 psig MAWP. Each boiler unit shall consist of a vertical tubeless boiler, boiler fittings, burner equipment, and automatic controls. The boiler (with all piping and wiring) shall be factory assembled as a self-contained unit. Each boiler shall be neatly finished,

thoroughly tested, and properly packaged for shipment. Both boiler and burner must be the product of the same manufacturer to assure undivided responsibility and simplified servicing. The boilers shall be inspected, certified, and bear all applicable national and local code labels. Boiler trim shall include relief valves dial type pressure gauge, low water cut off, and other items as required. The complete boiler shall carry the Underwriters Laboratory (UL) label.

B. Capacity

The boilers shall have the capacities as listed the equipment schedules.

C. Refractory Material

1. All refractory materials shall consist of non-asbestos materials. The boiler section subject to direct flame shall be insulated with a high strength, low permanent linear change, high temperature limit castable material. Ceramic fiber insulation is not acceptable.

D. Access

1. An observation port shall be provided to view the combustion chamber. Unit shall be of gas-tight construction throughout. Handholes and cleanout openings shall be provided at the lower part of boiler so that the entire bottom of the boiler may be cleaned.

E. Boiler Trim

1. Boiler trim shall include safety relief valve(s), complete probe-type level control system to include feed pump, on/off control, and redundant low water cutoff. In addition, dial-type pressure gauge and stack temperature gauge shall be incorporated. Feedwater stop and check valves with fast closure and slow-opening blowdown valves incorporated as part of the complete package. Water column blowdown valve and steam stop valve shall be provided.

F. Vessel

1. Pressure vessel shall contain no tubes. It will be constructed of heavy gauge metal not less than 5/16" thick. Unit shall be provided with lifting hooks and a factory primed and painted steel jacket.

G. Factory Assembly

1. Units shall be assembled and wired with burner controls and trim.

H. Fuel Burning Equipment

1. Fuel-burning equipment shall be forced draft type-assembled, wired, mounted, and tested at the factory. The entire unit shall be ready for field connection to power and fuel supply. Equipment shall include forced draft fan, flame sensing

device, and control cabinet containing electronic flame safeguard and programmer & indicating lights for major operations. Burner modulation shall be standard on all boilers larger than 40 hp.

I. Motors and Controls

1. All motors shall be suitable for 480 volt, 60 hertz, 3 phase operation. Controls shall be 115 volt, 60 hertz, single phase. Magnetic motor starters or motor contractors, depending on voltage, shall be provided in the control cabinet.

J. Gas Burner

1. Gas burner shall be vertically oriented, down fired forced draft type with the following features: a main gas control group consisting of an automatic gas valve, automatic safety gas valve, gas volume modulating control valve, gas pressure regulator, checking gas cock, gas cock, etc., gas-electric ignition assembly consistent of a pilot burner, 6,000 volt ignition transformer, flame rod or UV scanner, and air flow safety switch. Fuel train shall comply with CSD-1 code.

K. Controls

1. Operating pressure control for automatic start and stop of burner operation.

2. Two low water cut-off probes to cause shut down of unit when water level drops to minimum safe level, (one in the water column and one in the boiler shell). The one in the shell shall be manual reset to comply with ANSI/ASME CSD-1 Code.

3. Gas fired boilers shall have an air safety switch to prevent operation until sufficient combustion air is assured.

4. A contact for a feedwater pump shall be included and consist of a single phase pump motor starter or contacts for 3 phase pump.

5. The control shall maintain a running history of operating hours, number of cycles, and the most recent six flame failures. This control shall have the capability to be connected to a keyboard display module which will retrieve that information

6. Burner motor controller shall have thermal overload protection.

7. All controls to be panel mounted and so located on the boiler as to provide ease of servicing the burner and boiler without disturbing the controls; and also located to prevent possible damage by water, fuel or heat of combustion gases. Controls connected to water or fuel shall be installed outside the main boiler control panel.

8. All controls shall be mounted and wired according to Underwriters' Laboratories requirements.

2.3 CONDENSATE RETURN/FEEDWATER SYSTEM

A. The condensate return/feedwater system shall be a vertically oriented vented system complete with a water level gauge glass, mechanical float type switch and makeup water valve assembly and (2) pumps(s). This system will be factory assembled and tested, including leak test to insure proper manufacturing. The system shall have a primer coat and finish coat of paint. Feedwater pumps shall provide feedwater and flow at a rate of 2.5 times the boiler evaporation rate for 105% of boiler pressure. Low pressure boilers (<30 psi) shall have feedwater pump flow control valves. Stainless steel pump internals shall be used and seals rated for 225F. Pump NPSHR must be at least 1.5 times the NPSHA with 200F feed water. Feedwater preheat system shall be incorporated to heat feedwater to 200°F temperature rise based on 100% make up rate.

2.4 BLOW-OFF SEPERATOR

A. The boiler blow-off separator shall be ASME Section VIII Div. I approved and National Board registered pressure vessel. The unit shall carry the "U" stamp and be rated for 75 psi in accordance with the 1991 National Boiler Blow-off Code. The separator shall be constructed of a minimum of 3/8" thick steel shell and 5/8" thick flat heads. All material vessel shall have a centrifugally baffled blow-off inlet to allow for the flashing of steam. It shall have adequate handhole openings to allow for internal inspection of vessel. The connections to be included on this vessel are a top vent for steam flash release, a bottom drain, a blowoff inlet and outlet as well as a cold water inlet. The system shall include an automatic cooling kit to insure that the proper blow-off water temperature is maintained before draining to the sewer system. The blow-off separator shall have a primer and finish coat of paint.

2.5 BOILER SOLIDS MANAGEMENT

A. An automatic blow-down valve with timer to be provided for fully automatic control of bottom boiler blow-off. This used in conjunction with the conductivity-based automatic surface blowdown will allow totally unmanned operation of blow-off which is essential to boiler pressure vessel longevity.

2.6 MAKEUP WATER SOFTENER SYSTEM

A. The water softening system shall consist of a twin tank alternating concept with meter initiation method. It shall also have a brine tank. The softener shall be equipped with a motor driven control valve with fully adjustable regeneration cycles. In addition, the softener shall have a self adjusting backwash controller and time brine refill control utilizing high capacity polystyrene resin to provide maximum hardness removal capacity and salt efficiency.

B. The softener system shall be capable of operating between 30 and 125 psig with a maximum water temperature of 110 degrees. It shall be able to deliver a ________ maximum daily system grain capacity. The service flow rate will be ___ GPM normal to ____ GPM peak based on 15 and 25 psig respectively. The backwash flow rate will be 6 GPM and the salt storage capacity will be a minimum of 50 pounds. The mineral tanks shall be constructed of seamless fiberglass to provide corrosion control. The brine tank shall be constructed of rigid polyethylene with a dust tight cover. The motor driven control valve shall be of all brass construction. These tanks will have a five year warranty and a one year warranty on all other components. Bypass valves and piping shall be included.

2.7 CARBON FILTRATION

A. Carbon filtration shall be used to dechlorinate city water. A complete system including fiberglass tank, automatic backwash valve and granular-activated carbon. System sizing shall provide no more than 3 gpm per cubic foot of carbon media. Bypass piping and valves shall be included.

2.8 CHEMICAL TREATMENT

A. Provide chemical treatment system to maintain the following parameters. Typically only oxygen scavenging is required. If sulfite is used to control oxygen, then 5-10 ppm residual sulfite is recommended in boiler water.

2.9 CHEMICAL PARAMETERS

Recommended Chemistry Limits for Clean Steam Boilers

	Make up Water	*Feed Water*	*Boiler Water*	*Method of Control / Removal*
Free chlorine	< 0.02 ppm		ND	Carbon Filtration
Dissolved oxygen		< 0.05 ppm	ND	De-aeration/ preheat/ sulfite
Hardness	< 0.05 ppm		< 1 ppm	Water softener
Suspended solids	< 1 ppm		< 15 ppm	Back wash/ blow down
ph			8.5 – 10	Neutralizer pre-treatment
Total dissolved solids			< 1500 ppm	Blow down
Total organic carbon	< 1 ppm		ND	Carbon Filtration

2.10 SKID MOUNTING

All the components in this specification shall be mounted on steel skid(s) with the appropriate number of lifting holes to insure ease of movement and installation of system. The steel skid shall be constructed of ¼" thick steel decking material welded to 4" structural steel channel primed and painted. All components shall be welded or bolted to the deck of the skid to insure that no movement is possible in shipment. All components are to be completely piped and wired. Two check valves shall be included on the feedwater line to the boiler. All blow-down piping fitting are to be forged steel. All interconnecting steel piping shall be schedule 80.

2.11 SINGLE SOURCE POWER CONNECTION

Single source power connection allows for a single power connection to the skid system that will then control all the components on the skid. This will include a fused disconnect as well as a control circuit transformer (3 phase). It shall also include all wiring to both 3 phase, if possible, and single phase requirements. When multiple boilers are specified, each boiler will get an additional non-fused disconnect.

2.12 SINGLE POINT WATER, DRAINS, AND STEAM CONNECTIONS

All cold water piping to the blow-off separator, water softener, and return system will be on a common header to allow a single water connection. All drains from the boiler, return tank ,water softener and carbon filter will be piped together to the blow down separator. The piping from the boiler steam outlet to the return system preheat kit will be included. Multiple boiler skids shall have high water protection for an idle boiler and an interconnecting steam header sized for 100 percent steam flow.

PART 3 - EXECUTION

3.1 EXAMINATION

A. 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.

   1. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

B. Examine mechanical spaces for suitable conditions where boilers will be installed. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 BOILER INSTALLATION

A. Install boilers support equipment level on concrete base. Concrete base is specified in Division 23 Section "Basic Mechanical Materials and Methods," and concrete materials and installation requirements are specified in Division 3.

B. Concrete Bases: Anchor boilers to concrete base.

   1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of base.
   2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.

3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.
5. Cast-in-place concrete materials and placement requirements are specified in Division 3.

C. Vibration Isolation: Rubber pads with a minimum static deflection of **0.25 inch.** Vibration isolation devices and installation requirements are specified in Division 23 Section "Mechanical Vibration and Seismic Controls."

D. Install gas-fired boilers according to NFPA 54.

E. Assemble and install boiler trim.

F. Install electrical devices furnished with boiler but not specified to be factory mounted.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect gas piping full size to boiler gas-train inlet with union.

C. Extend full size gas train vents through roof to atmosphere with appropriate terminations. Individual vents where applicable may be combined maintaining required free area of vent.

D. Connect steam and condensate piping to supply-, return-, and blowdown-boiler tappings with shutoff valve and union or flange at each connection.

E. Install piping from safety relief valves to nearest floor drain.

F. Install piping from safety valves to drip-pan elbow and to nearest floor drain.

G. Connect breeching full size to boiler outlet. Refer to Division 23 Section "Breechings, Chimneys, and Stacks" for venting materials.

H. Install piping adjacent to boiler to allow service and maintenance.

I. Ground equipment according to Division 26 Section "Grounding and Bonding."

J. Connect wiring according to Division 26 Section "Conductors and Cables."

K. 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 UL 486B.

3.4 FACTORY TESTING

A. Boiler inspection shall include a hydrostatic test in the presence of an inspector having a National Board Commission. He shall certify a Data Report which shall be delivered with the boiler as evidence of ASME Code compliance. In addition to an ASME symbol, the boiler shall bear a National Board Registration Number.

B. Proper operation of the boiler and all controls will be assured by filling with water and test firing at the factory. Test firing will include adjusting all operating and safety controls to the correct settings.

C. Hydrostatic test of boiler external piping shall be included with skid-mounted systems.

3.5 START-UP AND WARRANTY SERVICE

A. The boiler installation shall be inspected by the manufacturer prior to start-up.

B. The field start-up of the boiler shall be performed by factory certified mechanics.

C. The pressure vessel shall have a 10 year (120 month) material and workmanship warranty, when furnished as part of a prepiped system. All other components are covered by a one year (12 month) warranty.

D. Instructions for installation, operation, and maintenance of the boiler shall be contained in a manual provided with each boiler unit.

E. A wiring diagram specific to the boiler shall be included in the boiler panel box.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fire-tube boilers. Refer to Division 1 Section "Closeout Procedures."

END OF SECTION 230518

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SECTION 230519 – METERS AND GAGES

SECTION 230519 - METERS AND GAGES

PART 1 - DESIGN DIRECTIVE

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following meters and gages for mechanical systems:

1. Thermometers.
2. Gages.
3. Test plugs.
4. Flowmeters.
5. Thermal-energy meters.

B. Related Sections include the following:

1. Division 2 Section "Water Distribution" for domestic and fire-protection water service meters outside the building.
2. Division 2 Section "Natural Gas Distribution" for gas meters outside the building.
3. Division 22 Section "Domestic Water Piping" for domestic and fire-protection water service meters inside the building.
4. Division 23 Section "Steam and Condensate Piping" for steam and condensate meters.
5. Division 22 Section "Fuel Gas Piping" for gas meters inside the building.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated; include performance curves.

B. Shop Drawings: Schedule for flowmeters and thermal-energy meters indicating manufacturer's number, scale range, and location for each.

C. Product Certificates: For each type of flowmeter and thermal-energy meter, signed by product manufacturer.

D. Operation and Maintenance Data: For flowmeters and thermal-energy meters to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Comply with applicable UL standards pertaining to meters and gages and with applicable portions of ASME and Instrument Society of America (ISA) standards pertaining to construction and installation of meters and gages.

PART 2 - PRODUCTS

2.1 THERMOMETERS, GENERAL

A. Accuracy shall be 1% of range span, grade A.

B. Temperature ranges for services listed as follows (center of range shall be the scheduled fluid temperature):

1. Domestic Hot Water: 0° to 200°F with 2° scale divisions.
2. Domestic Cold Water: 30° to 130°F with 2° scale divisions.
3. Hot Water: 0° to 250°F with 2° scale divisions.
4. Chilled Water: 30° to 130°F with 2° scale divisions.
5. Steam and Condensate: 50° to 300°F with 2° scale divisions.

2.2 BIMETAL DIAL THERMOMETERS

A. Direct mounted, bimetal type with adjustable angle feature for 360° rotation and 180° angle adjustment. Hermetically sealed, 5" diameter case of welded stainless steel construction with external adjustment. Thermometer shall have a bimetal coil, plastic window, white dial with black markings. Stem Length of 6", or adjust length to be minimum 3" from insulation, 1/2" NPT stem connection.

B. Manufacturers:

1. Ashcroft, Dresser Industries, Instrument Div. #50EL60E series.
2. Trerice #B85600 series

2.3 THERMOMETER WELLS

A. Brass threaded thermometer wells for all piping systems, pressure rated to match piping system design pressure; with 2" extension for insulated piping and threaded cap nut with chain permanently (material to match well material) fastened to well and cap.

2.4 PRESSURE GAGES

A. General use, ASME B40. 1, Grade 2A, phosphor bronze bourdon tube type, bottom connection. Phenolic case, 4-1/2" diameter, with 1/2" NPS brass connector. White coated aluminum background, with permanently etched black markings. Accuracy shall be ± 1/2% of range span. The scale range for all gages shall be 2 times the operating pressure. All gages in liquid systems shall be vibration resistant (Plus performance or silicone filled).

B. Manufacturers:

1. Ashcroft, Dresser Industries, Instrument Div.

   a. Steam systems: #45-1279-04L
   b. Liquid systems: #45-1279-04L-XLL

2. Trerice

   a. Steam systems: #450B45TRL500PSI series
   b. Liquid systems: #450BG45TRL500PSI series

2.5 PRESSURE GAGE ACCESSORIES

A. Connectors:

1. Steam systems: Provide 1/2" NPS iron pig tail siphons.
2. Water systems steel: 1/2" NPS steel (for steel pipe) or brass (for copper pipe) nipple, length to allow minimum 3" beyond insulation cover.

B. Snubber

1. Steel piping systems: 1/2" stainless steel, Ashcroft #112S, or Ashcroft #1 12B, 1/2" brass, for copper piping systems
2. Provide a 1/2" ball or needle valve, carbon steel for steel piping systems or bronze for copper piping systems.

2.6 STEAM CONDENSATE METERS

A. Gravity type condensate meters shall constructed of a metal housing with a volumetric measuring drum and a self powered totalizer. Casing shall be cast iron with a copper metering drum. System shall be designed for operating temperature of 350° at 100% humidity.

1. Cadillac Condensate Meters as manufactured by Claussen Engineering, Camas WA

B. Pressure type condensate meters shall be a brass housing with an internal impeller capable of withstanding hot temperatures (220° F). The meter shall be self-powered not requiring power from an external source and have a self contained gauge. Provide a pulse output for remote meter reading.

1. Niagra series MTX, model 421, with model 860 infrared pulser.

2.7 ULTRASONIC FLOW METERS

A. The flow-energy meter shall be a clamp-on, dual channel transit-time design precluding the requirement of penetrating into the pipe. The dual channel operating mode shall be capable of acting as an energy meter using two strap on temperature sensors and a flow meter. The unit shall be able to calculate and display chilled water use in ton-hours. The flowmeter shall be completely microprocessor based. The flowmeter shall employ technology to insure operation on liquids with solids and or bubbles.

B. The flowmeter shall provide automatic transducer spacing utilizing a mounting track (ruler scales not acceptable). The flowmeter shall have the ability to indicate flow & energy rate, flow velocity, total energy, T1, T2 & delta T, signal strength, for both channels or paths. The flowmeter shall be equipped with an integral front panel keypad and multifunction display with the ability of displaying both channels and paths simultaneously. In addition, the flowmeter shall provide self and application diagnostics to isolate any fault conditions to either equipment failure or abnormal process conditions. The flowmeter shall have full HELP menu routines corresponding to all levels of programming and operation.

C. The flow-energy meter electronics shall be housed in a NEMA 4X enclosure and powered by 115VAC, 60Hz. One isolated 4 to 20 maDC and one 0 to 5000 Hz pulse output proportional to flow shall be provided for each channel or the average of both paths. In addition, using an open communications protocol such as Lon Works, Modbus, or BACnet the unit shall provide one 0 to 10 volt or 4-20mA output and four alarm relays assignable to flow velocity, liquid sonic velocity, signal strength or liquid aeration. An internal datalogger shall be provided to allow storage of all measured and calculated variables and alarms. A bi-directional RS-232 connection shall be provided to allow remote programming and interrogation.

D. The flow-energy meter shall have an accuracy of +/-1-2% of flow over a +/-40 fps flow range. Repeatability shall be 0. 1% of flow with a flow sensitivity of 0.001 fps at any flow rate including no flow conditions. Turndown shall be at least 1:200.

E. By use of either transit-time or Doppler modes of operation, the flowmeter shall be capable of measuring all liquids in full sonically conductive pipes. Flowmeters that simply offer stand alone transit-time or Doppler measurement modes are not acceptable. The flow meters shall be able to be used on steel pipes up to sch 80 and PVC pipes up to sch 80 thickness.

F. Supply and return temperature measurement shall be via platinum matched RTD'S.

G. Energy calculation shall be integral to the meter and shall utilize the feed temperature for mass calculation.

H. Flowmeters shall be:

1. Controlotron model 1010EDN
2. Panametrics model AT868.

2.8 LOW PRESSURE DROP FLOW METERS

A. Pitot tube type design sensing upstream total pressure and downstream static pressure. Meter shall have very low pressure drop.

1. Bell & Gossett Circuit Sensor
2. Taco Sentinel

2.9 TEST PLUGS

A. Manufacturers:

1. Flow Design, Inc.
2. MG Piping Products Co.
3. National Meter, Inc.
4. Peterson Equipment Co., Inc.
5. Sisco Manufacturing Co.
6. Trerice, H. O. Co.
7. Watts Industries, Inc.; Water Products Div.

B. Description: Corrosion-resistant brass or stainless steel body with core inserts and gasketed and threaded cap, with extended stem for units to be installed in insulated piping.

C. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F.

D. Core Inserts: One or two self-sealing rubber valves.

1. Insert material for air, water, oil, or gas service at 20 to 200 deg F shall be CR.
2. Insert material for air or water service at minus 30 to plus 275 deg F shall be EPDM.

E. Test Kit: Furnish one test kit(s) containing one pressure gage and adaptor, one thermometer(s), and carrying case. Pressure gage, adapter probes, and thermometer sensing elements shall be of diameter to fit test plugs and of length to project into piping.

1. Pressure Gage: Small bourdon-tube insertion type with 2- to 3-inch diameter dial and probe. Dial range shall be 0 to 200 psig.
2. Low-Range Thermometer: Small bimetallic insertion type with 1- to 2-inch diameter dial and tapered-end sensing element. Dial ranges shall be 25 to 125 deg F.
3. High-Range Thermometer: Small bimetallic insertion type with 1- to 2-inch diameter dial and tapered-end sensing element. Dial ranges shall be 0 to 220 deg F.
4. Carrying case shall have formed instrument padding.

PART 3 - EXECUTION

3.1 THERMOMETERS INSTALLATION

A. Install thermometers in vertical and tilted positions to allow reading by observer standing on floor.

B. Install thermometer wells in piping tee where thermometers are indicated, in vertical position. Fill well with oil or graphite and secure cap.

C. Install Pete's plug at temperature gauge locations.

3.2 INSTALLATION OF PRESSURE GAGES

A. Install pressure gages in piping tee with pressure gage valve, located on pipe at most readable position.

B. Install snubbers in liquid piping systems, siphons in steam piping systems.

C. Install Pete's plug at temperature gauge locations.

3.3 CONNECTIONS

A. Install meters and gages piping adjacent to machine to allow servicing and maintaining of machine.

3.4 CONDENSATE METERS

A. Install gravity type meters in systems that do not have condensate pumps.

B. Install pressure type meters in systems with condensate pumps.

C. All condensate meters shall have a valved bypass.

3.5 ULTRASONIC FLOW METERS

A. Install ultrasonic flow meters in chilled water systems at building entrances.

3.6 LOW PRESSURE DROP FLOW METERS

A. Install low pressure drop flow meters on piping system equipped with VFD's.

B. Comply with manufacturer's written recommendations for unrestricted pipe upstream and downstream of the meter.

END OF SECTION 230519

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SECTION 230523 – VALVES

SECTION 230523 - VALVES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following general-duty valves:

1. Copper-alloy ball valves.
2. Ferrous-alloy butterfly valves.
3. High-pressure butterfly valves.
4. Bronze check valves.
5. Gray-iron swing check valves.
6. Ferrous-alloy wafer check valves.
7. Spring-loaded, lift-disc check valves.
8. Bronze gate valves.
9. Cast-iron gate valves.
10. Bronze globe valves.
11. Cast-iron globe valves.
12. Chainwheel actuators.

B. Related Sections include the following:

1. Division 2 piping Sections for general-duty and specialty valves for site construction piping.
2. Division 13 fire-suppression piping and fire pump Sections for fire-protection valves.
3. Division 23 Section "Mechanical Identification" for valve tags and charts.
4. Division 23 Section "HVAC Instrumentation and Controls" for control valves and actuators.
5. Division 23 piping Sections for specialty valves applicable to those Sections only.

1.3 DEFINITIONS

A. The following are standard abbreviations for valves:

1. CWP: Cold working pressure.
2. EPDM: Ethylene-propylene-diene terpolymer rubber.
3. NBR: Acrylonitrile-butadiene rubber.
4. PTFE: Polytetrafluoroethylene plastic.
5. SWP: Steam working pressure.
6. TFE: Tetrafluoroethylene plastic.

1.4 SUBMITTALS

A. Product Data: For each type of valve indicated. Include body, seating, and trim materials; valve design; pressure and temperature classifications; end connections; arrangement; dimensions; and required clearances. Include list indicating valve and its application. Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories.

1.5 QUALITY ASSURANCE

A. ASME Compliance: ASME B31.1 for power piping valves and ASME B31.9 for building services piping valves.

1. Exceptions: Domestic hot- and cold-water, sanitary waste, and storm drainage piping valves unless referenced.

B. ASME Compliance for Ferrous Valves: ASME B16.10 and ASME B16.34 for dimension and design criteria.

C. NSF Compliance: NSF 61 for valve materials for potable-water service.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, grooves, and weld ends.
3. Set angle, gate, and globe valves closed to prevent rattling.
4. Set ball and plug valves open to minimize exposure of functional surfaces.
5. Set butterfly valves closed or slightly open.
6. Block check valves in either closed or open position.

B. Use the following precautions during storage:

1. Maintain valve end protection.
2. Store valves indoors and maintain at higher than ambient dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:

1. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.2 VALVES, GENERAL

A. Refer to Part 3 "Valve Applications" Article for applications of valves.

B. Bronze Valves: NPS 2 and smaller with threaded ends, unless otherwise indicated.

C. Ferrous Valves: NPS 2-1/2 and larger with flanged ends, unless otherwise indicated.

D. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

E. Valve Sizes: Same as upstream pipe, unless otherwise indicated.

F. Valve Actuators:

1. Chainwheel: For attachment to valves, of size and mounting height, as indicated in the "Valve Installation" Article in Part 3.
2. Gear Drive with position indicators: For quarter-turn valves NPS 8 and larger.
3. Handwheel with position indicators: For valves other than quarter-turn types.
4. Lever Handle: For quarter-turn valves NPS 6 and smaller, except plug valves.
5. Wrench: For plug valves with square heads. Furnish Owner with 1 wrench for every 10 plug valves, for each size square plug head.

G. Extended Valve Stems: On insulated valves.

H. Valve Flanges: ASME B16.1 for cast-iron valves, ASME B16.5 for steel valves, and ASME B16.24 for bronze valves.

I. Valve Bypass and Drain Connections: MSS SP-45.

2.3 BALL VALVES

A. Ball Valves, 2" and Smaller, Carbon Steel Body: rated for 150 psi saturated steam pressure, 2000 psi WOG pressure for 1/4" through 1", 1500 psi WOG pressure for 1-1/4" through 2"; two piece construction; with carbon steel body, regular port, 316 stainless steel ball and stem, replaceable "Teflon" or "TFE" seats and seals, blowout proof stem, vinyl covered steel handle, threaded ends and extended stem for insulated piping.

Apollo	73-14x series
Flowtech	S90
Neles-Jamesbury	4000 series
Watts	C-7000-SS series

B. Ball Valves, 3" and larger, Bronze Body: rated for 150 psi saturated steam pressure, 400 psi WOG pressure; two piece construction; with bronze body, regular port, B-16 chrome plated ball and stem, replaceable "Teflon" or "TFE" seats and seals, blowout-proof stem, vinyl covered steel handle, threaded or solder ends and extended stem for insulated piping.

	Threaded	*Solder*
Apollo	70-10x series	70-20x series
Flowtech	S51	
Neles-Jamesbury	351	341
Watts	B-6000 series	B-6001 series

C. Low Point Drain Valves: ¾" inlet bronze body rated for 150 psi saturated steam pressure, 400 psi WOG pressure; two piece construction; with bronze body, regular port, B-16 chrome plated ball and stem, replaceable 'Teflon' or 'TFE' seats and seals, blowout-proof stem, vinyl covered steel handle. System end shall be thread or solder, opposite end shall be ¾" hose connection with brass cap.

	Threaded	*Solder*
Apollo	78-104-01 series	N/A
Watts	B-6000-CC series	B-6001-CC series

2.4 BUTTERFLY VALVES

A. Steam Service and Building Chilled Water Isolation: Hi-Performance butterfly valves, 21/2" and Larger: MSS SP-67; ANSI Class 150 carbon steel body conforming to ASTM A 216, type WCB. Provide lever operators with locks for sizes 2" through 6" and gear operators with position indicator for sizes 8" through 24". Lug type, bi-directional valves with 316 stainless steel disc, 17-4 PH stainless steel shaft, filled (reinforced) TFE with TFE packing or Extreme seats and enhanced filled TFE packing. Seat retainer ring to be bolted in place with stainless steel bolts.

Flowseal	1LA-121RTG
Neles-Jamesbury	Wafer Sphere #81 5-L-1 1-2236XZ
Bray	Series 40

B. Water Service: Resilient seated lug type butterfly valves, 2-1/2" and Larger: MSS SP-67; ductile iron body. The disc shall be in constant contact with the seat, be constructed of aluminum bronze or 316 stainless steel, have a concentric self centering style, and shall be free floating without the use of pins of fasteners. The EPDM seat shall be rated for -20°F to 250°F. The shaft shall be stainless steel. Minimum pressure rating for valves ~12~ shall be 175 psi; valves >12~ shall be 150 psi. Provide lever operators with locks for sizes 2" through 6" and gear operators with position indicator for sizes greater than 6s.

Bray	S31/320
Demco	NE-C series

2.5 CHECK VALVES

A. Swing Check Valves, 2" and Smaller Bronze Body: MSS SP-80; Class 125, cast bronze body and cap conforming to ASTM B-62; with horizontal swing, Y-pattern, bronze disc; and having threaded or solder ends. Provide valves capable of being reground while the valve remains in the line. Provide Class 150 valves meeting the above specifications, with threaded end connections, where system pressure requires or where Class 125 valves are not available.

	Threaded	*Solder*
Crane	137	1342
Milwaukee Valve	509	1509
Watts	CVY	CVYS

B. Swing Check Valves, 2" and Smaller Bronze Body: MSS SP-80; Class 300, cast bronze body and cap conforming to ASTM B-61; with horizontal swing, Y-pattern, bronze disc; and having threaded ends. Provide valves capable of being reground while the valve remains in the line.

Crane	76E

C. Swing Check Valve, 2" and Smaller, shall be malleable iron body, cap, disc and hinge conforming to ASTM A-338, 300 psi SWP, threaded ends.

Crane	3461/2

D. Swing Check Valve, 21/2" and Larger, Cast Iron: MSS SP-71, class 250 cast iron body and cap, bronze (ASTM B-62) disc (d6") or bronze faced iron disk (>6") and hinge.

Crane	39E

E. Spring Loaded Silent Check Valve, 2" and smaller: MSS SP-61; 300 psi non shock pressure rating, 18-8 stainless steel construction throughout including guard cage, spring, valve disc, retaining ring and seat.

Durabla	BSS

F. Split Disc Wafer Check Valves: Cast iron body 125lb., ASTM A126-B, with replaceable EPDM seat, non-slam design, lapped and balanced twin bronze valve plates, 316 stainless steel trim and torsion spring. Provide valves designed to open and close at approximately one foot differential pressure.

Mueller	71 -A-H-B-6-H
Technocheck	5050

G. Wafer Check Valves: Cast iron body, 125lb., ASTM A126, with replaceable Buna 'N' or Viton 'O'-ring, non-slam design, 304 stainless steel disc, and 316 stainless steel pin & spring.

Check Rite	Model 210

2.6 GLOBE VALVES

A. Globe valves, 2" and smaller, malleable iron body: 125 SWP, body and union bonnet of ASTM A 338 malleable iron; with threaded ends, 13% chromium stainless steel disc and stem, TFE impregnated, non-asbestos packing, and malleable iron handwheel.

Crane	254XR

2.7 GLOBE TYPE BALANCING VALVE:

A. 3/8" through 2", with solder NPT connections, metal brass copper alloy construction with a minimum of four, 360° rotations of handwheel for maximum setting.

B. 21/2" and larger, with flanged connections, cast iron body with all other parts of nonferrous copper alloy construction with eight or twelve 360° rotations of handwheel for maximum setting.

C. Balancing valves to have provisions for measuring differential pressure, flow rates, flow temperature and air venting as an integral part of the valve body and be of the globe style, wye pattern design.

D. Balancing valves to provide 100% positive, leakproof shutoff against the same fluid pressure as the valve body pressure rating.

E. Provide manufacturer's preformed insulation covers when valves are installed in insulated piping systems.

Tour & Anderson	STAD & STAF
Armstrong	CBV-T & CBV-G

2.8 BALL TYPE BALANCING VALVE

A. Bronze body and brass ball construction with Teflon seat suitable for use in domestic water systems.

B. Valves shall have differential pressure ports and drain/purge port.

C. Valves shall have a memory stop.

D. Valves shall have calibrated name plate.

E. Manufacturers:

1. Bell & Gossett – Circuit Setter
2. Taco – Accu-Flo

2.9 AUTOMATIC FLOW CONTROL VALVES:

A. Flow control cartridge assembly shall be precision ground, all stainless steel; shall be available in a minimum of two PSID control ranges (minimum range shall be capable of being activated by 2 PSID), and shall be capable of controlling flow within 5±% of rated flow. All valves shall be supplied with pressure and temperature test ports, be permanently marked to show direction of flow, and have body tag to indicate flow rate, model number and PSID control range.

B. All products shall be warranted by the manufacturer for five years from date of shipment.

C. Accessible valves, <2":

1. Bronze body rated at 300 PSI/250°F.
2. NPT end connections.
3. Cartridge shall be available of being removed without disturbing the piping system.
4. Available flow rates of 0.55 GPM to 22.0 GPM in a 2-32 psid range.

Flow Design, Inc	Model YR
Griswold Controls	Isolator Y or Isolator R
Nexus	Ultramatic

D. Pre-assembled systems, ≤2", shall meet all of the requirements of part 'D', accessible valves, the supply side component shall be a single device that incorporates an isolation ball valve, strainer with blowdown, and one pressure/ temperature port (Griswold Isolator S). The return side shall include an accessible flow control valve, isolation valve, two pressure/ temperature ports (Griswold Isolator R), and the control valve. Assembly shall be Griswold CPP-2IRIS.

E. Accessible valves, >2":

1. Ductile or gray iron body, be rated at 150 PSI.
2. Flange end connections or be a wafer design.
3. Available flow rates of 18 GPM to 6,400 GPM in a 2-32 psid range

Flow Design, Inc	Model WS
Griswold Controls	Steel Flange or Uni-Flange valve
Nexus	Ultramatic

2.10 CHAINWHEEL ACTUATORS

A. Manufacturers:

1. Babbitt Steam Specialty Co.
2. Roto Hammer Industries, Inc.

B. Description: Valve actuation assembly with sprocket rim, brackets, and chain.

1. Sprocket Rim with Chain Guides: Ductile iron, of type and size required for valve.
2. Brackets: Type, number, size, and fasteners required to mount actuator on valve.
3. Chain: Hot-dip, galvanized steel, of size required to fit sprocket rim.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine piping system for compliance with requirements for installation tolerances and other conditions affecting performance.

1. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

C. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

D. Examine threads on valve and mating pipe for form and cleanliness.

E. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

F. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE APPLICATIONS

A. Refer to piping Sections for specific valve applications. If valve applications are not indicated, use the following:

1. Shutoff Service: Ball, butterfly, or gate valves.
2. Throttling Service: Ball, butterfly, or globe valves.
3. Pump Discharge: Spring-loaded, lift-disc check valves.
4. All butterfly valves shall be lug type suitable for dead end service.

B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP class or CWP ratings may be substituted.

C. Install automatic flow control valves per the manufacturer's written instructions and the following criteria:

1. A minimum of 5 pipe diameters upstream of the valve to a pipe fitting, 10 pipe diameters upstream of a pump.
2. A minimum of 2 pipe diameters downstream of the valve to a pipe fitting.
3. All automatic flow control valves shall have a 20 mesh strainer upstream of the valve.

D. Where automatic flow control valves control multiple heating devices (i.e. risers, entire floors, etc.), install a valve with a strainer upstream and an isolation valve downstream. Where automatic flow control valves control individual heating terminals, install pre-assembled systems (strainers on inlet and valves on outlet).

E. Chilled-Water Piping: Use the following types of valves:

1. Ball Valves, NPS 2 and Smaller: Two or Three-piece, 400-psig] CWP rating, copper alloy.
2. Butterfly Valves, NPS 2-1/2 and Larger: 250-psig CWP rating, ferrous alloy, with EPDM liner.
3. High-Performance Butterfly Valves, NPS 3 and Larger: Lug Type, Class 300.
4. Lift Check Valves, NPS 2 and Smaller: Type 2, Class 150, horizontal or vertical, bronze.
5. Swing Check Valves, NPS 2 and Smaller: Type 4, Class 125, bronze.
6. Swing Check Valves, NPS 2-1/2 and Larger: Type II, Class 125, gray iron.
7. Grooved-End, Ductile-Iron, Swing Check Valves, NPS 2-1/2 and Larger: 300-psig CWP rating.
8. Wafer Check Valves, NPS 2-1/2 and Larger: Dual-plate, double-flanged, Class 150 ferrous alloy.
9. Spring-Loaded, Lift-Disc Check Valves, NPS 2 and Smaller: Type IV, Class 125 minimum.
10. Spring-Loaded, Lift-Disc Check Valves, NPS 2-1/2 and Larger: Type I, Class 125, cast iron.
11. Globe Valves, NPS 2 and Smaller: Type 2, Class 125, bronze.

F. Domestic Water Piping: Use the following types of valves:

1. Angle Valves, NPS 2 and Smaller: Type 2, Class 125 , bronze.
2. Angle Valves, NPS 2-1/2 and Larger: Type II, Class 125, cast iron.
3. Ball Valves, NPS 2 and Smaller: Two-piece, 400-psig CWP rating, copper alloy.
4. Ball Valves, NPS 2-1/2 and Larger: Class 150, ferrous alloy.
5. Butterfly Valves, NPS 2-1/2 and Larger: Flanged, 250-psig CWP rating, ferrous alloy, with EPDM liner.
6. Lift Check Valves, NPS 2 and Smaller: Type 2, Class 125 , horizontal or vertical, bronze.
7. Swing Check Valves, NPS 2 and Smaller: Type 4, Class 125 , bronze.
8. Swing Check Valves, NPS 2-1/2 and Larger: Type II, Class 125, gray iron.
9. Grooved-End, Ductile-Iron, Swing Check Valves, NPS 2-1/2 and Larger: 175-psig CWP rating.
10. Wafer Check Valves, NPS 2-1/2 and Larger: Single -plate, long type, Class 150, ferrous alloy.
11. Spring-Loaded, Lift-Disc Check Valves, NPS 2 and Smaller: Type IV, Class 125 minimum .
12. Spring-Loaded, Lift-Disc Check Valves, NPS 2-1/2 and Larger: Type I, Class 125, cast iron.
13. Gate Valves, NPS 2 and Smaller: Type 1, Class 125 , bronze.
14. Gate Valves, NPS 2-1/2 and Larger: Type I, Class 125, OS&Y, bronze-mounted cast iron.
15. Globe Valves, NPS 2 and Smaller: Type 2, Class 125 , bronze.
16. Globe Valves, NPS 2-1/2 and Larger: Type I, Class 125, bronze-mounted cast iron.
17. Plug Valves, NPS 2 and Larger: Class 125 or 150, lubricated-type with FDA-approved-material sealant, cast iron.
18. Resilient-Seated, Eccentric Plug Valves, NPS 3 and Larger: 175-psig CWP rating, cast iron.

G. Heating Water Piping: Use the following types of valves:

1. Ball Valves, NPS 2 and Smaller: Two-piece, 400-psig CWP rating, copper alloy.
2. Butterfly Valves, NPS 2-1/2 and Larger: Single-flange, 175-psig CWP rating, ferrous alloy, with EPDMliner.
3. Lift Check Valves, NPS 2 and Smaller: Type 2, Class 125, horizontal, bronze.
4. Swing Check Valves, NPS 2 and Smaller: Type 4, Class 125, bronze.
5. Swing Check Valves, NPS 2-1/2 and Larger: Type II, Class 125, gray iron.
6. Grooved-End, Ductile-Iron, Swing Check Valves, NPS 2-1/2 and Larger: 300-psig CWP rating.
7. Wafer Check Valves, NPS 2-1/2 and Larger: Dual-plate, double-flanged, Class 125 or 150, ferrous alloy.
8. Spring-Loaded, Lift-Disc Check Valves, NPS 2 and Smaller: Type IV, Class 125 minimum.
9. Spring-Loaded, Lift-Disc Check Valves, NPS 2-1/2 and Larger: Type I, Class 125, cast iron.
10. Globe Valves, NPS 2 and Smaller: Type 2, Class 125, bronze.
11. Globe Valves, NPS 2-1/2 and Larger: Type I, Class 125, bronze-mounted cast iron.
12. Resilient-Seated, Eccentric Plug Valves, NPS 3 and Larger: 175-psig CWP rating, cast iron.

H. Low-Pressure Steam Piping: Use the following types of valves:

1. Ball Valves, NPS 2 and Smaller: Two or Three-piece, 400-psig CWP rating, copper alloy.
2. High-Performance Butterfly Valves, NPS 2-1/2 and Larger: Single-flange, Class 150.
3. Swing Check Valves, NPS 2 and Smaller: Type 4, Class 125, bronze.
4. Swing Check Valves, NPS 2-1/2 and Larger: Type II, Class 125, gray iron.
5. Globe Valves, NPS 2 and Smaller: Type 2, Class 125, bronze.
6. Globe Valves, NPS 2-1/2 and Larger: Type I, Class 125, bronze-mounted cast iron.

I. Steam Condensate Piping: Use the following types of valves:

1. Ball Valves, NPS 2 and Smaller: Two or Three-piece, 400-psig CWP rating, copper alloy.
2. High-Performance Butterfly Valves, NPS 3 and Larger: Single-flange, Class 150.
3. Swing Check Valves, NPS 2 and Smaller: Type 4, Class 125, bronze.
4. Swing Check Valves, NPS 2-1/2 and Larger: Type II, Class 125, gray iron.
5. Spring-Loaded, Lift-Disc Check Valves, NPS 2 and Smaller: Type IV, Class 125 minimum.
6. Spring-Loaded, Lift-Disc Check Valves, NPS 2-1/2 and Larger: Type I, Class 125, cast iron.
7. Globe Valves, NPS 2 and Smaller: Type 2, Class 125, bronze.
8. Globe Valves, NPS 2-1/2 and Larger: Type I, Class 125, bronze-mounted cast iron.

J. Select valves, except wafer and flangeless types, with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Solder-joint or threaded ends.
2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends.
3. For Copper Tubing, NPS 5 and Larger: Flanged ends.
4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends.
6. For Steel Piping, NPS 5 and Larger: Flanged ends.

3.3 VALVE INSTALLATION

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

C. Locate valves for easy access and provide separate support where necessary.

D. Install valves in horizontal piping with stem at or above center of pipe.

E. Install valves in position to allow full stem movement.

F. Install chainwheel operators on valves NPS 4 and larger and more than [84 inches above floor. Extend chains to 60 inches above finished floor elevation.

G. Install check valves for proper direction of flow and as follows:

1. Swing Check Valves: In horizontal position with hinge pin level.
2. Dual-Plate Check Valves: In horizontal or vertical position, between flanges.
3. Lift Check Valves: With stem upright and plumb.

3.4 JOINT CONSTRUCTION

A. Refer to Division 23 Section "Basic Mechanical Materials and Methods" for basic piping joint construction.

B. Grooved Joints: Assemble joints with keyed coupling housing, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.

C. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated.

3.5 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.6 VALVE PRESSURE/TEMPERATURE CLASSIFICATION SCHEDULES

VALVES – 2" AND SMALLER			
SERVICE	BALL	CHECK	GLOBE
Domestic hot and cold water.	1500 wog *see Note 1*	125	125
HVAC systems ≤21 0°F supply and return	1500 wog *see Note 1*	150	n/a
≥30 psig steam, gravity & pumped condensate return	1500 wog	300	125

Note 1: valve size may be extended to include d3" pipe line size.

VALVES – 2½" AND LARGER			
SERVICE	BUTTERFLY	CHECK	GLOBE
Domestic hot and cold Water.	150	125	N/A
HVAC systems ≤210°F supply and return	150	150	N/A
≥30 psig steam, gravity & pumped condensate return	150	300	125

END OF SECTION 230523

TABLE OF CONTENTS
SECTION 230529 – HANGERS AND SUPPORTS

SECTION 230529 - HANGERS AND SUPPORTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes hangers and supports for mechanical system piping and equipment.

B. Related Sections include the following:

1. Division 13 Sections on fire-suppression piping for fire-suppression pipe hangers.
2. Division 23 Section "Mechanical Vibration Controls and Seismic Restraints" for vibration isolation and seismic restraint devices.
3. Division 23 Section "Pipe Expansion Fittings and Loops" for pipe guides and anchors.
4. Division 23 Section "Metal Ducts and Non-Metal Ducts" for duct hangers and supports.

1.3 DEFINITIONS

A. MSS: Manufacturers Standardization Society for the Valve and Fittings Industry.

B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.4 PERFORMANCE REQUIREMENTS

A. Design channel support systems for piping to support multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.

B. Design heavy-duty steel trapezes for piping to support multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.

C. Design seismic restraint hangers and supports for piping and equipment.

D. Design and obtain approval from authorities having jurisdiction for seismic restraint hangers and supports for piping and equipment.

1.5 SUBMITTALS

A. Product Data: For each type of pipe hanger, channel support system component, and thermal-hanger shield insert indicated.

B. Shop Drawings: Signed and sealed by a qualified professional engineer for multiple piping supports and trapeze hangers and seismic restraints. Include design calculations and indicate size and characteristics of components and fabrication details.

1.6 QUALITY ASSURANCE

A. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

B. Engineering Responsibility: Design and preparation of Shop Drawings and calculations for each multiple pipe support, trapeze, and seismic restraint by a qualified professional engineer.

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Pipe Hangers:

a. B-Line Systems, Inc.
b. Carpenter & Patterson, Inc.
c. Empire Tool & Manufacturing Co., Inc.
d. Anvil Corp.
e. National Pipe Hanger Corp.
f. Piping Technology & Products, Inc.

2. Channel Support Systems:

a. B-Line Systems, Inc.
b. Anvil Corp.; Power-Strut Unit.
c. National Pipe Hanger Corp.
d. Thomas & Betts Corp.
e. Unistrut Corp.

3. Thermal-Hanger Shield Inserts:

a. Carpenter & Patterson, Inc.
b. Michigan Hanger Co., Inc.
c. PHS Industries, Inc.
d. Pipe Shields, Inc.
e. Rilco Manufacturing Co., Inc.
f. Value Engineered Products, Inc.

4. Powder-Actuated Fastener Systems:

    a. Gunnebo Fastening Corp.
    b. Hilti, Inc.
    c. ITW Ramset/Red Head.
    d. Masterset Fastening Systems, Inc.

2.2 MANUFACTURED UNITS

A. Pipe Hangers, Supports, and Components: MSS SP-58, factory-fabricated components. Refer to "Hanger and Support Applications" Article in Part 3 for where to use specific hanger and support types.

    1. Galvanized, Metallic Coatings: For piping and equipment that will not have field-applied finish.
    2. Nonmetallic Coatings: On attachments for electrolytic protection where attachments are in direct contact with copper tubing.

B. Channel Support Systems: MFMA-2, factory-fabricated components for field assembly.

    1. Coatings: Manufacturer's standard finish, unless bare metal surfaces are indicated.
    2. Nonmetallic Coatings: On attachments for electrolytic protection where attachments are in direct contact with copper tubing.

C. Thermal-Hanger Shield Inserts: 100-psi minimum compressive-strength insulation, encased in sheet metal shield.

    1. Material for Cold Piping: Water-repellent-treated, ASTM C 533, Type I calcium silicate with vapor barrier.
    2. Material for Hot Piping: Water-repellent-treated, ASTM C 533, Type I calcium silicate.
    3. For Trapeze or Clamped System: Insert and shield cover entire circumference of pipe.
    4. For Clevis or Band Hanger: Insert and shield cover lower 180 degrees of pipe.
    5. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.3 MISCELLANEOUS MATERIALS

A. Powder-Actuated Drive-Pin Fasteners: Powder-actuated-type, drive-pin attachments with pull-out and shear capacities appropriate for supported loads and building materials where used.

B. Mechanical-Anchor Fasteners: Insert-type attachments with pull-out and shear capacities appropriate for supported loads and building materials where used.

C. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars, black and galvanized.

D. Grout: ASTM C 1107, Grade B, factory-mixed and -packaged, nonshrink and nonmetallic, dry, hydraulic-cement grout.

1. Characteristics: Post hardening and volume adjusting; recommended for both interior and exterior applications.
2. Properties: Nonstaining, noncorrosive, and nongaseous.
3. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

A. Specific hanger requirements are specified in Sections specifying equipment and systems.

B. Comply with MSS SP-69 and SP-89 for pipe hanger selections and applications that are not specified in piping system Specification Sections.

C. Horizontal-Piping Hangers and Supports: 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.
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120 to 450 deg F pipes, NPS 4 to NPS 16, requiring up to 4 inches of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24, requiring clamp flexibility and up to 4 inches of insulation.
4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, NPS 1/2 to NPS 24, if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes, NPS 1/2 to NPS 4, 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.
7. Adjustable Steel Band Hangers (MSS Type 7): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
9. Adjustable Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 2.
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.
11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 3.
12. U-Bolts (MSS Type 24): For support of heavy pipe, NPS 1/2 to NPS 30.
13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. Pipe Saddle Supports (MSS Type 36): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange.

15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange and with U-bolt to retain pipe.
16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes, NPS 2-1/2 to NPS 36, if vertical adjustment is required, with steel pipe base stanchion support and cast-iron floor flange.
17. Single Pipe Rolls (MSS Type 41): For suspension of pipes, NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.
18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes, NPS 2-1/2 to NPS 20, from single rod if horizontal movement caused by expansion and contraction might occur.
19. Complete Pipe Rolls (MSS Type 44): For support of pipes, NPS 2 to NPS 42, if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes, NPS 2 to NPS 24, if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes, NPS 2 to NPS 30, if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

D. 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.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20, if longer ends are required for riser clamps.

E. 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 for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, 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 deg F piping installations.

F. Building Attachments: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
3. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
4. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.

5. C-Clamps (MSS Type 23) with retaining clip: For structural shapes. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
7. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
8. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
9. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
10. Malleable Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
11. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:

    a. Light (MSS Type 31): 750 lb.
    b. Medium (MSS Type 32): 1500 lb.
    c. Heavy (MSS Type 33): 3000 lb.

12. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams
13. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
14. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where head room is limited.

G. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:

1. Steel Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe, 360-degree insert of high-density, 100-psi minimum compressive-strength, water-repellent-treated calcium silicate or cellular-glass pipe insulation, same thickness as adjoining insulation with vapor barrier and encased in 360-degree sheet metal shield.

H. 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.
3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41 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 percent 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 percent 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 percent 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 one trapeze member.

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.

   1. The following schedule:

	Pipe Size	Steel Pipe	Copper Pipe	Cast Iron Pipe	Schedule 40 PVC Pipe W/100°F Fluid	Schedule 80 PVC Pipe W/120°F Fluid
HORIZONTAL	≤3/4"	7'	5'	10'	4'	3'
	1" – 1-1/4"	7'	6'	10'	4'	3.5'
	1-1/2"	9'	8'	10'	4'	3.5'
	2"	10'	8'	10'	4'	4'
	2-1/2"	11'	9'	10'	4'	4.5'
	≥3"	12'	10'	10'	4'	4.5'
	4"	12'	10'	10'	4'	5'
	6"	12'	10'	10'	4'	6'
	8"	12'	10'	10'	4'	6.5'

	Pipe Size	Steel Pipe	Copper Pipe	Cast Iron Pipe	Schedule 40 PVC Pipe W/100°F Fluid	Schedule 80 PVC Pipe W/120°F Fluid
	10"	12'	10'	10'	4'	7'
VERTICAL	All sizes: at every floor or as scheduled	12'	12'	10'	4'	

B. Channel Support System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled channel systems.

1. Field assemble and install according to manufacturer's written instructions.

C. Heavy-Duty Steel Trapeze Installation: Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated, heavy-duty trapezes.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.
2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D-1.1.

D. Install building attachments within concrete slabs or attach to structural steel. Space attachments within maximum piping span length indicated in MSS SP-69. Install additional attachments at concentrated loads, including valves, flanges, guides, strainers, and expansion joints, and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

E. Install powder-actuated drive-pin fasteners in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.

F. Install mechanical-anchor fasteners in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

G. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.

H. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

I. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

J. Pipe Slopes: Install hangers and supports to provide required pipe slopes and so maximum pipe deflections allowed by ASME B31.9, "Building Services Piping," is not exceeded.

K. Insulated Piping: Comply with the following:

1. Attach clamps and spacers to piping.

   a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
   b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
   c. Do not exceed pipe stress limits according to ASME B31.9.

2. Install MSS SP-58, Type 39 protection saddles, if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.

   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40 protective shields on cold piping with vapor barrier. Shields shall span arc of 180 degrees.

   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

4. Shield Dimensions for Pipe: Not less than the following:

   a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
   b. NPS 4: 12 inches long and 0.06 inch thick.
   c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
   d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
   e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.

5. Pipes NPS 8 and Larger: Include wood inserts.
6. Insert Material: Length at least as long as protective shield.
7. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.3 HANGER RODS

A. Hanger rods shall be carbon steel, sizes per the following schedule:

Pipe size	*Rod size*
≤2"	3/8"
2½" -> 3"	1/2"
4" -> 5"	5/8"
6" -> 8"	3/4"
10" -> 12"	7/8"
≥14"	1"

3.4 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure above or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make smooth bearing surface.

3.5 METAL FABRICATION

A. Cut, drill, and fit miscellaneous metal fabrications for heavy-duty steel trapezes and equipment supports.

B. Fit exposed connections together to form hairline joints. Field-weld connections that cannot be shop-welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1 procedures for shielded metal arc welding, appearance and quality of welds, and methods used in correcting welding work, and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.

3.6 ADJUSTING

A. Hanger Adjustment: Adjust hangers to distribute loads equally on attachments and to achieve required slope of pipe.

3.7 PAINTING

A. Touching Up: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 9 Section "Painting."

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 230529

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SECTION 230548 – MECHANICAL SEISMIC RESTRAINT & VIBRATION ISOLATION

SECTION 230548 - MECHANICAL SEISMIC RESTRAINT & VIBRATION ISOLATION

PART 1 - GENERAL

1.1 INTENT

A. It is the intent of this Section to establish standards for quality and performance for certain basic materials used in providing mechanical work specified under Section 230501 BASIC MECHANICAL MATERIALS AND METHODS.

B. Refer to SECTION 230626, paragraph 1.2, INTENT, for detailed definitions as to how the BASIC MATERIALS sections (including this Section) shall be interpreted for the project.

C. Manufacturer's qualifications, firms regularly engaged in manufacture of seismic restraint products, of type, size and capacity required, whose products have been in satisfactory use in similar service for not less than 5 years.

D. Codes and Standards:

1. 2006 International Building Code.
2. Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA) Seismic Restraint Manual Guidelines for Mechanical Systems, 1991 edition.
3. ASHRAE HVAC Applications Handbook, Seismic Restraint Design, 1999 edition.

1.2 RELATED DOCUMENTS

A. Section 230500, General Requirements for Mechanical Work

B. Section 230501, Basic Materials and Methods For Mechanical Work

C. Section 233113, Metal Ducts

D. Section 230593, Testing, Adjusting and Balancing

E. Refer to sections of Division 23 for schedules identifying seismic restraints and vibration isolation devices required for this project.

1.3 SHOP DRAWING SUBMITTALS

A. Shop drawings shall include:

1. Itemized list detailing the mechanical systems and components to be isolated, including: the equipment identification mark, isolator type, actual load, static deflection under load, specified minimum deflection, additional deflection to solid under load and the ratio of spring height to spring diameter. List shall include number and location of isolators for each piece of equipment.
2. Itemized list detailing mechanical systems and components to be seismically restrained, associated seismic restraint system to be used, device loading, and reference to specific

drawings showing base and construction where applicable. List shall include number and location of seismic restraints and anchors for each piece of equipment.

3. Itemized list detailing all plumbing system components requiring seismic mounting and/or restraints. Equipment shall include, but not be limited to: water heaters, booster pumps, expansion tanks, storage tanks, air compressors, vacuum pumps and tanks. List shall include number and location of seismic restraints including expansion bolts, brackets and mounting requirements for each piece of equipment.
4. Itemized list detailing mechanical systems and components which are to be neither isolated nor seismically restrained.
5. Seismic restraint calculations.
6. Professional Structural Engineer's personal signature and rubber stamped seal (photocopied or stamped signatures and photocopied seals are prohibited) verifying design and calculations for seismic restraining systems; including calculation information that verifies snubber capacities for isolated equipment. Certification shall be by a professional Structural Engineer with a State of Maine P.E. registration.
7. All seismic restraining devices shall have a pre-approved number from California OSHPD or some other recognized government agency showing maximum restraint ratings. Devices shall indicate that they meet the requirements for design and testing ad indicated in ASCE 7 Appendix A.
8. Detail drawings on equipment bases including dimensions, structural member sizes, support point locations, maximum loading at each location, and concrete and steel details such as anchor bolt locations.
9. Detail drawings on vibration isolation and seismic restraint systems for pipes and ductwork including locations, methods of suspension, support guides, and maximum loading at each location. Locations shall be shown on MEP coordination drawings. Coordination drawings as described from process detailed in 230501.
10. Detail drawing on piping systems showing pipe expansion loops required at building expansion/seismic joints. Include manufacturer's recommended connection and installation requirements. Locations of all trades expansion loops must be shown on MEP coordination drawings.
11. Load-versus-deflection curves, by manufacturer, for each vibration isolator.

B. In addition to other requirements for approval of substitutions:

1. Contractor must prove substitute systems meet the deflection and structural design of systems specified.
2. Requests for substitution of "internally isolated" mechanical equipment in lieu of specified isolation and restraint systems must include certification by equipment manufacturer that equipment supports meet specified isolation and seismic restraint criteria. Certification must be sealed by structural engineer.

C. Shop drawing for equipment shall include bolt points and diameter of inserts, certified by structural engineer.

1.4 OTHER SUBMITTALS

A. Before field welding is performed, submit three copies of the Welders' Performance Qualification Record meeting ANSI B31.1/31.9 showing that the welder was tested under approved procedure specification for metals included on project.

B. Submit record of static deflection as designed and as measured in field, for fans, pumps and other equipment.

C. Submit four copies of manufacturer's installation instructions and drawings.

D. Submit four copies of final inspection report which includes: Certification by a Structural Engineer with P.E. registration in the state in which the project is located, that:

E. Manufacturer of vibration isolation and seismic control equipment shall guarantee performance of vibration isolation and seismic restraint systems including specified isolation system deflection.

PART 2 - PRODUCTS

2.1 SEISMIC RESTRAINT SYSTEMS - GENERAL

A. Seismic devices shall be by manufacturer with five years experience in designing and manufacturing seismic devices. Acceptable manufacturers are Mason Industries and Vibration Mountings and Controls.

B. Mechanical systems shall comply with 2006 IBC with NH Amendments. Fire protection systems shall comply with 2006 IBC with NH Amendments and NFPA 14.

C. Systems for normal mechanical systems (i.e., equipment, piping and ductwork) shall be capable of safely accepting 0.5 "G" external force in any direction, without failure and without permanent displacement of system being restrained.

D. Systems for life safety equipment (e.g. fire protection systems) shall be capable of safely accepting 1.0 "G" external force in any direction, without failure and without permanent displacement of system being restrained.

E. Systems shall maintain mechanical equipment, piping and ductwork in a captive position. Systems shall NOT short circuit vibration isolation systems and shall NOT transmit objectionable vibration or noise. Systems shall be non-resonant with the equipment forcing frequencies and with the building structure's natural frequencies.

2.2 VIBRATION ISOLATION SYSTEMS – GENERAL

A. Vibration isolation shall be by manufacturer with 5 years experience in designing and manufacturing isolation devices. Acceptable manufacturers are Mason Industries, Vibration Mounting and Controls, Amber/Booth, Korfund Dynamics and Kinetics Noise Control.

B. Isolators shall have either known non-deflected heights or calibration markings so that, after adjustment, when carrying their load, the deflection under load can be verified to determine if the load is within the proper range of the device and if the correct degree of vibration isolation is being provided according to the design.

C. Isolators shall operate in the linear portion of their load-versus-deflection curve. Load-versus-deflection curves shall be linear over a deflection range of not less than 50% above the design deflection.

D. Theoretical vertical natural frequency for each support point, based upon load per isolator and isolator stiffness, shall NOT differ from the design objectives for the equipment as a whole by more than +/-10%. Isolators shall be non-resonant with the equipment forcing frequencies and with the building structure's natural frequencies.

E. Neoprene mountings shall have a Shore hardness of 30 to 60 +/-5, after minimum aging of 20 days or corresponding oven-aging.

2.3 SEISMIC RESTRAINT PRODUCTS

A. Refer to paragraph 2.1, SEISMIC RESTRAINT SYSTEM – GENERAL, for general requirements.

B. Type SR-PM:

1. Shall be plate structural members or square metal tubing in welded assembly with resilient pads; with minimum 5/8" thick pad limit stops in all directions; for use on each corner or side of equipment being restrained.
2. Shall be field bolted or welded to structural deck.
3. Shall be Mason Industries "Type Z-1011" and "Type Z-1225" or acceptable equivalent.

C. Type SR-C:

1. Shall be metal cable type with end fastening devices.
2. Shall be field bolted to structure. Cables and clamps shall be furnished by manufacturer of restraint device.
3. Shall be used for four-point independent bracing of systems (equipment, ductwork or piping) which are suspended from structure.
4. Shall be installed taut for non-isolated systems; shall be installed slack with ½" cable deflection for isolated systems.
5. Shall be Mason Industries "Type SCB" seismic restraining system or acceptable equivalent.

D. Type SR-B:

1. For non-isolated equipment: Equipment shall be field bolted or welded as required to resist seismic forces. Powder shot attachment is NOT acceptable.

E. Type SR-SB, for non-isolated equipment:

1. Shall be solid bracing, field bolted to structure as required to resist seismic forces. Powder shot attachment is NOT acceptable.
2. Shall be Mason Industries "Type SSB" anchors with solid steel braces, or Mason Industries "Type B22" struts with pipe clamps and bolts.

F. Type SR-H, for non-isolated equipment:

1. Shall be malleable iron extension split pipe clamp, field bolted to structure as required to resist seismic forces. Powder shot attachment is NOT acceptable.
2. Shall be Grinnell Figure 138R threaded rod or acceptable equivalent.

2.4 COMBINATION VIBRATION ISOLATION/SEISMIC RESTRAINT PRODUCTS

A. Refer to paragraph 2.1, SEISMIC RESTRAINT SYSTEMS – GENERAL, and paragraph 2.2, VIBRATION ISOLATION SYSTEMS – GENERAL, for general requirements.

B. Type SRVI-SI:

1. Shall be spring isolators having a minimum O.D. to O.H. of 0.8 to 1 and minimum run-out of 50% to solid.
2. Shall incorporate snubbing restraint in all directions.
3. Shall be cable of supporting equipment as a fixed elevation during equipment erection.
4. Shall have ductile iron housing. Cast or aluminum housing is NOT acceptable.
5. Shall be field bolted or welded to structural deck.
6. Shall be Mason Industries "Type SSLFH" or acceptable equivalent.

C. Type SRVI-DD:

1. Shall be double deflection neoprene isolator encased in ductile iron or steel casing, with minimum 0.30 static deflection.
2. Shall be field bolted or welded to structural deck.
3. Shall be Mason Industries "Type BR" or "Type RBA" or acceptable equivalent.

D. Type SRVI-RSM:

1. Shall be adjustable, restrained spring mounts with separate neoprene pad isolation and built-in vertical limit stops. Neoprene pad shall be minimum ¼" thick neoprene acoustical base pad. Vertical limit stops shall have minimum ¼" clearance under normal operation.
2. Shall have reserve deflection (from loaded to solid height) of 50% of rated deflection.
3. Shall have minimum diameter of 0.8 of the loaded operating height.
4. Shall be designed and installed so that ends of springs remain parallel.
5. Shall have cadmium-plated or electro-galvanized springs, cadmium-plated hardware, and other metal parts hot-dip galvanized; when used in corrosive environments.
6. Shall have tapped holes in top plate, for bolting, when used on equipment subject to wind loads.
7. Shall be capable of supporting equipment at a fixed elevation during equipment erection. Installed and operating heights shall be identical.
8. Shall be field bolted or welded to deck.
9. Shall be Mason Industries "Type SLR" or acceptable equivalent.

2.5 VIBRATION ISOLATION PRODUCTS

A. Refer to paragraph 2.2, VIBRATION ISOLATION SYSTEMS – GENERAL, for general requirements.

B. Type VI-ASI:

1. Shall be spring isolators with minimum ¼" thick neoprene acoustical base pad and adjustment bolts.
2. Shall have reserve deflection (from loaded to solid height) or 50% of rated deflection.
3. Shall have minimum diameter of 0.8 of the loaded operating height.
4. Shall be designed and installed so that ends of springs remain parallel.
5. Shall have cadmium-plated or electro-galvanized springs, cadmium-plated hardware and other metal parts hot-dip galvanized; when used in corrosive environments.
6. Shall be non-resonant with the equipment forcing frequencies and with the structural natural frequencies.
7. Shall be used only in conjunction with Seismic Restraint Type SR-PM.
8. Shall be Mason Industries "Type SLF" or acceptable equivalent.

C. Type VI-SH:

1. Shall be spring hanger rod isolators with spring and neoprene isolator elements in a steel box retainer. Spring shall be seated on steel washer in a neoprene cup with a rod isolation bushing.
2. Shall e Mason Industries "Type HS" or acceptable equivalent.

D. Type VI-EH:

1. Shall be elastomer hanger rod isolators with steel retainer box, molded unit-type neoprene element, and projecting bushing lining rod clearance hole. Neoprene element shall be minimum 1-3/4" thick. Retainer box shall encase neoprene mounting.
2. Shall have minimum clearance of 1/8" between mounting hanger rod and neoprene bushing.
3. Shall have minimum static deflection of 0.35".
4. Shall be Mason Industries "Type HD" or acceptable equivalent.

E. Type VI-SEH:

1. Shall be combination spring/elastomer hanger rod isolators with spring and neoprene isolator elements in a steel housing. Spring diameters and housing sizes shall be large enough to permit the hanger rod to swing through a 30 degree arc before contacting the housing. Neoprene shall be double deflection molded unit-type neoprene element, with projecting bushing lining rod clearance hole. Neoprene element shall be minimum 1-3/4" thick. Single deflection is NOT acceptable. Spring shall be seated in a neoprene cup with extended rod bushing.
2. Shall have minimum clearance of 1/8" between mounting hanger rod and neoprene bushing.
3. Shall have minimum static deflection of 0.30".
4. Shall have reserve deflection (from loaded to solid height) or 50% of rated deflection.

5. Shall have cadmium-plated or electro-galvanized springs, cadmium-plated hardware and other metal parts hot-dip galvanized; when used in corrosive environments.
6. Shall have minimum diameter of 0.8 of the loaded operating height.
7. Shall be Mason Industries "Type 30N" or acceptable equivalent.

F. Type VI-E50:

1. Shall be pad-type elastomer mountings with minimum -.750" pad thickness, 50 psi maximum loading, ribbed or waffled design, 0.10" deflection per pad, 1/16" galvanized steel plate between multiple layers or pad thickness and suitable bearing plate that distributes load.
2. Shall be Mason Industries "Super W" or acceptable equivalent.

G. Type VI-PA:

1. Shall be all-directional acoustical pipe anchor, with telescopic arrangement of two steel tubes separated by heavy-duty neoprene and duck or neoprene isolation material; with maximum loading of 500 psi. Neoprene material shall be minimum ½" thick. Vertical restraints shall be provided by similar material and shall prevent vertical travel in either direction.
2. Shall be balanced for equal resistance in any direction.
3. Shall be bolted or welded to structure.
4. Shall be Mason Industries "Type ADA" or acceptable equivalent.

2.6 EQUIPMENT BASES AND RAILS

A. Scope:

1. For floor-mounted vibration-isolated equipment, if required, provide steel rails, steel frames or concrete inertia blocks, supported by vibration isolators.
2. For ceiling-suspended vibration-isolated equipment, if required, provide steel frames suspended from vibration isolators. Isolators shall be installed in hanger rods and positioned vertically unless equipment frame is suitably rigid to span between isolators and is approved for such application by equipment manufacturer.
3. For roof-mounted equipment, provide roof curbs, secured to roof structure and equipment.

B. General:

1. Equipment rails, frames and inertia blocks shall meet seismic restraint criteria specified in paragraph 2.1, SEISMIC RESTRAINT SYSTEMS – GENERAL. Units shall form a rigid support structure which will not twist, rack, deform or deflect so as to negatively affect operation of supported equipment or performance of vibration isolation.
2. Units shall support basic equipment units and motors, pipe and duct elbow supports, electrical control elements and other components requiring resilient support, so as to prevent vibration transfer from equipment to building structure.

C. Steel Frames:

1. For floor-mounted equipment requiring supplemental base: frame shall have structural steel sections and side mounting brackets for attachment to vibration isolators for equipment and for associated piping.
2. For ceiling-suspended equipment, frames shall have structural steel sections and suspension rods for attachment to vibration isolators for equipment and for associated piping.

D. Concrete Inertia Blocks for floor-mounted centrifugal pumps and unbalanced equipment:

1. Inertia blocks shall be formed of stone-aggregate concrete (150 pcf) cast between appropriate steel reinforcing perimeter structural steel channels.
2. Inertia block thickness shall be minimum of 1/12 longest dimension of mounted equipment or equipment assembly, but not less than six inches.
3. Inertia block shall have side-mounting brackets for attachment of vibration isolators or corner pockets.

E. Rails for floor-mounted equipment not requiring supplemental base:

1. Rail Type R-IB:

   a. Shall be I-beam type, rail type spring isolators with steel members of sufficient strength to prevent flexure with equipment operation. Springs shall be acceptable equivalent to Vibration Isolation Type VI-ASI and Seismic Restraint Type SR-PM; or Seismic Restraint Type SRVI-SI.
   b. Shall be Mason Industries "Type ICS"

2. Rail Type R-IC:

   a. Shall be inverted channel type.
   b. Shall be Mason Industries "Type MC" or acceptable equivalent.

F. Roof Curbs:

1. Type SRVI-RT: for rooftop units shall be aluminum base with structural steel reinforcement, Mason Industries "Type RSC".

2.7 FLEXIBLE PIPE CONNECTORS

A. Units shall be by Mason, Flexonics, Keflex or Metroflex, as follows. Pressure ratings given are for maximum/minimum sizes in range given.

B. All pumps, compressors, air handlers and other rotating equipment shall have flexible piping connections as follows:

1. If the static deflection of the equipment isolators is ½" or less, provide a single sphere elastomeric, nylon cord reinforced connector, Mason Industries Type MFNC or

equivalent. Provide ductile iron floating flanges and acoustical control cables with isolating bushings.

2. If the static deflection of the equipment isolators is more than ½", provide a twin sphere connector as above, Mason Industries Type MFTNC or equivalent.
3. For refrigerant piping connections 7/8" and larger, provide flexible metal hose with stainless steel bellows and braided shroud. Connections less than 7/8" can be made with three elbow offsets with 10 pipe diameters between elbows or with a length of soft annealed Type "K" copper tube bent in a horseshoe configuration with a diameter of about 12".

C. Rotating machinery which is not mounted on vibration isolators shall be fitted with piping connectors as described in A, 1 or A, 2 above, as appropriate.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

A. Furnish services of isolation manufacturer for field supervision of installation of vibration isolation units, associated hangers and bases. Obtain copy of manufacturer's installation instructions and drawings, for Contractor's use during installation.

B. Install devices in accordance with manufacturer's written instructions. Vibration isolators must NOT cause any change of position of equipment or piping resulting in piping stresses or misalignment.

C. Locate vibration isolation devices for ease of inspection and adjustment as well as for proper operation.

D. Position vibration isolation hangers so that hanger housing may rotate 360° without contacting any object.

E. Piping, ductwork and conduit shall NOT be suspended from one another and shall NOT physically contact one another, under any circumstances. Vibrating systems shall be kept free from non-vibrating systems.

F. Install equipment with flexibility in wiring connection.

G. For overhead suspended non-isolated systems, install seismic restraint system taut. For isolated systems, install seismic restraint system slack with ½" cable deflection.

3.2 INSTALLATION OF EQUIPMENT BASES AND SUPPORTS

A. With concrete base, provide supports for pipe elbows at suction and discharge connections. Where concrete base is non-rectangular, "T" shaped, or "L" shaped, locate mounting under projections and main body of concrete base, to eliminate cantilevering of projections.

B. If equipment is mounted on housekeeping pads, pads shall be properly doweled or expansion shielded to structural deck to meet seismic restraint criteria.

C. Operating clearance between the isolated equipment's support (frame, rigid steel base, or concrete inertia block) and the housekeeping pad or floor shall be 2" minimum.

D. Where base anchoring is insufficient to resist seismic forces, supplementary restraints shall be installed. Restraints shall be attached to equipment at point(s) above the equipment's center of gravity, as required. Vertically mounted tanks may require this additional restraint.

E. Equipment structural steel or concrete inertia base shall be placed in position and supported temporarily by blocks or shims, as appropriate, prior to installation of isolators or equipment.

1. Isolators shall be installed without raising equipment and frame assembly.
2. After installation is under full operational load, isolators shall be adjusted so that the load is transferred from the blocks to the isolators. When isolators are properly adjusted, blocks or shims shall be barely free and shall be removed.

F. Ensure that overhead supported equipment does NOT over-stress the building structure. This might be accomplished by bracing from:

1. Flanges of structural beams.
2. Upper or lower truss chords in bar joist construction at the panel points.
3. Cast-in-place inserts or drilled and shielded inserts in concrete structures.

G. Verify that equipment which is mounted on vibration isolators has free movement in all directions and does NTO create any impact NOR transmit any motion or vibration to or through the seismic snubbers. If excessive vibration or impact des occur: adjust, secure, balance or otherwise correct the installation to operate properly without vibration, contact or impact.

H. Prior to start-up, remove foreign matter between bases and equipment.

I. Isolators for condensing units shall be located between equipment base and roof/steel support system.

3.3 INSTALLATION OF PIPING SUPPORTS

A. Piping connected to vibration isolated equipment shall be installed so that isolators are NOT strained NOR forced out of alignment and so that equipment "floats" freely on isolators.

B. Drain piping connected to vibration isolated equipment shall be isolated from building structure, non-isolated systems and non-isolated components.

C. Pipe elbows at inlets or discharges to isolated equipment shall be supported from below and shall be braced to unit base above vibration isolators. Inlet and discharge piping shall be supported by appropriate isolation units for 50 foot minimum distance along each pipe in direction away from base.

D. Vertical risers passing through floors shall be secured above and below each floor with riser clamps.

E. Floor-mounted piping shall be supported by supplemental floor support system as required by job conditions.

F. Isolators shall be installed with the isolator hanger box attached to, or hung as close as possible to, the structure. Isolators shall be suspended from substantial structural members, not from slab diaphragm unless specifically permitted. Hanger rods shall be aligned to clear the hanger box.

G. When required, supplementary steel shall be sized for a maximum deflection of 0.08 inches at center span.

3.4 INSTALLATION OF FLEXIBLE PIPE CONNECTORS

A. Provide flexible pipe connections.

1. To isolate movement of equipment and piping from each other.
2. To isolate movement of main piping from branch piping installed at an angle to main.
3. To isolate movement between piping supported off ceiling/floor structure and piping supported off wall/column structure.
4. Where piping crosses building seismic or expansion joint.
5. For fire protection risers only, at each floor penetration.

B. "Movement" for which isolation is required shall include:

1. Thermal expansion, where applicable.
2. Vibration.
3. Seismic-related movement, to the extent referenced by Code.
4. Normal building movement due to settlement, wind, etc.

C. Anchor any branch piping adjacent to flexible connectors to ensure that movement is absorbed in flexible connection.

3.5 WELDING PROCEDURES

A. Field welding shall be done by experienced welders who have demonstrated their ability with proof of qualification as outlined in ANSI B31.1/B31.9.

3.6 INSPECTION

A. Furnish services of Structural Engineer with P.E. registration in the state in which the project is located, to review the system, to inspect the completed system and to verify that there are no isolation short circuits in equipment mounting/bases, isolators or seismic restraints. The Engineer shall furnish written certification on installation; refer to paragraph 1.4.D.

3.7 VIBRATION ISOLATION AND SEISMIC RESTRAINT SCHEDULE

A. Seismic restraint shall be provided on following piping systems at turns of more than 4 feet and throughout entire run; where piping is supported by hangers longer than 12" as measured from top of pipe to bottom of supporting structure. Restraint type and maximum spacing of restraints shall be as follows:

PIPE SEISMIC RESTRAINT SCHEDULE				
Piping	***Pipe Size***	***Seismic Restraint Type***	***Maximum Spacing between Seismic Restraints***	
			Transverse	***Longitudinal***
Compressed air piping	1" & larger	SR-C	20'-0"	40'-0"
Fuel gas piping	1" & larger	SR-C	20'-0"	40'-0"
Other piping in mechanical rooms	1-1/4" & larger	SR-C	40'-0"	80'-0"
Other piping in any space	2-1/2" & larger	SR-C	40'-0"	80'-0"
Horizontal chimneys and stacks	Any size	SR-C	30'-0"	N/A
Vertical chimneys and stacks	Any size	SR-B		At every floor level

B. Vibration isolation shall be provided on piping within 50 feet of connection to isolated equipment. Isolation type, minimum deflection and maximum spacing of isolation devices shall be as follows:

PIPE VIBRATION ISOLATION SCHEDULE			
Piping	***Vibration Isolation Type***	***Minimum Deflection***	***Maximum Isolation Spacing***
Horizontal water piping within 50 feet or 100 diameters of rotating equipment	VI-SEH	1" *	At every hanger
Vertical water piping within 50 feet or 100 diameters of rotating equipment	VI-PA VI-E50	1"	At every hanger or floor
Steam piping upstream of PRV and 25 feet downstream	VI-EH	3/8"	At every hanger
*use deflection of associated equipment isolator, if greater			

C. Seismic restraint shall be provided on ductwork at every turn, at duct ends, and throughout entire run; where ductwork is supported by hangers longer than 12", as measured from duct-hanger attachment point to bottom of supporting structure. Restraint type, minimum deflection, and maximum spacing of restraints shall be as follows:

Ductwork	***Seismic Restraint Type***	***Maximum Spacing between Seismic Restraints***	
		Transverse	***Longitudinal***
With cross-sectional area of 6 square feet or greater	SR-C	30'-0"	60'-0"
Round ducts with diameter of 28" or larger	SR-C	30'-0"	60'-0"
Duct risers	SR-B	At each floor	N/A

D. Seismic restraint shall be provided on all rotating mechanical equipment. Vibration isolation shall be provided on mechanical equipment where indicated. Isolation and restraint device types and minimum deflection shall be as follows:

SUSPENDED EQUIPMENT SEISMIC RESTRAINT & VIBRATION ISOLATION SCHEDULE			
Suspended Equipment	***Isolator Type***	***Minimum Static Deflection***	***Seismic Restraint Type***
In-line pumps	SRVI-DD*	0.30"	SR-C
In-line exhaust fans	VI-SEH	1"	SR-C
Air handling units	VI-SEH	0.75"	SR-C
Unit Heaters	VI-EH	0.30"	SR-C
Fan coil units	VI-EH	0.30"	SR-C
VAV boxes with flexible duct connections	NA	NA	SR-C
Air control valve assemblies	NA	NA	SR-C
Diffusers in ceilings not seismically restrained	NA	NA	SR-C
Diffusers in seismically restrained ceilings.	NA	NA	Earthquake clips to ceiling
Wall-mounted non-isolated equipment, if not specified elsewhere	NA	NA	SR-B
Non-isolated equipment suspended from structure, if not specified elsewhere	NA	NA	SR-C

* Combination seismic restraint and isolator ** Provide thrust restraints

BASE-MOUNTED EQUIPMENT
SEISMIC RESTRAINT & VIBRATION ISOLATION SCHEDULE

Base-Mounted Equipment	*Isolator Type*	*Minimum Static Deflection*	*Seismic Restraint Type*
Circulating pumps	SRVI-SI*	0.30"	SRVI-SI*
Air handling units	VI-ASI	0.75"	SRVI-SI
Vacuum Pump	VI-ASI	.75"	SRVI-SI*
Air Compressor	VI-ASI	.75"	SRVI-SI*
Utility Blower	VI-ASI	1"	SRVI-RSM*
Boilers	VI-E50	0.10"	SR-B
Boiler Feed System	N/A	N/A	SR-B
Expansion Tanks	N/A	N/A	SR-B
Gas Humidifier	VI-E50	0.10"	SR-B
RO/DI Equipment	N/A	N/A	SR-B
Water Heater	N/A	N/A	SR-B
Roof-mounted non-isolated equipment, if not specified elsewhere	N/A	N/A	SR-B
Floor-mounted non-isolated equipment, if not specified elsewhere	N/A	N/A	SR-B
* Combination seismic restraint and isolator			

E. Each floor-mounted pump over 10 HP shall be bolted and grouted to reinforced concrete inertia base. Support concrete base by isolators as specified.

F. For each pump under 10 HP, bases shall be securely bolted to concrete housekeeping pad and shall be grouted according to manufacturer's instructions. Grout shall be high quality, non-shrink type by Chem-Comp or acceptable equivalent.

G. Set utility blowers on concrete inertia pad with isolators as scheduled.

END OF SECTION 230548

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SECTION 230553 – MECHANICAL IDENTIFICATION

SECTION 230553 - MECHANICAL IDENTIFICATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following mechanical identification materials and their installation:

1. Equipment nameplates.
2. Equipment markers.
3. Equipment signs.
4. Access panel and door markers.
5. Pipe markers.
6. Duct markers.
7. Valve tags.
8. Valve schedules.
9. Warning tags.

1.3 SUBMITTALS

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

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Valve numbering scheme.

D. Valve Schedules: For each piping system. Furnish extra copies (in addition to mounted copies) to include in maintenance manuals.

1.4 QUALITY ASSURANCE

A. ASME Compliance: Comply with ASME A13.1, "Scheme for the Identification of Piping Systems," for letter size, length of color field, colors, and viewing angles of identification devices for piping.

1.5 COORDINATION

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with location of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 EQUIPMENT IDENTIFICATION DEVICES

A. Equipment Nameplates: Metal, with data engraved or stamped, for permanent attachment on equipment.

1. Data:

   a. Manufacturer, product name, model number, and serial number.
   b. Capacity, operating and power characteristics, and essential data.
   c. Labels of tested compliances.

2. Location: Accessible and visible.
3. Fasteners: As required to mount on equipment.

B. Equipment Markers: Engraved, color-coded laminated plastic. Include contact-type, permanent adhesive.

1. Terminology: Match schedules as closely as possible.
2. Data:

   a. Name and plan number.
   b. Equipment service.
   c. Design capacity.
   d. Other design parameters such as pressure drop, entering and leaving conditions, and speed.

3. Size: 2-1/2 by 4 inches for control devices, dampers, and valves; 4-1/2 by 6 inches for equipment.

C. Equipment Signs: ASTM D 709, Type I, cellulose, paper-base, phenolic-resin-laminate engraving stock; Grade ES-2, black surface, black phenolic core, with white melamine subcore, unless otherwise indicated. Fabricate in sizes required for message. Provide holes for mechanical fastening.

1. Data: Instructions for operation of equipment and for safety procedures.
2. Engraving: Manufacturer's standard letter style, of sizes and with terms to match equipment identification.
3. Thickness: 1/16 inch for units up to 20 sq. in. or 8 inches in length, and 1/8 inch for larger units.
4. Fasteners: Self-tapping, stainless-steel screws or contact-type, permanent adhesive.

D. Access Panel and Door Markers: 1/16-inch- thick, engraved laminated plastic, with abbreviated terms and numbers corresponding to identification. Provide 1/8-inch center hole for attachment.

1. Fasteners: Self-tapping, stainless-steel screws or contact-type, permanent adhesive.

2.2 PIPING IDENTIFICATION DEVICES

A. Manufactured Pipe Markers, Snap-on or Strap-on type vinyl markers with integral flow arrows and factory applied graphics. Seton Name Plate Corp., - Setmark General: Preprinted, color-coded, with lettering indicating service, and showing direction of flow.

1. Colors: Comply with ASME A13.1, unless otherwise indicated.
2. Lettering: Use the following legend:

HWS	Heating hot water supply
HWR	Heating hot water return
FO	Fuel oil
GAS	Fuel gas
LPS	Low pressure steam supply
LPCR	Low pressure condensate return
HPS	High pressure steam supply
HPCR	High pressure condensate return
CPD	Condensate pump discharge
CHWS	Chilled water supply
CHWR	Chilled water return
MCHWS	Medium chilled water supply
MCHWR	Medium chilled water return
CWF	Condenser water flow (from chiller to tower)
CWR	Condenser water return (from tower to chiller)
CW	Domestic cold water
HW	Domestic hot water
HWR	Domestic hot water recirculating
SAN VENT	Sanitary vent
SAN S	Sanitary sewer
STR S	Storm sewer
RD	Roof (storm) drainage
DPD	Drainage pump discharge
SPKLR or SPRINKLER	Sprinkler piping only
FIRE PROTECT. WATER	fire standpipe or combined sprinkler standpipe
HALON F.P.	Halon fire protection piping
OX	Oxygen
AIR	Compressed Air
VAC	Vacuum
MED. VAC	Medical vacuum
NON-POT. WTR	Non-potable water
POT. CW	Potable cold water (label required when potable and non-potable water are in same building)
POT. HW	Potable hot water (label required when potable and non-potable water are in same building)

3. Pipes with OD, Including Insulation, Less Than 6 Inches: Full-band pipe markers extending 360 degrees around pipe at each location.
4. Pipes with OD, Including Insulation, 6 Inches and Larger: Either full-band or strip-type pipe markers at least three times letter height and of length required for label.

5. Arrows: Integral with piping system service lettering to accommodate both directions; or as separate unit on each pipe marker to indicate direction of flow.

B. Pretensioned Pipe Markers: Precoiled semirigid plastic formed to cover full circumference of pipe and to attach to pipe without adhesive.

C. Shaped Pipe Markers: Preformed semirigid plastic formed to partially cover circumference of pipe and to attach to pipe with mechanical fasteners that do not penetrate insulation vapor barrier.

D. Self-Adhesive Pipe Markers: Plastic with pressure-sensitive, permanent-type, self-adhesive back.

E. Plastic Tape: Continuously printed, vinyl tape at least 3 mils thick with pressure-sensitive, permanent-type, self-adhesive back.

1. Width for Markers on Pipes with OD, Including Insulation, Less Than 6 Inches: 3/4 inch minimum.
2. Width for Markers on Pipes with OD, Including Insulation, 6 Inches or Larger: 1-1/2 inches minimum.

2.3 DUCT IDENTIFICATION DEVICES

A. Identify air supply, return, exhaust, intake, and relief ductwork with stenciled signs and arrows, showing ductwork service and direction of flow, in black or white (whichever provides most contrast with ductwork color). Label all ducts in mechanical equipment rooms and in congested corridors when concealed by ceilings.

2.4 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers, with numbering scheme approved by Architect. Provide 5/32-inch hole for fastener.

1. Material: .0359" thick polished brass.
2. Valve-Tag Fasteners: Brass beaded chain or S-hook.

2.5 VALVE SCHEDULES

A. Valve Schedules: For each piping system, on standard-size bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Valve-Schedule Frames: Glazed display frame for removable mounting on masonry walls for each page of valve schedule. Include mounting screws.
2. Frame: Extruded aluminum.
3. Glazing: ASTM C 1036, Type I, Class 1, Glazing Quality B, 2.5-mm, single-thickness glass.

2.6 WARNING TAGS

A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags; of plasticized card stock with matte finish suitable for writing.

1. Size: 3 by 5-1/4 inches minimum.
2. Fasteners: Brass grommet and wire.
3. Nomenclature: Large-size primary caption such as DANGER, CAUTION, or DO NOT OPERATE.
4. Color: Yellow background with black lettering.

2.7 CEILING PINS FOR EQUIPMENT LOCATION IDENTIFICATION

A. All devices located above ceilings shall be identified by color coded markers installed on the suspended ceiling grid. Markers shall be ¾" round with self-adhesive glue.

2.8 IDENTIFICATION

A. All underground piping shall have a metal detection underground warning tape installed above the pipe at a depth recommended by the manufacturer. The tape shall be capable of being identified by a metal detector, have a brightly colored background, and shall continuously identify the pipe with black letters.

Label Identification Chart				
Product	*Tape Verbiage*	*Manufacturer*	*Part Number 2" wide*	*Part Number 6" wide*
LP Gas	Caution Buried Gas Line Below	Seton	57355	57361
Sanitary	Caution Buried Sewer Line Below	Seton	57352	57358
Water	Caution Buried Water Line Below	Seton	57353	57359
Miscellaneous	Caution Buried Pipeline Below	Seton	57357	57363

PART 3 - EXECUTION

3.1 APPLICATIONS, GENERAL

A. Products specified are for applications referenced in other Division 15 Sections. If more than single-type material, device, or label is specified for listed applications, selection is Installer's option.

3.2 EQUIPMENT IDENTIFICATION

A. Install and permanently fasten equipment nameplates on each major item of mechanical equipment that does not have nameplate or has nameplate that is damaged or located where not easily visible. Locate nameplates where accessible and visible. Include nameplates for the following general categories of equipment:

1. Fuel-burning units, including boilers, furnaces, heaters, stills, and absorption units.
2. Pumps, compressors, chillers, condensers, and similar motor-driven units.
3. Heat exchangers, coils, evaporators, cooling towers, heat recovery units, and similar equipment.
4. Fans, blowers, primary balancing dampers, and mixing boxes.
5. Packaged HVAC central-station and zone-type units.

B. Install equipment markers with permanent adhesive on or near each major item of mechanical equipment. Data required for markers may be included on signs, and markers may be omitted if both are indicated.

1. Letter Size: Minimum 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
2. Data: Distinguish among multiple units, indicate operational requirements, indicate safety and emergency precautions, warn of hazards and improper operations, and identify units.
3. Locate markers where accessible and visible. Include markers for the following general categories of equipment:

   a. Main control and operating valves, including safety devices and hazardous units such as gas outlets.
   b. Fire department hose valves and hose stations.
   c. Meters, gages, thermometers, and similar units.
   d. Fuel-burning units, including boilers, furnaces, heaters, stills, and absorption units.
   e. Pumps, compressors, chillers, condensers, and similar motor-driven units.
   f. Heat exchangers, coils, evaporators, cooling towers, heat recovery units, and similar equipment.
   g. Fans, blowers, primary balancing dampers, and mixing boxes.
   h. Packaged HVAC central-station and zone-type units.
   i. Tanks and pressure vessels.
   j. Strainers, filters, humidifiers, water-treatment systems, and similar equipment.

C. Install equipment signs with screws or permanent adhesive on or near each major item of mechanical equipment. Locate signs where accessible and visible.

1. Identify mechanical equipment with equipment markers in the following color codes:

   a. Green: For cooling equipment and components.
   b. Yellow: For heating equipment and components.
   c. Green and Yellow: For combination cooling and heating equipment and components.
   d. Brown: For energy-reclamation equipment and components.

2. Letter Size: Minimum 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
3. Data: Distinguish among multiple units, indicate operational requirements, indicate safety and emergency precautions, warn of hazards and improper operations, and identify units.
4. Include signs for the following general categories of equipment:

   a. Main control and operating valves, including safety devices and hazardous units such as gas outlets.
   b. Fuel-burning units, including boilers, furnaces, heaters, stills, and absorption units.
   c. Pumps, compressors, chillers, condensers, and similar motor-driven units.
   d. Heat exchangers, coils, evaporators, cooling towers, heat recovery units, and similar equipment.
   e. Fans, blowers, primary balancing dampers, and mixing boxes.
   f. Packaged HVAC central-station and zone-type units.
   g. Tanks and pressure vessels.
   h. Strainers, filters, humidifiers, water-treatment systems, and similar equipment.

D. Stenciled Equipment Sign Option: Stenciled signs may be provided instead of laminated-plastic equipment signs, at Installer's option, if lettering larger than 1 inch high is needed for proper identification because of distance from normal location of required identification.

E. Install access panel markers with screws on equipment access panels.

3.3 PIPING IDENTIFICATION

A. Install manufactured pipe markers indicating service on each piping system. Install with flow indication arrows showing direction of flow.

1. Pipes with OD, Including Insulation, Less Than 6 Inches: Pretensioned pipe markers. Use size to ensure a tight fit.
2. Pipes with OD, Including Insulation, 6 Inches and Larger: Shaped pipe markers. Use size to match pipe and secure with fasteners.

B. Locate pipe markers and color bands where piping is exposed in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior nonconcealed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls on both sides, floors, ceilings, and nonaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 25 feet along each run.
7. On piping above removable acoustical ceilings. Omit intermediately spaced markers.

3.4 DUCT IDENTIFICATION

A. Install duct markers with permanent adhesive on air ducts in the following color codes:

1. Green: For cold-air supply ducts.
2. Yellow: For hot-air supply ducts.
3. Blue: For exhaust-, outside-, relief-, return-, and mixed-air ducts.
4. ASME A13.1 Colors and Designs: For hazardous material exhaust.
5. Letter Size: Minimum 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

B. Locate markers near points where ducts enter into concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.

C. Label all ducts in mechanical equipment rooms and in congested corridors when concealed by ceilings.

3.5 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; plumbing fixture supply stops; shutoff valves; faucets; convenience and lawn-watering hose connections; and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following:

1. Provide square tags for HVAC systems: Seton Nameplate #SVT-15BL, Brady "Series 23000", or acceptable equivalent.
2. Provide round tags for plumbing systems: Seton Nameplate #250-BL, Brady "Series 23000" or acceptable equivalent.

3. Provide hexagonal or octagonal tags for fire protection systems: Seton Nameplate #XVT-15, #OVT-20 or acceptable equivalent.

C. Whenever Owner's standards differ from above, observe and follow Owner's standard labeling.

3.6 VALVE-SCHEDULE INSTALLATION

A. Mount valve schedule on wall in accessible location in each major equipment room.

3.7 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.

3.8 ADJUSTING

A. Relocate mechanical identification materials and devices that have become visually blocked by other work.

3.9 CLEANING

A. Clean faces of mechanical identification devices and glass frames of valve schedules.

3.10 CEILING PINS FOR EQUIPMENT IDENTIFICATION

A. All devices located above ceilings, as scheduled below, shall be identified by color coded markers installed on the suspended ceiling grid. Markers shall be ¾" round with self-adhesive glue.

1.	VAVs/Air Valves	Light Blue
2.	Reheat Coils	Light Blue
3.	Fire/Smoke Dampers	Red Glow
4.	Smoke Dampers	Red Glow
5.	Plumbing Valves	Black
6.	HVAC Valves	Orange
7.	Volume Dampers	Dark Blue
8.	Control Air Pressure	Green Glow
9.	Regulating Valves	Dark Blue
10.	Steam Valves	Yellow
11.	Steam Condensate	Yellow Glow

END OF SECTION 230553

TABLE OF CONTENTS
SECTION 230593 – TESTING, ADJUSTING AND BALANCING

SECTION 230593 - TESTING, ADJUSTING, AND BALANCING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section specifies the requirements and procedures for total mechanical systems testing, adjusting, and balancing. Requirements include measurement and establishment of the fluid (hydronic and air) quantities of the mechanical systems as required to meet design specifications, and recording and reporting the results.

B. Test, adjust, and balance the following mechanical systems:

1. Supply air systems.
2. Return air systems.
3. Exhaust air systems.
4. Outside air systems.
5. Hot water systems.
6. Condenser water systems.
7. Chilled water systems.
8. Domestic hot water recirculation systems.

1.3 DEFINITIONS

A. Adjust: To regulate fluid flow rate and air patterns at the terminal equipment, such as to reduce fan speed or adjust a damper.

B. Balance: To proportion flows within the distribution system, including submains, branches, and terminals, according to design quantities.

C. Draft: A current of air, when referring to localized effect caused by one or more factors of high air velocity, low ambient temperature, or direction of airflow, whereby more heat is withdrawn from a person's skin than is normally dissipated.

D. Procedure: An approach to and execution of a sequence of work operations to yield repeatable results.

E. Report Forms: Test data sheets for recording test data in logical order.

F. Static Head: The pressure due to the weight of the fluid above the point of measurement. In a closed system, static head is equal on both sides of the pump.

G. Suction Head: The height of fluid surface above the centerline of the pump on the suction side.

H. System Effect: A phenomenon that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.

I. System Effect Factors: Allowances used to calculate a reduction of the performance ratings of a fan when installed under conditions different from those presented when the fan was performance tested.

J. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.

K. Test: A procedure to determine quantitative performance of a system or equipment.

L. Testing, Adjusting, and Balancing Agent: The entity responsible for performing and reporting the testing, adjusting, and balancing procedures.

M. AABC: Associated Air Balance Council.

N. AMCA: Air Movement and Control Association.

O. CTI: Cooling Tower Institute.

P. NEBB: National Environmental Balancing Bureau.

Q. SMACNA: Sheet Metal and Air Conditioning Contractors' National Association.

1.4 SUBMITTALS

A. The first submittal, to be made within thirty days of award of the Mechanical Contractor's' Contract, shall consist of the following:

1. Submit a synopsis of the testing, adjusting, and balancing procedures.
2. Submit sample forms of each type required.
3. Submit proof that all required instrumentation has been calibrated to tolerances specified in the referenced standards, within a period of six months prior to starting the project.
4. Contractor qualifications:

    a. NEEB certificate.
    b. AABC certificate.
    c. Project portfolio illustrating ten years of experience; project names and references

5. Contract Documents Examination Report

B. The second submittal, to be made after the first submittal has been satisfactorily reviewed, shall be made after the balancing work has been performed.

1. Submit testing, adjusting, and balancing reports bearing the signature of the test and balance lead technician. The reports shall be certified proof that the systems have been

tested, adjusted, and balanced in accordance with the referenced standards; are an accurate representation of how the systems have been installed; are a true representation of how the systems are operating at the completion of the testing, adjusting, and balancing procedures; and are an accurate record of all final quantities measured, to establish normal operating values of the systems. Final reports shall be type written, organized and formatted as specified below

2. Report forms shall be those included in the first submittal for each respective item and system to be tested, adjusted, and balanced. Bind report forms complete with schematic systems diagrams and other data Divide the contents of the binder into the below listed divisions, separated by divider tabs:

   a. General Information and Summary
   b. Air Systems
   c. Hydronic Systems
   d. Special Systems

3. Provide the following minimum information, forms and data:

   a. General Information and Summary: Inside cover sheet to identify testing, adjusting, and balancing agency, Contractor, Owner, Architect, Engineer, and Project; including addresses, contact names, and telephone numbers. Provide a listing of the instruments used for the procedures along with the proof of calibration.
   b. The remainder of the report shall contain the appropriate forms containing as a minimum, the information indicated on standard report forms for each respective item and system. Prepare a schematic diagram for each item of equipment and system to accompany each respective report form.
   c. Provide a plan indicating the location of each air terminal with the reference number clearly indicated.

1.5 QUALITY ASSURANCE

A. Testing, Adjusting, and Balancing Conference: Meet with the Owner's and the Architect's representatives on approval of the testing, adjusting, and balancing strategies and procedures plan to develop a mutual understanding of the details. Ensure the participation of testing, adjusting, and balancing team members, equipment manufacturers' authorized service representatives, HVAC controls Installer, and other support personnel. Provide 7 days' advance notice of scheduled meeting time and location.

   1. Agenda Items: Include at least the following:

      a. Submittal distribution requirements.
      b. Contract Documents examination report.
      c. Testing, adjusting, and balancing plan.
      d. Work schedule and Project site access requirements.
      e. Coordination and cooperation of trades and subcontractors.
      f. Coordination of documentation and communication flow.

B. Certification of Testing, Adjusting, and Balancing Reports: Certify the testing, adjusting, and balancing field data reports. This certification includes the following:

1. Review field data reports to validate accuracy of data and to prepare certified testing, adjusting, and balancing reports.
2. Certify that the testing, adjusting, and balancing team complied with the approved testing, adjusting, and balancing plan and the procedures specified and referenced in this Specification.

C. Testing, Adjusting, and Balancing Reports: Use standard forms from NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems."

D. Instrumentation Type, Quantity, and Accuracy: As described in NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems," Section II, "Required Instrumentation for NEBB Certification."

E. Instrumentation Calibration: Calibrate instruments at least every 6 months or more frequently if required by the instrument manufacturer.

1.6 CONTRACTOR QUALIFICATION

A. The Contractor shall have one of the following qualifications:

1. Be an independent testing, adjusting, and balancing agency certified by National Environmental Balancing Bureau (NEBB) or Associated Air Balance Council (AABC) in those testing and balancing disciplines required for this project.
2. Be an independent testing, adjusting, and balancing agency with a minimum of ten years experience with similar projects. The contractor shall provide suitable evidence of past performance, including references, justifying the firm's capabilities. Noncertified contractors who have favorably worked on campus are:

   a. Boone Testing & Balancing, East Burke, VT

1.7 PROJECT CONDITIONS

A. Partial Owner Occupancy: The Owner may occupy completed areas of the building before Substantial Completion. Cooperate with the Owner during testing, adjusting, and balancing operations to minimize conflicts with the Owner's operations.

B. Systems shall be fully operational prior to beginning of procedures.

1.8 COORDINATION

A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist testing, adjusting, and balancing activities.

B. Notice: Provide 7 days' advance notice for each test. Include scheduled test dates and times.

C. Perform testing, adjusting, and balancing after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

D. Balancer shall review drawings with the mechanical contractor and the commissioning agent to review the locations of balancing devices, specifically the locations of volume dampers in duct systems.

1.9 WARRANTY

A. General Warranty: The national project performance guarantee specified in this Article shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by the Contractor under requirements of the Contract Documents.

B. Special Guarantee: Provide a guarantee on NEBB forms stating that NEBB will assist in completing the requirements of the Contract Documents if the testing, adjusting, and balancing Agent fails to comply with the Contract Documents. Guarantee includes the following provisions:

1. The certified Agent has tested and balanced systems according to the Contract Documents.
2. Systems are balanced to optimum performance capabilities within design and installation limits.

1.10 CODES AND STANDARDS:

1. NEBB: "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems'.
2. AABC: "National Standards For Total System Balance".
3. ASHRAE: ASHRAE Handbook, 1999 HVAC Applications, Chapter 36, "Testing, Adjusting, and Balancing".

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine Contract Documents to become familiar with project requirements and to discover conditions in systems' designs that may preclude proper testing, adjusting, and balancing of systems and equipment.

1. Contract Documents are defined in the General and Supplementary Conditions of the Contract.
2. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.

B. Examine approved submittal data of HVAC systems and equipment.

C. Examine project record documents described in Division 1 Section "Project Record Documents."

D. Examine Architect's and Engineer's design data, including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine equipment performance data, including fan and pump curves. Relate performance data to project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system. Calculate system effect factors to reduce the performance ratings of HVAC equipment when installed under conditions different from those presented when the equipment was performance tested at the factory. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," Sections 7 through 10; or in SMACNA's "HVAC Systems--Duct Design," Sections 5 and 6. Compare this data with the design data and installed conditions.

F. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Specification Sections have been performed.

G. Examine system and equipment test reports.

H. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are properly installed, and their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.

I. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.

J. Examine air-handling equipment to ensure clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

K. Examine terminal units, such as variable-air-volume boxes and mixing boxes, to verify that they are accessible and their controls are connected and functioning.

L. Examine plenum ceilings, utilized for supply air, to verify that they are airtight. Verify that pipe penetrations and other holes are sealed.

M. Examine strainers for clean screens and proper perforations.

N. Examine 3-way valves for proper installation for their intended function of diverting or mixing fluid flows.

O. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

P. Examine open-piping-system pumps to ensure absence of entrained air in the suction piping.

Q. Examine equipment for installation and for properly operating safety interlocks and controls.

R. Examine automatic temperature system components to verify the following:

1. Dampers, valves, and other controlled devices operate by the intended controller.
2. Dampers and valves are in the position indicated by the controller.
3. Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in multizone units, mixing boxes, and variable-air-volume terminals.
4. Automatic modulating and shutoff valves, including 2-way valves and 3-way mixing and diverting valves, are properly connected.
5. Thermostats and humidistats are located to avoid adverse effects of sunlight, drafts, and cold walls.
6. Sensors are located to sense only the intended conditions.
7. Sequence of operation for control modes is according to the Contract Documents.
8. Controller set points are set at design values. Observe and record system reactions to changes in conditions. Record default set points if different from design values.
9. Interlocked systems are operating.
10. Changeover from heating to cooling mode occurs according to design values.

S. Report deficiencies discovered before and during performance of testing, adjusting, and balancing procedures.

3.2 PREPARATION

A. Prepare a testing, adjusting, and balancing plan that includes strategies and step-by-step procedures.

B. Complete system readiness checks and prepare system readiness reports. Verify the following:

1. Permanent electrical power wiring is complete.
2. Hydronic systems are filled, clean, and free of air.
3. Automatic temperature-control systems are operational.
4. Equipment and duct access doors are securely closed.
5. Balance, smoke, and fire dampers are open.
6. Isolating and balancing valves are open and control valves are operational.
7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
8. Windows and doors can be closed so design conditions for system operations can be met.

3.3 GENERAL TESTING AND BALANCING PROCEDURES

A. Perform testing and balancing procedures on each system according to the procedures contained in NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and this Section.

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to the insulation Specifications for this Project.

C. Mark equipment settings with paint or other suitable, permanent identification material, including damper-control positions, valve indicators, fan-speed-control levers, and similar controls and devices, to show final settings.

3.4 FUNDAMENTAL AIR SYSTEMS' BALANCING PROCEDURES

A. Before operating the system, perform these steps:

1. Obtain copies of satisfactorily reviewed shop drawings of all air handling equipment, outlets (supply, return, and exhaust) and temperature control diagrams.
2. Compare design to installed equipment and field installations.
3. Walk the system from the system air handling equipment to terminal units to determine variations of installation from design.
4. Insure new filters are installed.
5. Check all dampers (volume and fire) for correct and locked position, and temperature control for completeness of installation before starting fans.
6. Prepare report test sheets for both fans and outlets. Obtain manufacturer's outlet factors and recommended procedures for testing. Prepare a summation of required outlet volumes to permit a crosscheck with required fan volumes.
7. Determine best locations in main and branch ductwork for most accurate duct traverses.
8. Place outlet dampers in the full open position.
9. Prepare schematic diagrams of system "as-built" ductwork and piping layouts to facilitate reporting.
10. Check lubrication of all motors and bearings.
11. Check fan belt tension.
12. Check fan rotation.
13. Prepare individual schematic drawings of each air handling unit. Perform an air handler profile report.

3.5 CONSTANT-VOLUME AIR SYSTEMS' BALANCING PROCEDURES

A. The procedures in this Article apply to constant-volume supply-, return-, and exhaust-air systems. Additional procedures are required for variable-air-volume, multizone, dual-duct, induction-unit supply-air systems and process exhaust-air systems. These additional procedures are specified in other articles in this Section.

B. Adjust fans to deliver total design airflows within the maximum allowable rpm listed by the fan manufacturer.

1. Measure fan static pressures to determine actual static pressure as follows:

    a. Measure outlet static pressure as far downstream from the fan as practicable and upstream from restrictions in ducts such as elbows and transitions.
    b. Measure static pressure directly at the fan outlet or through the flexible connection.
    c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from flexible connection and downstream from duct restrictions.
    d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.

2. Measure static pressure across each air-handling unit component.

    a. Simulate dirty filter operation and record the point at which maintenance personnel must change filters.

    b. Record fan motor operating point confirming the fan and the motor are operating in a stable range. Check fan construction versus operating point.

3. Measure static pressures entering and leaving other devices such as sound traps, heat recovery equipment, and air washers under final balanced conditions.
4. Compare design data with installed conditions to determine variations in design static pressures versus actual static pressures. Compare actual system effect factors with calculated system effect factors to identify where variations occur. Recommend corrective action to align design and actual conditions.
5. Adjust fan speed higher or lower than design with the approval of the Architect. Make required adjustments to pulley sizes, motor sizes, and electrical connections to accommodate fan-speed changes.
6. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure no overload will occur. Measure amperage in full cooling, full heating, and economizer modes to determine the maximum required brake horsepower.
7. Balance constant volume air handlers with the filters artificially loaded to 50% of change out.

C. Adjust volume dampers for main duct, submain ducts, and major branch ducts to design airflows within specified tolerances.

1. Measure static pressure at a point downstream from the balancing damper and adjust volume dampers until the proper static pressure is achieved.

    a. Where sufficient space in submains and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.

2. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submains and branch ducts to design airflows within specified tolerances.

D. Measure terminal outlets and inlets without making adjustments.

1. Measure terminal outlets using a direct-reading hood or the outlet manufacturer's written instructions and calculating factors.

E. Adjust terminal outlets and inlets for each space to design airflows within specified tolerances of design values. Make adjustments using volume dampers rather than extractors and the dampers at the air terminals.

1. Adjust each outlet in the same room or space to within specified tolerances of design quantities without generating noise levels above the limitations prescribed by the Contract Documents.
2. Adjust patterns of adjustable outlets for proper distribution without drafts.

3.6 VARIABLE-AIR-VOLUME SYSTEMS' ADDITIONAL PROCEDURES

A. Compensating for Diversity: When the total airflow of all terminal units is more than the fan design airflow volume, place a selected number of terminal units at a maximum set-point airflow condition until the total airflow of the terminal units equals the design airflow of the fan. Select the reduced airflow terminal units so they are distributed evenly among the branch ducts.

B. Pressure-Independent, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Set outside-air dampers at minimum, and return- and exhaust-air dampers at a position that simulates full-cooling load.
2. Select the terminal unit that is most critical to the supply-fan airflow and static pressure. Measure static pressure. Adjust system static pressure so the entering static pressure for the critical terminal unit is not less than the sum of the terminal unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge duct losses.
3. Measure total system airflow. Adjust to within 10 percent of design airflow.
4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use the terminal unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units as described for constant-volume air systems.
5. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow as described for constant-volume air systems.

   a. If air outlets are out of balance at minimum airflow, report the condition but leave the outlets balanced for maximum airflow.

   b. Record fan motor operating point confirming the fan and the motor are operating in a stable range. Check fan construction versus operating point.

6. Remeasure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return-air ducts and inlets as described for constant-volume air systems.
7. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure adequate static pressure is maintained at the most critical unit.
8. Record the final fan performance data.

3.7 FUNDAMENTAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports with pertinent design data and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against approved pump flow rate. Correct variations that exceed plus or minus 5 percent.

B. Prepare schematic diagrams of systems' "as-built" piping layouts.

C. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:

1. Open all manual valves for maximum flow.
2. Check makeup-water-station pressure gage for adequate pressure for highest vent.
3. Check flow-control valves for specified sequence of operation and set at design flow.
4. Set differential-pressure control valves at the specified differential pressure. Do not set at fully closed position when pump is positive-displacement type, unless several terminal valves are kept open.
5. Set system controls so automatic valves are wide open to heat exchangers.
6. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.
7. Check air vents for a forceful liquid flow exiting from vents when manually operated.

3.8 HYDRONIC SYSTEMS' BALANCING PROCEDURES

A. Determine water flow at pumps. Use the following procedures, except for positive-displacement pumps:

  1. Verify impeller size by operating the pump with the discharge valve closed. Verify with the pump manufacturer that this will not damage pump. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on the manufacturer's pump curve at zero flow and confirm that the pump has the intended impeller size.
  2. Check system resistance. With all valves open, read pressure differential across the pump and mark the pump manufacturer's head-capacity curve. Adjust pump discharge valve until design water flow is achieved.
  3. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on the pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.
  4. Report flow rates that are not within plus or minus 5 percent of design.

B. Set calibrated balancing valves, if installed, at calculated pre-settings; with dynamic balancing valves balancer shall record the pressure reading of the valves.

C. Measure flow at all stations and adjust, where necessary, to obtain first balance.

  1. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.

D. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than design flow.

E. Adjust balancing stations to within specified tolerances of design flow rate as follows:

  1. Determine the balancing station with the highest percentage over design flow.
  2. Adjust each station in turn, beginning with the station with the highest percentage over design flow and proceeding to the station with the lowest percentage over design flow.
  3. Record settings and mark balancing devices.

F. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures, including outdoor-air temperature.

G. Measure the differential-pressure control valve settings existing at the conclusions of balancing.

3.9 VARIABLE-FLOW HYDRONIC SYSTEMS' ADDITIONAL PROCEDURES

A. Balance systems with automatic 2- and 3-way control valves by setting systems at maximum flow through heat-exchange terminals and proceed as specified above for hydronic systems.

3.10 HEAT EXCHANGERS

A. Measure water flow through all circuits.

B. Adjust water flow to within specified tolerances.

C. Measure inlet and outlet water temperatures.

D. Measure inlet steam pressure. Check the setting and operation of automatic temperature-control valves, self-contained control valves, and pressure-reducing valves.

E. Record safety valve settings.

F. Verify operation of steam traps.

3.11 MOTORS

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer, model, and serial numbers.
2. Motor horsepower rating.
3. Motor rpm.
4. Efficiency rating if high-efficiency motor.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter thermal-protection-element rating.

B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass for the controller to prove proper operation. Record observations, including controller manufacturer, model and serial numbers, and nameplate data.

3.12 CHILLERS

A. Balance water flow through each evaporator and condenser to within specified tolerances of design flow with all pumps operating. With only one chiller operating in a multiple chiller installation, do not exceed the flow for the maximum tube velocity recommended by the chiller manufacturer. Measure and record the following data with each chiller operating at design conditions:

1. Evaporator water entering and leaving temperatures, pressure drop, and water flow.
2. Condenser water entering and leaving temperatures, pressure drop, and water flow.
3. Evaporator and condenser refrigerant temperatures and pressures, using instruments furnished by the chiller manufacturer.
4. Power factor if factory-installed instrumentation is furnished for measuring kW.
5. The kW input if factory-installed instrumentation is furnished for measuring kW.
6. Capacity: Calculate in tons of cooling.
7. Air-Cooled Chillers: Verify condenser-fan rotation and record fan data, including number of fans and entering- and leaving-air temperatures.

3.13 COOLING TOWERS

A. Shut off makeup water for the duration of the test, and then make sure the makeup and blow-down systems are fully operational after tests and before leaving the equipment. Perform the following tests and record the results:

1. Measure condenser water flow to each cell of the cooling tower.
2. Measure entering- and leaving-water temperatures.
3. Measure wet- and dry-bulb temperatures of entering air.
4. Measure wet- and dry-bulb temperatures of leaving air.
5. Measure condenser water flow rate recirculating through the cooling tower.
6. Measure cooling tower pump discharge pressure.
7. Adjust water level and feed rate of makeup-water system.

3.14 CONDENSING UNITS

A. Verify proper rotation of fans and measure entering- and leaving-air temperatures. Record compressor data.

3.15 HEAT-TRANSFER COILS

A. Water Coils: Measure the following data for each coil:

1. Entering- and leaving-water temperatures.
2. Water flow rate.
3. Water pressure drop.
4. Dry-bulb temperatures of entering and leaving air.
5. Wet-bulb temperatures of entering and leaving air for cooling coils designed for less than 7500 cfm.
6. Airflow.
7. Air pressure drop.

3.16 TEMPERATURE TESTING

A. During testing, adjusting, and balancing, report need for adjustment in temperature regulation within the automatic temperature-control system.

B. Measure indoor wet- and dry-bulb temperatures every other hour for a period of 2 successive 8-hour days, in each separately controlled zone, to prove correctness of final temperature settings. Measure when the building or zone is occupied.

C. Measure outside-air, wet- and dry-bulb temperatures.

3.17 FUME HOODS

A. Determine total airflow into the room where the fume hood is located and balance systems to ensure adequate air supply to all hoods.

1. Set fume-hood door opening at position of normal use.
2. Energize the exhaust fan and adjust airflow to provide the indicated average fume-hood face velocity at hood opening.
3. Measure exhaust airflow volume by measuring airflow by Pitot-tube duct traverse.
4. Measure air velocity using Pitot-tube traverse method.
5. Record each face velocity measurement taken at 4- to 6-inch increments over the entire hood door opening.
6. Calculate the average face velocity by averaging all velocity measurements.
7. Calculate the airflow volume of exhaust-hood face velocity by multiplying the calculated average face velocity by the opening area. Compare this quantity with exhaust volume at exhaust fan and report duct leakage.
8. Measure airflow volume supplied by makeup fan. Verify that the makeup system supplies the proper amount of air to keep the space at the indicated pressure with the exhaust systems in all operating conditions.
9. Retest for average face velocity. Adjust hood baffles, fan drives, and other parts of the system to provide the indicated average face velocity and the indicated auxiliary air-supply percentages.
10. Retest and adjust the systems until fume-hood performance complies with Contract Documents.

3.18 TEMPERATURE-CONTROL VERIFICATION

A. Verify that controllers are calibrated and commissioned.

B. Check transmitter and controller locations and note conditions that would adversely affect control functions.

C. Record controller settings and note variances between set points and actual measurements.

D. Verify operation of limiting controllers (i.e., high- and low-temperature controllers).

E. Verify free travel and proper operation of control devices such as damper and valve operators.

F. Verify sequence of operation of control devices. Note air pressures and device positions and correlate with airflow and water-flow measurements. Note the speed of response to input changes.

G. Confirm interaction of electrically operated switch transducers.

H. Confirm interaction of interlock and lockout systems.

I. Verify main control supply-air pressure and observe compressor and dryer operations.

J. Record voltages of power supply and controller output. Determine if the system operates on a grounded or nongrounded power supply.

K. Note operation of electric actuators using spring return for proper fail-safe operations.

3.19 TOLERANCES

A. Set HVAC system airflow and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans: Plus 5 to plus 10 percent.
2. Air Outlets and Inlets: 0 to minus 10 percent.
3. Heating-Water Flow Rate: 0 to minus 10 percent.
4. Cooling-Water Flow Rate: 0 to minus 5 percent.

3.20 REPORTING

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article above, prepare a report on the adequacy of design for systems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

B. Status Reports: As Work progresses, prepare reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.21 FINAL REPORT

A. General: Typewritten, or computer printout in letter-quality font, on standard bond paper, in 3-ring binder, tabulated and divided into sections by tested and balanced systems.

B. Include a certification sheet in front of binder signed and sealed by the certified testing and balancing engineer.

1. Include a list of the instruments used for procedures, along with proof of calibration.

C. Final Report Contents: In addition to the certified field report data, include the following:

1. Pump curves.
2. Fan curves.
3. Manufacturers' test data.
4. Field test reports prepared by system and equipment installers.
5. Other information relative to equipment performance, but do not include approved Shop Drawings and Product Data.

D. General Report Data: In addition to the form titles and entries, include the following data in the final report, as applicable:

1. Title page.
2. Name and address of testing, adjusting, and balancing Agent.
3. Project name.
4. Project location.
5. Architect's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
8. Report date.
9. Signature of testing, adjusting, and balancing Agent who certifies the report.
10. Summary of contents, including the following:

    a. Design versus final performance.
    b. Notable characteristics of systems.
    c. Description of system operation sequence if it varies from the Contract Documents.

11. Nomenclature sheets for each item of equipment.
12. Data for terminal units, including manufacturer, type size, and fittings.
13. Notes to explain why certain final data in the body of reports vary from design values.
14. Test conditions for fans and pump performance forms, including the following:

    a. Settings for outside-, return-, and exhaust-air dampers.
    b. Conditions of filters.
    c. Cooling coil, wet- and dry-bulb conditions.
    d. Face and bypass damper settings at coils.
    e. Fan drive settings, including settings and percentage of maximum pitch diameter.
    f. Inlet vane settings for variable-air-volume systems.
    g. Settings for supply-air, static-pressure controller.
    h. Other system operating conditions that affect performance.

E. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present with single-line diagrams and include the following:

1. Quantities of outside, supply, return, and exhaust airflows.
2. Water and steam flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Terminal units.
6. Balancing stations.

F. Air-Handling Unit Test Reports: For air-handling units with coils, include the following:

1. Unit Data: Include the following:

    a. Unit identification.
    b. Location.
    c. Make and type.

d. Model number and unit size.
e. Manufacturer's serial number.
f. Unit arrangement and class.
g. Discharge arrangement.
h. Sheave make, size in inches, and bore.
i. Sheave dimensions, center-to-center and amount of adjustments in inches.
j. Number of belts, make, and size.
k. Number of filters, type, and size.

2. Motor Data: Include the following:

a. Make and frame type and size.
b. Horsepower and rpm.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches, and bore.
f. Sheave dimensions, center-to-center and amount of adjustments in inches.

3. Test Data: Include design and actual values for the following:

a. Total airflow rate in cfm.
b. Total system static pressure in inches wg.
c. Fan rpm.
d. Discharge static pressure in inches wg.
e. Filter static-pressure differential in inches wg.
f. Preheat coil static-pressure differential in inches wg.
g. Cooling coil static-pressure differential in inches wg.
h. Heating coil static-pressure differential in inches wg.
i. Outside airflow in cfm.
j. Return airflow in cfm.
k. Outside-air damper position.
l. Return-air damper position.
m. Vortex damper position.

G. Apparatus-Coil Test Reports: For apparatus coils, include the following:

1. Coil Data: Include the following:

a. System identification.
b. Location.
c. Coil type.
d. Number of rows.
e. Fin spacing in fins per inch.
f. Make and model number.
g. Face area in sq. ft..
h. Tube size in NPS.
i. Tube and fin materials.
j. Circuiting arrangement.

2. Test Data: Include design and actual values for the following:

   a. Airflow rate in cfm.
   b. Average face velocity in fpm.
   c. Air pressure drop in inches wg.
   d. Outside-air, wet- and dry-bulb temperatures in deg F.
   e. Return-air, wet- and dry-bulb temperatures in deg F.
   f. Entering-air, wet- and dry-bulb temperatures in deg F.
   g. Leaving-air, wet- and dry-bulb temperatures in deg F.
   h. Water flow rate in gpm.
   i. Water pressure differential in feet of head or psig.
   j. Entering-water temperature in deg F.
   k. Leaving-water temperature in deg F.
   l. Refrigerant expansion valve and refrigerant types.
   m. Refrigerant suction pressure in psig.
   n. Refrigerant suction temperature in deg F.
   o. Inlet steam pressure in psig.

H. Fan Test Reports: For supply, return, and exhaust fans, include the following:

1. Fan Data: Include the following:

   a. System identification.
   b. Location.
   c. Make and type.
   d. Model number and size.
   e. Manufacturer's serial number.
   f. Arrangement and class.
   g. Sheave make, size in inches, and bore.
   h. Sheave dimensions, center-to-center and amount of adjustments in inches.

2. Motor Data: Include the following:

   a. Make and frame type and size.
   b. Horsepower and rpm.
   c. Volts, phase, and hertz.
   d. Full-load amperage and service factor.
   e. Sheave make, size in inches, and bore.
   f. Sheave dimensions, center-to-center and amount of adjustments in inches.
   g. Number of belts, make, and size.

3. Test Data: Include design and actual values for the following:

   a. Total airflow rate in cfm.
   b. Total system static pressure in inches wg.
   c. Fan rpm.
   d. Discharge static pressure in inches wg.
   e. Suction static pressure in inches wg.

I. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data: Include the following:

a. System and air-handling unit number.
b. Location and zone.
c. Traverse air temperature in deg F.
d. Duct static pressure in inches wg.
e. Duct size in inches.
f. Duct area in sq. ft.
g. Design airflow rate in cfm.
h. Design velocity in fpm.
i. Actual airflow rate in cfm.
j. Actual average velocity in fpm.
k. Barometric pressure in psig.

J. Air-Terminal-Device Reports: For terminal units, include the following:

1. Unit Data: Include the following:

a. System and air-handling unit identification.
b. Location and zone.
c. Test apparatus used.
d. Area served.
e. Air-terminal-device make.
f. Air-terminal-device number from system diagram.
g. Air-terminal-device type and model number.
h. Air-terminal-device size.
i. Air-terminal-device effective area in sq. ft..

2. Test Data: Include design and actual values for the following:

a. Airflow rate in cfm.
b. Air velocity in fpm.
c. Preliminary airflow rate as needed in cfm.
d. Preliminary velocity as needed in fpm.
e. Final airflow rate in cfm.
f. Final velocity in fpm.
g. Space temperature in deg F.

K. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:

1. Unit Data: Include the following:

a. System and air-handling unit identification.
b. Location and zone.
c. Room or riser served.
d. Coil make and size.
e. Flowmeter type.

2. Test Data: Include design and actual values for the following:

   a. Airflow rate in cfm.
   b. Entering-water temperature in deg F.
   c. Leaving-water temperature in deg F.
   d. Water pressure drop in feet of head or psig.
   e. Entering-air temperature in deg F.
   f. Leaving-air temperature in deg F.

L. Packaged Chiller Reports: For each chiller, include the following:

1. Unit Data: Include the following:

   a. Unit identification.
   b. Make and model number.
   c. Manufacturer's serial number.
   d. Refrigerant type and capacity in gal..
   e. Starter type and size.
   f. Starter thermal protection size.

2. Condenser Test Data: Include design and actual values for the following:

   a. Refrigerant pressure in psig.
   b. Refrigerant temperature in deg F.
   c. Entering-water temperature in deg F.
   d. Leaving-water temperature in deg F.
   e. Entering-water pressure in feet of head or psig.
   f. Water pressure differential in feet of head or psig.

3. Evaporator Test Reports: Include design and actual values for the following:

   a. Refrigerant pressure in psig.
   b. Refrigerant temperature in deg F.
   c. Entering-water temperature in deg F.
   d. Leaving-water temperature in deg F.
   e. Entering-water pressure in feet of head or psig.
   f. Water pressure differential in feet of head or psig.

4. Compressor Test Data: Include design and actual values for the following:

   a. Make and model number.
   b. Manufacturer's serial number.
   c. Suction pressure in psig.
   d. Suction temperature in deg F.
   e. Discharge pressure in psig.
   f. Discharge temperature in deg F.
   g. Oil pressure in psig.
   h. Oil temperature in deg F.
   i. Voltage at each connection.
   j. Amperage for each phase.

k. The kW input.
l. Crankcase heater kW.
m. Chilled water control set point in deg F.
n. Condenser water control set point in deg F.
o. Refrigerant low-pressure-cutoff set point in psig.
p. Refrigerant high-pressure-cutoff set point in psig.

5. Refrigerant Test Data: Include design and actual values for the following:

a. Oil level.
b. Refrigerant level.
c. Relief valve setting in psig.
d. Unloader set points in psig.
e. Percentage of cylinders unloaded.
f. Bearing temperatures in deg F.
g. Vane position.
h. Low-temperature-cutoff set point in deg F.

M. Cooling Tower or Condenser Test Reports: For cooling towers or condensers, include the following:

1. Unit Data: Include the following:

a. Unit identification.
b. Make and type.
c. Model and serial numbers.
d. Nominal cooling capacity in tons.
e. Refrigerant type and weight in lb.
f. Water-treatment chemical feeder and chemical.
g. Number and type of fans.
h. Fan motor make, frame size, rpm, and horsepower.
i. Fan motor voltage at each connection.
j. Sheave make, size in inches, and bore.
k. Sheave dimensions, center-to-center and amount of adjustments in inches.
l. Number of belts, make, and size.

2. Pump Test Data: Include design and actual values for the following:

a. Make and model number.
b. Manufacturer's serial number.
c. Motor make and frame size.
d. Motor horsepower and rpm.
e. Voltage at each connection.
f. Amperage for each phase.
g. Water flow rate in gpm.

3. Water Test Data: Include design and actual values for the following:

a. Entering-water temperature in deg F.
b. Leaving-water temperature in deg F.

c. Water temperature differential in deg F.
d. Entering-water pressure in feet of head or psig.
e. Leaving-water pressure in feet of head or psig.
f. Water pressure differential in feet of head or psig.
g. Water flow rate in gpm.
h. Bleed water flow rate in gpm.

4. Air Data: Include design and actual values for the following:

a. Duct airflow rate in cfm.
b. Inlet-duct static pressure in inches wg.
c. Outlet-duct static pressure in inches wg.
d. Average entering-air, wet-bulb temperature in deg F.
e. Average leaving-air, wet-bulb temperature in deg F.
f. Ambient wet-bulb temperature in deg F.

N. Heat-Exchanger/Converter Test Reports: For steam and hot-water heat exchangers, include the following:

1. Unit Data: Include the following:

a. Unit identification.
b. Location.
c. Service.
d. Make and type.
e. Model and serial numbers.
f. Ratings.

2. Steam Test Data: Include design and actual values for the following:

a. Inlet pressure in psig.
b. Condensate flow rate in lb/h.

3. Primary Water Test Data: Include design and actual values for the following:

a. Entering-water temperature in deg F.
b. Leaving-water temperature in deg F.
c. Entering-water pressure in feet of head or psig.
d. Water pressure differential in feet of head or psig.
e. Water flow rate in gpm.

4. Secondary Water Test Data: Include design and actual values for the following:

a. Entering-water temperature in deg F.
b. Leaving-water temperature in deg F.
c. Entering-water pressure in feet of head or psig.
d. Water pressure differential in feet of head or psig.
e. Water flow rate in gpm.

O. Pump Test Reports: For pumps, include the following data. Calculate impeller size by plotting the shutoff head on pump curves.

1. Unit Data: Include the following:

a. Unit identification.
b. Location.
c. Service.
d. Make and size.
e. Model and serial numbers.
f. Water flow rate in gpm.
g. Water pressure differential in feet of head or psig.
h. Required net positive suction head in feet of head or psig.
i. Pump rpm.
j. Impeller diameter in inches.
k. Motor make and frame size.
l. Motor horsepower and rpm.
m. Voltage at each connection.
n. Amperage for each phase.
o. Full-load amperage and service factor.
p. Seal type.

2. Test Data: Include design and actual values for the following:

a. Static head in feet of head or psig.
b. Pump shutoff pressure in feet of head or psig.
c. Actual impeller size in inches.
d. Full-open flow rate in gpm.
e. Full-open pressure in feet of head or psig.
f. Final discharge pressure in feet of head or psig.
g. Final suction pressure in feet of head or psig.
h. Final total pressure in feet of head or psig.
i. Final water flow rate in gpm.
j. Voltage at each connection.
k. Amperage for each phase.

P. Instrument Calibration Reports: For instrument calibration, include the following:

1. Report Data: Include the following:

a. Instrument type and make.
b. Serial number.
c. Application.
d. Dates of use.
e. Dates of calibration.

3.22 ADDITIONAL TESTS

A. Within 90 days of completing testing, adjusting, and balancing, perform additional testing and balancing to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial testing, adjusting, and balancing procedures were not performed during near-peak summer and winter conditions, perform additional inspections, testing, and adjusting during near-peak summer and winter conditions.

END OF SECTION 230593

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SECTION 230626 – ROTARY SCREW WATER CHILLERS

SECTION 230626 - ROTARY-SCREW WATER CHILLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes packaged, water-cooled, electric-motor-driven, rotary-screw water chillers with the following features:

1. Motor controller.
2. Microprocessor-based controls.

1.3 DEFINITIONS

A. EER: Energy-efficiency ratio.

B. IPLV: Integrated part-load value.

1.4 SUBMITTALS

A. Product Data: Include refrigerant, rated capacities, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: Complete set of manufacturer's certified prints of water chiller assemblies, control panels, sections, and elevations, and unit isolation. Include the following:

1. Assembled unit dimensions.
2. Operating weight and load distribution.
3. Required clearances for maintenance and operation.
4. Size and location of piping and wiring connections.
5. Vibration Isolation Calculations and Details: Signed and sealed by a qualified professional engineer.

   a. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
   b. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails and equipment mounting frames.

6. Wiring Diagrams: Power, signal, and control wiring.

C. Coordination Drawings: Floor plans drawn to scale and coordinated with the following:

1. Structural supports.
2. Piping roughing-in requirements.
3. Wiring roughing-in requirements, including spaces reserved for electrical equipment.
4. Access requirements, including working clearances for mechanical controls and electrical equipment, and tube pull and service clearances.

D. Certificates: For certification required in "Quality Assurance" Article.

E. Manufacturer Seismic Qualification Certification: Submit certification that water chillers, accessories, and components will withstand seismic forces defined in Division 23 Section "Mechanical Vibration and Seismic Controls." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

   a. The term "withstand" means" the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

F. Source quality-control test reports.

G. Startup service reports.

H. Operation and Maintenance Data: For each water chiller to include in emergency, operation and maintenance manual.

I. Warranties: Special warranties specified in this Section.

1.5 QUALITY ASSURANCE

A. ARI Certification: Signed by manufacturer certifying compliance with requirements in ARI 550/590, "Water Chilling Packages Using the Vapor Compression Cycle."

B. ASHRAE Certification: Signed by manufacturer certifying compliance with ASHRAE 15 for safety code for mechanical refrigeration. Comply with ASHRAE Guideline 3 for refrigerant leaks, recovery, and handling and storage requirements.

C. ASME Compliance: Fabricate and label water chiller heat exchangers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

D. Comply with NFPA 70.

E. Comply with UL 1995.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Ship water chillers from the factory fully charged with refrigerant or nitrogen.

1.7 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

B. Coordinate installation of roof curbs and roof penetrations. These items are specified in Division 7 Section "Roof Accessories."

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of water chillers that fail in materials or workmanship.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

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

1. Trane Company (The).
2. Carrier; a United Technologies Company.
3. McQuay International.
4. YORK International Corporation.

2.2 PACKAGED WATER CHILLERS

A. Description: Factory-assembled and -tested water chiller complete with compressor, evaporator, condenser, controls, interconnecting unit piping and wiring, indicated accessories, and mounting frame.

B. Description: Factory-assembled and -tested water chiller complete with compressor, heat exchanger, and controls integrated with compressor operation.

C. Description: Factory-assembled and -tested water chiller complete with casing, compressor, heat exchanger, condenser coils and fans, and controls integrated with compressor operation.

1. Casing: Weatherproof, constructed of hot-dip galvanized steel with factory-painted finish.

2. Fans: Propeller type, statically and dynamically balanced, with vertical air discharge for high efficiency and low sound; located in its own compartment to eliminate cross flow of condenser air during fan cycling; and equipped with heavy-gage, weather-protected fan guard.
3. Fan Motor: Direct drive, weatherproof, with bearings permanently lubricated, and having built-in current- and thermal-overload protection.

D. Fabricate water chiller mounting frame and attachment to the pressure vessel with reinforcement strong enough to resist water chiller movement during a seismic event when the water chiller mounting frame is anchored to the building structure.

2.3 COMPRESSORS

A. Description: Positive displacement, oil injected with direct-drive, hermetically sealed motor.

1. Casing: Cast iron, precision machined for minimum clearance about periphery of rotors.
2. Rotors: Twin screw.

B. Capacity Control: Hydraulically operated, modulating or stepped sliding valve to maintain chilled-water temperature set point without hunting within throttling range. Throttling range shall be from 100 to 20 percent of full load.

C. Oil Lubrication System: Positive-displacement submersible pump with heater, oil filter, and sight glass.

D. Refrigerant and Oil: HFC-134a.

E. Refrigerant Compatibility: Seals, O-rings, motor windings, and internal water chiller parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.

F. Refrigerant Circuit: independent circuits. Each circuit shall include an electronic expansion valve, compressor suction and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core filter drier, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.

2.4 HEAT EXCHANGERS

A. Evaporator:

1. Description: Shell-and-tube design, ASME labeled.
2. Shell Material: Carbon steel.
3. Tube Construction: Individually replaceable, expanded into tube sheets.

   a. Material: Copper.
   b. Internal Finish: Enhanced.

4. Water Box: marine , with design working pressure of 150 psig, and having [**flanged**] water-nozzle connections with a thermistor-type temperature sensor factory installed in each nozzle.

B. Condenser:

1. Description: Shell-and-tube design, ASME labeled.
2. Shell Material: Carbon steel.
3. Tube Construction: Externally enhanced and individually replaceable, expanded into tube sheets.

    a. Material: Copper.
    b. Minimum Size: 3/4-inch OD; 0.028-inch wall thickness.
    c. Internal Finish: Enhanced .

4. Water Box: Marine, with design working pressure of 300 psig and having flanged water-nozzle connections with a thermistor-type temperature sensor factory installed in each nozzle.

2.5 INSULATION

A. Cold Surfaces: Closed-cell, flexible elastomeric, thermal insulation complying with ASTM C 534, Type II, for sheet materials.

1. Thickness: [**3/4 inch (19 mm)**] **<Insert thickness>**.
2. Adhesive: As recommended by insulation manufacturer.
3. Factory apply insulation over entire surfaces of water chiller components.

    a. Apply adhesive to 100 percent of insulation contact surface.
    b. Seal seams and joints.
    c. After adhesive has fully cured, apply two coats of protective coating to insulation.

2.6 ACCESSORIES

A. Pressure Relief Valve: Single- or multiple-reseating-type, spring-loaded relief valve.

2.7 CONTROLS

A. Control Panel: Stand-alone, microprocessor based.

B. Enclosure: Unit-mounted, NEMA 250, Type [1] enclosure, hinged or lockable; factory wired with a single-point power connection and a separate control circuit.

C. Status Display: Multiple-character liquid-crystal display or light-emitting diodes and keypad. Display the following conditions:

1. Date and time.
2. Operating or alarm status.

3. Operating hours.
4. Outside-air temperature if required for chilled-water reset.
5. Temperature and pressure of operating set points.
6. Entering and leaving temperatures of chilled water.
7. Entering and leaving temperatures of condenser water (for water-cooled water chillers only).
8. Refrigerant pressures in evaporator and condenser.
9. Saturation temperature in evaporator and condenser.
10. Oil temperature and pressure.
11. Percent of maximum motor amperage.
12. Current-limit set point.
13. Number of compressor starts.
14. **<Insert other status display items.>**

D. Control Functions:

1. Manual or automatic startup and shutdown time schedule.
2. Entering and leaving chilled-water temperature, control set points, and motor load limit. Chilled-water temperature shall be reset based on **[return-water]** **[outside-air]** **[space]** temperature.
3. Current limit and demand limit.
4. Condenser-water temperature.
5. External water chiller emergency stop.
6. **<Insert other control functions.>**

E. Manually Reset Safety Controls: The following conditions shall shut down water chiller and require manual reset:

1. Low evaporator **[pressure]** **[temperature]**; high condenser pressure.
2. Low chilled-water temperature.
3. Low oil differential pressure.
4. High or low oil pressure.
5. High oil temperature.
6. High compressor-discharge temperature.
7. Loss of chilled- or condenser-water flow.
8. Electrical overload.
9. Sensor- or detection-circuit fault.
10. Processor communication loss.
11. Starter fault.
12. **<Insert other reset safety control items.>**

F. Building Management System Interface: Factory-installed hardware and software to enable building management system to monitor and control chilled-water set point and chiller-control displays and alarms.

2.8 MOTORS

A. Comply with requirements in Division 23 Section "Motors."

1. Open-drive motors shall have flanged or flexible coupling suitable for direct connection to compressor.

2.9 Variable Frequency Drive (VFD)

1. The chiller shall be equipped with a Variable Frequency Drive (VFD) to automatically regulate each compressor speed in response to cooling load and compressor pressure lift. The chiller control shall coordinate compressor speed and guide vane position to optimize chiller efficiency.
2. The unit shall be equipped with a line reactor.

2.10 MAGNETIC ENCLOSED CONTROLLERS

A. Enclosure: Unit mounted, [**NEMA 250**] , Type [**1**] , with hinged access door with lock and key or padlock and key.

B. Control Circuit: 120 V; obtained from [**integral control power transformer**] with a control power [**transformer**] of enough capacity to operate connected pilot and indicating and control devices.

C. Overload Relay: Shall be sized according to UL 1995 or shall be an integral component of water chiller control microprocessor.

D. Star-Delta Controller: NEMA ICS 2, closed transition.

E. Accessories: Devices shall be factory installed in controller enclosure, unless otherwise indicated.

1. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:

   a. Selectable, digital display of the following:

      1) Phase Currents, Each Phase: Plus or minus 1 percent.
      2) Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
      3) Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
      4) Three-Phase Real Power: Plus or minus 2 percent.
      5) Three-Phase Reactive Power: Plus or minus 2 percent.
      6) Power Factor: Plus or minus 2 percent.
      7) Frequency: Plus or minus 0.5 percent.
      8) Integrated Demand with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2 percent.

9) Accumulated energy, in megawatt hours (joules), plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.

b. Mounting: Display and control unit flush or semirecessed in instrument compartment door.

2. Phase-Failure and Undervoltage Relays: Solid-state sensing circuit with adjustable undervoltage setting and isolated output contacts for hard-wired connections.

2.11 SOURCE QUALITY CONTROL

A. Factory test and rate water chillers, before shipping, according to ARI 550/590, "Water Chilling Packages Using the Vapor Compression Cycle." Stamp with ARI label.

B. Factory test heat exchangers hydrostatically at 1.50 times the design pressure.

C. Factory test and inspect evaporator and water-cooled condenser according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. Stamp with ASME label.

D. Factory test and inspect water boxes at 150 percent of working pressure.

E. Rate sound power level according to ARI 575 procedure.

F. Rate sound power level according to ARI 370 procedure.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Before water chiller installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, piping, and electrical to verify actual locations, sizes, and other conditions affecting water chiller performance, maintenance, and operations.

1. Final water chiller locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 WATER CHILLER INSTALLATION

A. Install water chillers on concrete base. Concrete base is specified in Division 23 Section "Basic Mechanical Materials and Methods," and concrete materials and installation requirements are specified in Division 3.

B. Concrete Bases: Anchor chiller mounting frame to concrete base.

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.
5. Cast-in-place concrete materials and placement requirements are specified in Division 3.

C. Vibration Isolation: Mount water chiller on vibration isolation equipment base as specified in Division 23 Section "Mechanical Vibration and Seismic Controls."

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

E. Charge water chiller with refrigerant if not factory charged.

F. Install separate devices furnished by manufacturer.

3.3 CONNECTIONS

A. Chilled- and condenser-water piping installation requirements are specified in Division 23 Section "Hydronic Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to chiller to allow service and maintenance.

C. Evaporator Connections: Connect inlet to evaporator with controller-bulb well, shutoff valve, thermometer, strainer, pressure gage, and union or flange. Connect outlet to evaporator with shutoff valve, flow switch, balancing valve, thermometer, pressure gage, and union or flange.

D. Condenser Connections: Connect inlet to condenser with shutoff valve, thermometer, plugged tee, and pressure gage. Connect outlet to condenser with shutoff valve, thermometer, drain line and shutoff valve, strainer, and plugged tee.

E. Refrigerant Pressure Relief Valve Connections: Extend vent piping to the outside without valves or restrictions.

F. Ground water chillers according to Division 26 Section "Grounding and Bonding."

G. Connect wiring according to Division 26 Section "Conductors and Cables."

H. 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 UL 486B.

3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assemblies, installations, and connections.

C. Complete installation and startup checks according to manufacturer's written instructions and perform the following:

1. Verify that refrigerant charge is sufficient and water chiller has been leak tested.
2. Verify that pumps are installed and functional.
3. Verify that thermometers and gages are installed.
4. Operate water chiller for run-in period according to manufacturer's written instructions.
5. Check bearing lubrication and oil levels.
6. Verify that refrigerant pressure relief is vented outside (for water-cooled water chillers).
7. Verify proper motor rotation.
8. Verify static deflection of vibration isolators, including deflection during water chiller startup and shutdown.
9. Verify and record performance of chilled-[**and condenser-**]water flow and low-temperature interlocks.
10. Verify and record performance of water chiller protection devices.
11. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.

D. Prepare a written startup report that records results of tests and inspections.

E. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to site outside normal occupancy hours for this purpose.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain water chillers. Refer to Division 1 Section "[**Demonstration and Training**]."

END OF SECTION 230626

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SECTION 230628 – RECIPROCATING WATER CHILLERS

SECTION 230628 - RECIPROCATING WATER CHILLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes packaged, air-cooled, electric-motor-driven, scroll water chillers.

1.3 DEFINITIONS

A. EER: Energy-efficiency ratio.

B. IPLV: Integrated part-load value.

1.4 SUBMITTALS

A. Product Data: Include refrigerant, rated capacities, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: Complete set of manufacturer's certified prints of water chiller assemblies, control panels, sections and elevations, and unit isolation. Include the following:

1. Assembled unit dimensions.
2. Weight and load distribution.
3. Required clearances for maintenance and operation.
4. Size and location of piping and wiring connections.
5. Vibration Isolation Calculations and Details: Signed and sealed by a qualified professional engineer.

   a. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
   b. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails and equipment mounting frames.

6. Wiring Diagrams: Power, signal, and control wiring.

C. Coordination Drawings: Floor plans drawn to scale and coordinated with the following:

1. Structural supports.
2. Piping roughing-in requirements.

3. Wiring roughing-in requirements, including spaces reserved for electrical equipment.
4. Access requirements, including working clearances for mechanical controls and electrical equipment, and tube pull and service clearances.

D. Certificates: For certification required in "Quality Assurance" Article.

E. Manufacturer Seismic Qualification Certification: Submit certification that water chillers, accessories, and components will withstand seismic forces defined in Division 23 Section "Mechanical Vibration and Seismic Controls." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

   a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

F. Source quality-control test reports.

G. Startup service reports.

H. Operation and Maintenance Data: For each water chiller to include in emergency, operation, and maintenance manuals.

I. Warranties: Special warranties specified in this Section.

1.5 QUALITY ASSURANCE

A. ARI Certification: Signed by manufacturer certifying compliance with requirements in ARI 550/590, "Water Chilling Packages Using the Vapor Compression Cycle."

B. ASHRAE Certification: Signed by manufacturer certifying compliance with ASHRAE 15 for safety code for mechanical refrigeration. Comply with ASHRAE Guideline 3 for refrigerant leaks, recovery, and handling and storage requirements.

C. ASME Compliance: Fabricate and label water chiller heat exchangers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

D. Comply with NFPA 70.

E. Comply with UL 1995.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Ship water chillers from the factory fully charged with refrigerant or nitrogen.

1.7 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

B. Coordinate installation of roof curbs and roof penetrations. These items are specified in Division 7 Section "Roof Accessories."

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of water chillers that fail in materials or workmanship.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Scroll Water Chillers:

   a. Carrier; a United Technologies Company.
   b. Dunham-Bush.
   c. McQuay International.
   d. Trane Company (The).
   e. YORK International Corporation.

2.2 PACKAGED WATER CHILLERS

A. Description: Factory-assembled and -tested water chiller complete with compressor(s), evaporator, condenser, controls, interconnecting unit piping and wiring, indicated accessories, and mounting frame.

B. Description: Factory-assembled and -tested water chiller complete with compressor, heat exchanger, and controls integrated with compressor operation.

C. Description: Factory-assembled and -tested water chiller complete with casing, compressor, heat exchanger, condenser coils and fans, and controls integrated with compressor operation.

1. Casing: Weatherproof, constructed of hot-dip galvanized steel with factory-painted finish.
2. Acoustical sound blanket.
3. Acoustical compressor enclosure.
4. Fans: Propeller type, statically and dynamically balanced, with vertical air discharge for high efficiency and low sound; located in its own compartment to eliminate cross flow of

condenser air during fan cycling; and equipped with heavy-gage, weather-protected fan guard.

5. Fan Motor: Direct drive, weatherproof, with bearings permanently lubricated, and having built-in current- and thermal-overload protection.

D. Fabricate water chiller mounting frame and attachment to the pressure vessel with reinforcement strong enough to resist water chiller movement during a seismic event when the water chiller mounting frame is anchored to the building structure.

2.3 SCROLL COMPRESSORS

A. Description: Positive displacement, direct drive with suction and discharge service valves, crankcase oil heater, and suction strainer. The compressor shall be capable of operating at part-load conditions without increased vibration over normal vibration at full-load operation and shall be capable of continuous operation at its lowest step of unloading.

B. Capacity Control: Hot-gas bypass.

C. Refrigerant and Oil: HFC-134a.

D. Refrigerant Compatibility: Seals, O-rings[**, motor windings,**] and internal water chiller parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.

E. Refrigerant Circuit: **<Insert number>** independent circuits. Each circuit shall include [**a thermal**] [**an electronic**] expansion valve, refrigerant charging connections, compressor suction and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core filter drier, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.

2.4 HEAT EXCHANGERS

A. Evaporator:

1. Description: Shell-and-tube design, ASME labeled.
2. Shell Material: Carbon steel.
3. Tube Construction: Individually replaceable, expanded into tube sheets.

   a. Material: Copper.
   b. Internal Finish: Enhanced.

B. Condenser:

1. Description: Shell-and-tube design, ASME labeled.
2. Shell Material: Carbon steel.
3. Tube Construction: Externally enhanced and individually replaceable, expanded into tube sheets.

   a. Material: Copper.
   b. Minimum Size: 3/4-inch (19-mm) OD; 0.028-inch (0.71-mm) wall thickness.

c. Minimum Size: 5/8-inch (16-mm) OD; 0.020-inch (0.5-mm) wall thickness.
d. Internal Finish: **[Enhanced]** .

C. Air-Cooled Condenser: Copper tubes with mechanically bonded **[copper]** fins[**with corrosion-resistant coating**], integral subcooling circuit, leak tested at 450 psig (3105 kPa).

1. Safety and Operating Options: Controls for low-ambient operation down to **<Insert temperature>**.

2.5 INSULATION

A. Cold Surfaces: Closed-cell, flexible elastomeric, thermal insulation complying with ASTM C 534, Type II, for sheet materials.

1. Thickness: [**3/4 inch (19 mm)**] .
2. Adhesive: As recommended by insulation manufacturer.
3. Factory apply insulation over entire surfaces of water chiller components.

a. Apply adhesive to 100 percent of insulation contact surface.
b. Seal seams and joints.
c. After adhesive has fully cured, apply two coats of protective coating to insulation.

2.6 ACCESSORIES

A. Factory-installed hot-gas bypass.

B. Low-ambient head pressure.

C. Chilled and condenser-water flow switch.

D. Suction and discharge pressure gages.

2.7 CONTROLS

A. Control Panel: Stand-alone, microprocessor based.

B. Enclosure: Unit-mounted, NEMA 250, Type **[1]** enclosure, hinged or lockable; factory wired with a single-point power connection and a separate control circuit.

C. Status Display: Multiple-character liquid-crystal display or light-emitting diodes and keypad. Display the following conditions:

1. Date and time.
2. Operating or alarm status.
3. Operating hours.
4. Outside-air temperature if required for chilled-water reset.
5. Temperature and pressure of operating set points.
6. Entering and leaving temperatures of chilled water.

7. Entering and leaving temperatures of condenser water (for water-cooled water chillers only).
8. Refrigerant pressures in evaporator and condenser.
9. Saturation temperature in evaporator and condenser.
10. No cooling load condition.
11. Elapsed time meter (compressor run status).
12. Water pump status (optional).
13. Antirecycling timer status.
14. Percent of maximum motor amperage.
15. Current-limit set point.
16. Number of compressor starts.

D. Control Functions:

1. Manual or automatic startup and shutdown time schedule.
2. Entering and leaving chilled-water temperature, control set points, and motor load limit. Chilled-water temperature shall be reset based on **[return-water]** **[outside-air]** **[space]** temperature.
3. Current limit and demand limit.
4. Condenser-water temperature (for water-cooled water chillers only).
5. External water chiller emergency stop.
6. Antirecycling timer.
7. Automatic lead-lag switching.
8. Start and run during a temperature of **<Insert typical conditions available from manufacturers>** **<Insert other temperature>**.

E. Manually Reset Safety Controls: The following conditions shall shut down water chiller and require manual reset:

1. Low evaporator pressure or high condenser pressure.
2. Low chilled-water temperature.
3. Refrigerant high pressure.
4. High or low oil pressure.
5. High oil temperature.
6. Loss of chilled-water flow.
7. Loss of condenser-water flow (for water-cooled water chillers only)
8. Control device failure.
9. Compressor motor current-overload.
10. Starter fault.

F. Building Management System Interface: Factory-installed hardware and software to enable building management system to monitor and control chilled-water set point and chiller-control displays and alarms.

2.8 MOTORS

A. Comply with requirements in Division 23 Section "Motors."

1. Open-drive motors shall have flanged or flexible coupling suitable for direct connection to compressor.

2.9 MAGNETIC ENCLOSED CONTROLLERS

A. Enclosure: Unit mounted , [**NEMA 250**] , Type [**1**] , with hinged access door with lock and key or padlock and key.

B. Control Circuit: 120 V; obtained from [**integral control power transformer**] with a control power [**transformer**] of enough capacity to operate connected pilot, indicating and control devices, plus 100 percent spare capacity.

C. Overload Relay: Shall be sized according to UL 1995 or shall be an integral component of water chiller control microprocessor.

D. Across-the-Line Controller: NEMA ICS 2, Class A, full voltage, nonreversing; include isolation switch and current-limiting fuses.

1. fused disconnectFusible Disconnecting Means: NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 947-4-1.
2. Nonfusible Disconnecting Means: NEMA KS 1, heavy-duty, nonfusible switch.
3. Circuit-Breaker Disconnecting Means: NEMA AB 1, motor-circuit protector with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.

E. Accessories: Devices shall be factory installed in controller enclosure, unless otherwise indicated.

1. Control Relays: Auxiliary and adjustable time-delay relays.
2. Meters: Panel type, 2-1/2-inch (64-mm) minimum diameter with 90- or 120-degree scale and plus or minus 2 percent accuracy. Where indicated, provide transfer device with an off position. Meters shall indicate the following:

   a. Ammeter: Output current, with current sensors rated to suit application.
   b. Voltmeter: Output voltage.
   c. Frequency Meter: Output frequency.
   d. Real-time clock with current time and date.
   e. Running log of total power versus time.
   f. Total run time.
   g. Fault-log, maintaining last four faults with time and date stamp of each.
   h. **<Insert additional features>**

3. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:

   a. Selectable, digital display of the following:

      1) Phase Currents, Each Phase: Plus or minus 1 percent.
      2) Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
      3) Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
      4) Three-Phase Real Power: Plus or minus 2 percent.
      5) Three-Phase Reactive Power: Plus or minus 2 percent.
      6) Power Factor: Plus or minus 2 percent.
      7) Frequency: Plus or minus 0.5 percent.

b. Mounting: Display and control unit flush or semirecessed in instrument compartment door.

4. Phase-Failure and Undervoltage Relays: Solid-state sensing circuit with adjustable undervoltage setting and isolated output contacts for hard-wired connection.

2.10 SOURCE QUALITY CONTROL

A. Factory test and rate water chillers, before shipping, according to ARI 550/590, "Water Chilling Packages Using the Water Compression Cycle." Stamp with ARI label.

B. Factory test and inspect evaporator and water-cooled condenser according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. Stamp with ASME label.

C. Rate sound power level according to ARI 575 procedure.

D. Rate sound power level according to ARI 370 procedure.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Before water chiller installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, piping, and electrical to verify actual locations, sizes, and other conditions affecting water chiller performance, maintenance, and operations.

1. Final water chiller locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 WATER CHILLER INSTALLATION

A. Install water chillers on concrete base. Concrete base is specified in Division 23 Section "Basic Mechanical Materials and Methods," and concrete materials and installation requirements are specified in Division 3.

B. Concrete Bases: Anchor chiller mounting frame to concrete base.

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

4. Install anchor bolts to elevations required for proper attachment to supported equipment.
5. Cast-in-place concrete materials and placement requirements are specified in Division 3.

C. Vibration Isolation: Mount water chiller on vibration isolation equipment base as specified in Division 23 Section "Mechanical Vibration and Seismic Controls."

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

E. Charge water chiller with refrigerant if not factory charged.

F. Install separate devices furnished by manufacturer.

3.3 CONNECTIONS

A. Chilled and condenser-water piping installation requirements are specified in Division 23 Section "Hydronic Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to chiller to allow service and maintenance.

C. Evaporator Connections: Connect inlet to evaporator with controller-bulb well, shutoff valve, thermometer, strainer, pressure gage, and union or flange. Connect outlet to evaporator with shutoff valve, flow switch, balancing valve, thermometer, pressure gage, and union or flange.

D. Condenser Connections: Connect inlet to condenser with shutoff valve, thermometer, plugged tee, and pressure gage. Connect outlet to condenser with shutoff valve, thermometer, drain line and shutoff valve, strainer, and plugged tee.

E. Refrigerant Pressure Relief Valve Connections: Extend vent piping to the outside without valves or restrictions.

F. Ground water chillers according to Division 26 Section "Grounding and Bonding."

G. Connect wiring according to Division 26 Section "Conductors and Cables."

H. 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 UL 486B.

3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assemblies, installations, and connections.

C. Complete installation and startup checks according to manufacturer's written instructions and perform the following:

1. Verify that refrigerant charge is sufficient and water chiller has been leak tested.
2. Verify that pumps are installed and functional.
3. Verify that thermometers and gages are installed.
4. Operate water chiller for run-in period according to manufacturer's written instructions.
5. Check bearing lubrication and oil levels.
6. Verify that refrigerant pressure relief is vented outside (for water-cooled water chillers).
7. Verify proper motor rotation.
8. Verify static deflection of vibration isolators, including deflection during water chiller startup and shutdown.
9. Verify and record performance of chilled-[**and condenser-**]water flow and low-temperature interlocks.
10. Verify and record performance of water chiller protection devices.
11. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.

D. Prepare a written startup report that records results of tests and inspections.

E. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to site outside normal occupancy hours for this purpose.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain water chillers. Refer to Division 1 Section " [**Demonstration and Training**]."

END OF SECTION 230628

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SECTION 230642 – PACKAGED COOLING TOWERS

SECTION 230642 - PACKAGED COOLING TOWERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes factory-fabricated, mechanical-draft cooling towers.

1.3 SUBMITTALS

A. Product Data: Include rated capacities, pressure drop, fan performance, rating curves with selected points indicated, startup instructions, furnished specialties, and accessories for each model indicated.

B. Shop Drawings: Certified by a qualified professional engineer. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
2. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment.

C. Coordination Drawings: Show structural supports, piping roughing-in requirements, wiring roughing-in requirements (determine spaces reserved for electrical equipment), and access requirements for service and maintenance.

D. Product Certificates: Signed by manufacturers of cooling towers to include certified performance curves plotting leaving-water temperature against wet-bulb temperature.

E. Maintenance Data: For each cooling tower to include in maintenance manuals specified in Division 1. Include part lists for tower fill, water distribution system, fans, bearings, fan drives, vibration isolators, controls, basin heaters, and accessories.

1.4 QUALITY ASSURANCE

A. Manufacturer's Certification: Certify cooling tower's thermal performance according to CTI 201.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction.

1.5 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3 Section "Cast-in-Place Concrete."

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 7 Section "Roof Accessories."

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver cooling tower as a factory-assembled unit with protective crating and covering.

B. Rig units for unloading and moving as recommended by equipment manufacturer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Forced-Draft, Counterflow Cooling Towers:

   a. Baltimore Aircoil Co.
   b. Evapco, Inc.

2.2 FORCED-DRAFT, COUNTERFLOW COOLING TOWERS

A. Description: Forced-draft, counterflow cooling tower that is factory fabricated and assembled.

B. Fan: Belt driven, cast aluminum, propeller.

1. Bearings: Self-aligning ball bearings or bronze sleeve bearings, with lubricating lines and fittings.
2. Vibration Cutout Switch: De-energize fan motors if excessive vibration occurs.

C. Fan: Belt-driven, hot-dip galvanized steel, forward-curved centrifugal fan; statically and dynamically balanced.

1. Bearings: Self-aligning ball bearings or bronze sleeve bearings, with lubricating lines and fittings.

D. Capacity-Control Dampers: Galvanized-steel, fan-discharge dampers, with linkages, electric damper operator, controller, end switches, transformer, and weatherproof enclosure. Operate dampers to vary airflow through cooling tower and to regulate condenser leaving-water temperature.

E. Hot-Water Distribution System: Header pipe and removable branch pipes for even distribution of water over fill material.

1. Pipe Material: Galvanized steel.
2. Nozzles: Removable plastic, brass, or ceramic nozzles.
3. Maximum Pressure Drop: 8 psig.

F. Casing: Galvanized steel complying with ASTM A 653/A 653M, G-235 coating designation.

1. Fasteners: Corrosion resistance equal to or better than the materials being fastened.
2. Joints: Sealed watertight.
3. Welded Connections: Continuous and watertight.
4. Rigging Supports: For handling cooling towers at construction site.

G. Collecting Basin: Galvanized steel complying with ASTM A 653/A 653M, G-235 coating designation.

1. Removable strainer with openings smaller than nozzle orifices.
2. Overflow connection.
3. Makeup water connection.
4. Drain Connection: Side.

H. Fill Material: PVC; resistant to rot, decay, and biological attack; with maximum flame-spread rating of five according to ASTM E 84; and fabricated, formed, and installed by manufacturer to ensure that water breaks up into droplets.

I. Drift-Eliminator Material: PVC; resistant to rot, decay, and biological attack; with maximum flame-spread rating of five according to ASTM E 84.

J. Water-Level Control: Manufacturer's standard mechanical makeup water valve, and plastic or bronze float with an adjustable linkage.

K. Inlet Screen Material: Galvanized steel mesh mounted in removable frames.

L. Discharge-Hood Material: Galvanized steel according to ASTM A 653/A 653M, G-235 coating designation.

M. Basin heaters; selected to maintain 40 °F basin water temperature at –20 °F. Heaters shall be provided with low water cutout and thermostat.

N. Vibration cutout switch; electronic remote vibration switch with contact for BMS monitoring.

O. Controls; enclosed control panel containing contactors, control circuit transformer, pilot lights with single point power connection.

P. Disconnect switch; non-fused, single throw, 3-pole design in Nema 3R enclosure.

2.3 MOTORS

A. Refer to Division 23 Section "Motors" for general requirements for factory-installed motors.

B. Motor Construction: NEMA MG 1, general purpose, continuous duty, Design B.

C. Enclosure Type: Totally enclosed, fan cooled, energy efficient.

D. Motor Speed: Two speed, two winding.

2.4 VIBRATION CONTROL

A. Vibration rail with restrained-spring isolators-1" deflection.

2.5 SOURCE QUALITY CONTROL

A. Verification of Performance: Test and certify cooling towers according to CTI 201.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine proposed route of moving cooling towers into place and verify that it is free of interferences.

B. Examine elements and surfaces to support cooling tower.

C. Verify piping and wiring roughing-in locations.

D. Verify suitability of branch-circuit wiring.

3.2 INSTALLATION

A. Install cooling towers according to manufacturer's written instructions.

B. Install cooling towers level and plumb, and fasten to supporting structure with vibration isolators and seismic restraints.

C. Maintain recommended clearances for service and maintenance.

D. Install cooling towers and their support structures to withstand the effects of seismic events according to authorities having jurisdiction.

E. Electrical Wiring: Install electrical devices furnished by cooling tower manufacturer that are not factory mounted.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties. The following are specific connection requirements:

1. Install piping adjacent to cooling towers to allow service and maintenance.
2. Install flexible pipe connections for towers mounted on vibration isolators.
3. Pitch piping down to drain into sump.
4. Connect overflow drain and bleed lines to sanitary sewage system.
5. Domestic Water Piping: Comply with applicable requirements of Division 22 Section "Water Distribution Piping." Connect to water-level control with shutoff valve and union or flange at each connection.
6. Condenser-Water Piping: Comply with applicable requirements of Division 23 Section "Hydronic Piping." Connect to supply and return cooling-tower connections with shutoff valve, flow control valve, and union or flange on supply connection to the tower and shutoff valve and union or flange to return connection from the tower to the chiller.

B. Electrical: Comply with applicable requirements in Division 26 Sections.

C. Ground equipment.

1. 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 UL 486B.

3.4 FIELD QUALITY CONTROL

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

3.5 ADJUSTING

A. Set and balance condenser-water flow to each tower inlet.

B. Adjust water-level control for proper operating level.

3.6 CLEANING

A. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes including chips, scratches, and abrasions.

3.7 COMMISSIONING

A. Complete installation and startup checks according to manufacturer's written instructions and do the following:

1. Clean entire unit and wash basins.
2. Ensure accessories are properly installed.
3. Check makeup water float.
4. Check clearances for airflow and for tower servicing.
5. Check for vibration isolation and structural support.

B. Obtain wet-bulb, tower-size, and performance selection tables from manufacturer.

C. Lubricate bearings on fans and shaft as recommended by manufacturer.

D. Ensure fan wheels rotate in correct direction without vibration or binding.

E. Adjust belts to proper alignment and tension.

F. Start cooling-tower and condenser-water pumps. Follow manufacturers written starting procedures.

G. Check water level in tower basin.

H. Check operation of tower basin, makeup line, automatic freeze protect dump, and controlling device.

I. Check operation of basin immersion heater and control thermostat.

J. Ensure system chemical treatment is working, and measure chemical treatment levels. Check operation of tower basin automatic blow-down, and controlling device.

K. Verify that tower discharge is not recirculating into air intakes.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel as specified below:

1. Train Owner's maintenance personnel on procedures and schedules for starting up and shutting down, troubleshooting, servicing, and maintaining cooling towers.
2. Review data in maintenance manuals. Refer to Division 1 Section "Contract Closeout."
3. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
4. Schedule training with Owner, through Architect, with at least seven days' advance notice.

END OF SECTION 230642

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SECTION 230713 – DUCT INSULATION

SECTION 230713 - DUCT INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes semirigid and flexible duct, plenum, and breeching insulation; insulating cements; field-applied jackets; accessories and attachments; and sealing compounds.

B. Related Sections include the following:

1. Division 23 Section "Pipe Insulation" for insulation of piping.
2. Division 23 Section "Equipment Insulation" for insulation materials and application for pumps, tanks, hydronic specialties, and other equipment.
3. Division 23 Section "Hangers and Supports" for pipe insulation shields and protection saddles.

1.3 SUBMITTALS

A. Product Data: Identify thermal conductivity, thickness, and jackets (both factory and field applied, if any), for each type of product indicated.

B. Shop Drawings: Show fabrication and installation details for the following:

1. Removable insulation sections at access panels.
2. Application of field-applied jackets.
3. Applications at linkages for control devices.

1.4 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of mechanical insulation products, of types and sizes required, whose products have been in satisfactory use in similar services for not less than 10 years.

B. Installer's Qualifications: Firms with at least 5 years successful installation experience on projects with mechanical insulation systems similar to that required for this project.

C. Flame/Smoke Ratings: Provide composite mechanical insulation (insulation, jackets, coverings, sealers, mastics and adhesives) with flame-spread index of 25 or less, and smoke developed index of 50 or less, as tested by ASTM E 84 (NFPA 255) method.

1.5 SCHEDULING

A. Schedule insulation application after testing duct systems. Insulation application may begin on segments of ducts that have satisfactory test results.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Armacell LLC
2. Certainteed Corp.
3. Foster Products Corp.
4. IMCOA
5. Johns Manville Products Corp.
6. Knauf Fiber Glass GmbH.
7. Owens-Corning Fiberglas Corp.
8. Pittsburgh Corning Corp.

2.2 INSULATION MATERIALS

A. Rigid fiberglass ductwork insulation shall conform to ASTM C 612, Class 1, 6.0 PCF density, 'R' = 6.6 @ 1.5" thickness, 75°F mean temperature.

B. Flexible fiberglass ductwork insulation shall conform to ASTM C 553, Type I, Class B-4, 0.75 PCF density, out of package 'R' = 5.1 @ 1.5" thickness, 75°F mean temperature differential.

C. Duct insulation cover shall be fiberglass reinforced foil and paper (Foil Scrim Kraft) jacket conforming with ASTM C 1136. Install per manufacturer's written instructions.

2.3 FIELD-APPLIED JACKETS

A. PVC Jacket: High-impact, ultraviolet-resistant PVC; 20 mils thick; roll stock ready for shop or field cutting and forming.

1. Adhesive: As recommended by insulation material manufacturer.
2. PVC Jacket Color: White or gray.

B. Aluminum Jacket: Deep corrugated sheets manufactured from aluminum alloy complying with ASTM B 209, and having an integrally bonded moisture barrier over entire surface in contact with insulation. Metal thickness and corrugation dimensions are scheduled at the end of this Section.

1. Finish: Stucco-embossed finish.
2. Moisture Barrier: 1-mil- thick, heat-bonded polyethylene and kraft paper.

2.4 ACCESSORIES AND ATTACHMENTS

A. Glass Cloth and Tape: Comply with MIL-C-20079H, Type I for cloth and Type II for tape. Woven glass-fiber fabrics, plain weave, presized a minimum of 8 oz./sq. yd.

1. Tape Width: 4 inches.

B. Bands: 3/4 inch wide, in one of the following materials compatible with jacket:

1. Galvanized Steel: 0.005 inch thick.
2. Aluminum: 0.007 inch thick.

C. Wire: 0.080-inch, nickel-copper alloy; 0.062-inch, soft-annealed, stainless steel; or 0.062-inch, soft-annealed, galvanized steel.

D. Weld-Attached Anchor Pins and Washers: Copper-coated steel pin for capacitor-discharge welding and galvanized speed washer. Pin length sufficient for insulation thickness indicated.

1. Welded Pin Holding Capacity: 100 lb for direct pull perpendicular to the attached surface.

2.5 VAPOR RETARDERS

A. Mastics: Materials recommended by insulation material manufacturer that are compatible with insulation materials, jackets, and substrates.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

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

3.3 GENERAL APPLICATION REQUIREMENTS

A. Apply insulation materials, accessories, and finishes according to the manufacturer's written instructions; with smooth, straight, and even surfaces; and free of voids throughout the length of ducts and fittings.

B. Refer to schedules at the end of this Section for materials, forms, jackets, and thicknesses required for each duct system.

C. Use accessories compatible with insulation materials and suitable for the service. Use accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Apply multiple layers of insulation with longitudinal and end seams staggered.

E. Seal joints and seams with vapor-retarder mastic.

F. Keep insulation materials dry during application and finishing.

G. Apply insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by the insulation material manufacturer.

H. Apply insulation with the least number of joints practical.

I. Apply insulation over fittings and specialties, with continuous thermal and vapor-retarder integrity, unless otherwise indicated.

J. Hangers and Anchors: Seal penetrations in insulation at hangers, supports, anchors, and other projections with vapor-retarder mastic. Apply insulation continuously through hangers and around anchor attachments.

K. Insulation Terminations: Seal ends with a compound recommended by the insulation material manufacturer to maintain vapor retarder.

L. Apply insulation with integral jackets as follows:

1. Pull jacket tight and smooth.
2. Joints and Seams: Cover with tape and vapor retarder as recommended by insulation material manufacturer to maintain vapor seal.
3. Vapor-Retarder Mastics: Apply mastic on seams and joints and at ends adjacent to duct flanges and fittings.

M. Cut insulation according to manufacturer's written instructions to prevent compressing insulation to less than 75 percent of its nominal thickness.

N. Install vapor-retarder mastic on ducts and plenums.

1. Overlap insulation facing at seams and seal with vapor-retarder mastic and pressure-sensitive tape having same facing as insulation. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-retarder seal.

O. Roof Penetrations: Apply insulation for interior applications to a point even with top of roof flashing.

1. Seal penetrations with vapor-retarder mastic.
2. Apply insulation for exterior applications tightly joined to interior insulation ends.
3. Seal insulation to roof flashing with vapor-retarder mastic.

P. Interior Wall and Partition Penetrations: Apply insulation continuously through walls and partitions, except fire-rated walls and partitions.

Q. Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire/smoke damper sleeves for fire-rated wall and partition penetrations.

R. Floor Penetrations: Terminate insulation at underside of floor assembly and at floor support at top of floor.

1. Taper termination and seal insulation ends with vapor-retarder mastic.

3.4 MINERAL-FIBER INSULATION APPLICATION

A. Flexible Fiberglass Applications for Ducts and Plenums: Secure blanket insulation with adhesive and anchor pins and speed washers.

1. Apply adhesives according to manufacturer's recommended coverage rates per square foot, for 100 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install anchor pins and speed washers on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

    a. On duct sides with dimensions 18 inches and smaller, along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
    b. On duct sides with dimensions larger than 18 inches. Space 16 inches o.c. each way, and 3 inches maximum from insulation joints. Apply additional pins and clips to hold insulation tightly against surface at cross bracing.
    c. Anchor pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
    d. Do not overcompress insulation during installation.

4. Impale insulation over anchors and attach speed washers.
5. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
6. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation segment with 1/2-inch staples, 1 inch o.c., and cover with pressure-sensitive tape having same facing as insulation.
7. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. Secure with steel band at end joints and spaced a maximum of 18 inches o.c.
8. Apply insulation on rectangular duct elbows and transitions with a full insulation segment for each surface. Apply insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
9. Insulate duct stiffeners, hangers, and flanges that protrude beyond the insulation surface with 6-inch- wide strips of the same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with anchor pins spaced 6 inches o.c.
10. Apply vapor-retarder mastic to open joints and breaks.

B. Rigid Fiberglass Applications for Ducts and Plenums: Secure board insulation with adhesive and anchor pins and speed washers.

1. Apply adhesives according to manufacturer's recommended coverage rates per square foot, for 100 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Space anchor pins as follows:

    a. On duct sides with dimensions 18 inches and smaller, along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
    b. On duct sides with dimensions larger than 18 inches. Space 16 inches o.c. each way, and 3 inches maximum from insulation joints. Apply additional pins and clips to hold insulation tightly against surface at cross bracing.
    c. Anchor pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
    d. Do not overcompress insulation during installation.

4. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
5. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation segment with 1/2-inch staples, 1 inch o.c., and cover with pressure-sensitive tape having same facing as insulation.
6. Apply insulation on rectangular duct elbows and transitions with a full insulation segment for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Apply insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
7. Insulate duct stiffeners, hangers, and flanges that protrude beyond the insulation surface with 6-inch- wide strips of the same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with anchor pins spaced 6 inches o.c.
8. Apply vapor-retarder mastic to open joints, breaks, and punctures for insulation indicated to receive vapor retarder.

3.5 DUCT SYSTEM APPLICATIONS

A. Insulation materials and thicknesses are specified in schedules at the end of this Section.

B. Materials and thicknesses for systems listed below are specified in schedules at the end of this Section.

C. Insulate the following plenums and duct systems:

1. Indoor supply ductwork.
2. Outdoor exposed supply and return ductwork.
3. Outdoor air intake duct.

D. Items Not Insulated: Unless otherwise indicated, do not apply insulation to the following systems, materials, and equipment:

1. Exposed supply ducts in conditioned space.
2. Return and exhaust air ductwork within building.
3. Metal ducts with duct liner.
4. Factory-insulated flexible ducts.
5. Factory-insulated plenums, casings, terminal boxes, and filter boxes and sections.
6. Flexible connectors.
7. Vibration-control devices.
8. Testing agency labels and stamps.
9. Nameplates and data plates.
10. Access panels and doors in air-distribution systems.

3.6 INDOOR DUCT AND PLENUM APPLICATION SCHEDULE

A. Service: Supply-air ducts, concealed, exposed and in mechanical rooms.

1. Material: Flexible fiberglass.
2. Thickness: 1-1/2 inches.
3. Insulation Cover: Yes.

B. Service: Outside-air ducts, concealed.

1. Material: Rigid fiberglass.
2. Thickness: 2 inches.
3. Insulation Cover: Yes.

3.7 OUTDOOR DUCT AND PLENUM APPLICATION SCHEDULE

A. Service: Supply-air ducts.

1. Material: Rigid fiberglass.
2. Thickness: 3 inches.
3. Field-Applied Jacket: Aluminum.

    a. Aluminum Thickness: 0.032 inch.

4. Vapor Retarder Required: Yes.

B. Service: Return-air ducts.

1. Material: Rigid fiberglass.
2. Thickness: 2 inches.
3. Number of Layers: One.
4. Field-Applied Jacket: Aluminum.

    a. Aluminum Thickness: 0.032 inch.

5. Vapor Retarder Required: Yes.

END OF SECTION 230713

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SECTION 230716 – HVAC EQUIPMENT INSULATION

SECTION 230716 - HVAC EQUIPMENT INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes blanket, board, and block insulation; insulating cements; field-applied jackets; accessories and attachments; and sealing compounds.

B. Related Sections include the following:

1. Division 23 Section "Duct Insulation" for insulation materials and application for ducts and plenums.
2. Division 23 Section "Pipe Insulation" for insulation for piping systems.

1.3 SUBMITTALS

A. Product Data: Identify thermal conductivity, thickness, and jackets (both factory and field applied, if any), for each type of product indicated.

B. Shop Drawings: Show fabrication and installation details for the following:

1. Field application for each equipment type.
2. Removable insulation sections at access panels.
3. Application of field-applied jackets.

1.4 QUALITY ASSURANCE

A. Manufacturer's qualifications: Fire regularly engaged in manufacturer of mechanical insulation products, of types and sizes required, whose products have been in satisfactory use in similar services for not less than 10 years.

B. Installer's Qualifications: Firms with at least 5 years successful installation experience on projects with mechanical insulation systems similar to that required for this project.

C. Flame/Smoke Ratings: Provide composite mechanical insulation (insulation, jackets, coverings, sealers, mastics and adhesives) with flame-spread index of 25 or less, and smoke developed index of 50 or less, as tested by ASTM E 84 (NFPA 255) method.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Ship insulation materials in containers marked by manufacturer with appropriate ASTM specification designation, type and grade, and maximum use temperature.

1.6 COORDINATION

A. Coordinate clearance requirements with equipment Installer for insulation application.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Armacell LLC
2. Certainteed Corp.
3. Foster Products Corp.
4. IMCOA
5. Johns Manville Products Corp.
6. Knauf Fiber Glass GmbH.
7. Owens-Corning Fiberglas Corp.
8. Pittsburgh Corning Corp.

2.2 INSULATION MATERIALS

A. Rigid fiberglass equipment insulation shall conform to ASTM C 612, Class 2, 6.0 PCF density, 'k' = 0.23 @ 75°F mean temperature. Cover insulation with pre-sized glass cloth jacketing material, not less than 7.8 ounces per square yard. Provide a trowel or glove grade water based general purpose mastic (white or light gray) suitable for interior or exterior applications. Install per manufacturer's written installation instructions.

B. Flexible Elastomeric Thermal Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type II for sheet materials.

1. Adhesive: As recommended by insulation material manufacturer.
2. Ultraviolet-Protective Coating: As recommended by insulation manufacturer.

2.3 FIELD-APPLIED JACKETS

A. PVC Jacket: High-impact, ultraviolet-resistant PVC; 20 mils thick; roll stock ready for shop or field cutting and forming.

1. Adhesive: As recommended by insulation material manufacturer.
2. PVC Jacket Color: White or gray.

B. Aluminum Jacket: Deep corrugated sheets manufactured from aluminum alloy complying with ASTM B 209, and having an integrally bonded moisture barrier over entire surface in contact with insulation. Metal thickness and corrugation dimensions are scheduled at the end of this Section.

1. Finish: Stucco-embossed finish.
2. Moisture Barrier: 1-mil- thick, heat-bonded polyethylene and kraft paper.

2.4 ACCESSORIES AND ATTACHMENTS

A. Glass Cloth and Tape: Comply with MIL-C-20079H, Type I for cloth and Type II for tape. Woven glass-fiber fabrics, plain weave, presized a minimum of 8 oz./sq. yd.

1. Tape Width: 4 inches.

B. Bands: 3/4 inch wide, in one of the following materials compatible with jacket:

1. Galvanized Steel: 0.005 inch thick.
2. Aluminum: 0.007 inch thick.

C. Wire: 0.080-inch, nickel-copper alloy; 0.062-inch, soft-annealed, stainless steel; or 0.062-inch, soft-annealed, galvanized steel.

D. Self-Adhesive Anchor Pins and Speed Washers: Galvanized steel plate, pin, and washer manufactured for attachment to duct and plenum with adhesive. Pin length sufficient for insulation thickness indicated.

2.5 VAPOR RETARDERS

A. Mastics: Materials recommended by insulation material manufacturer that are compatible with insulation materials, jackets, and substrates.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

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

3.3 GENERAL APPLICATION REQUIREMENTS

A. Apply insulation materials, accessories, and finishes according to the manufacturer's written instructions; with smooth, straight, and even surfaces; and free of voids throughout the length of equipment. Insulation shall be installed such that will allow free view of the equipment nameplates.

B. Refer to schedules at the end of this Section for materials, forms, jackets, and thicknesses required for each equipment system.

C. Use accessories compatible with insulation materials and suitable for the service. Use accessories that do not corrode, soften, or otherwise attack insulation or jacket in either the wet or dry state.

D. Apply multiple layers of insulation with longitudinal and end seams staggered.

E. Seal joints and seams with vapor-retarder mastic on insulation indicated to receive a vapor retarder.

F. Keep insulation materials dry during application and finishing.

G. Apply insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by the insulation material manufacturer.

H. Apply insulation with the least number of joints practical.

I. Apply insulation over fittings and specialties, with continuous thermal and vapor-retarder integrity, unless otherwise indicated.

J. Hangers and Anchors: Where vapor retarder is indicated, seal penetrations in insulation at hangers, supports, anchors, and other projections with vapor-retarder mastic. Apply insulation continuously through hangers and around anchor attachments.

K. Insulation Terminations: For insulation application where vapor retarders are indicated, seal ends with a compound recommended by the insulation material manufacturer to maintain vapor retarder.

L. Apply insulation with integral jackets as follows:

  1. Pull jacket tight and smooth.
  2. Joints and Seams: Cover with tape and vapor retarder as recommended by insulation material manufacturer to maintain vapor seal.
  3. Vapor-Retarder Mastics: Where vapor retarders are indicated, apply mastic on seams and joints and at ends adjacent to flanges and fittings.

M. Cut insulation according to manufacturer's written instructions to prevent compressing insulation to less than 75 percent of its nominal thickness.

N. Install vapor-retarder mastic on equipment scheduled to receive vapor retarders. Overlap insulation facing at seams and seal with vapor-retarder mastic and pressure-sensitive tape having same facing as insulation. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-retarder seal.

O. Insulate the following cold (below ambient) equipment:

  1. Refrigeration equipment, including chillers, tanks and pumps.
  2. Drip pans under chilled equipment.
  3. Cold water storage tanks.
  4. Cold and chilled water pumps.
  5. Pneumatic water tanks.

6. Roof drain bodies.
7. Air separators

P. Insulate the following hot (above ambient temperature) equipment:

1. Hot water storage tanks.
2. Heat exchangers.
3. Condensate receivers.
4. Hot water pumps.
5. Fuel oil heaters.
6. Air separators.

Q. Omit insulation from the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Manholes.
5. Handholes.
6. Cleanouts.

3.4 INDOOR TANK AND VESSEL INSULATION APPLICATION

A. Blankets, Board, and Block Applications for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.

1. Apply adhesives according to manufacturer's recommended coverage rates per square foot, for 100 percent coverage of tank and vessel surfaces.
2. Groove and score insulation materials to fit as closely as possible to the equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joint. Stagger end joints.
3. Protect exposed corners with secured corner angles.
4. Install adhesive-attached or self-adhesive anchor pins and speed washers on sides of tanks and vessels as follows:

   a. Do not weld anchor pins to ASME-labeled pressure vessels.
   b. On tank and vessel, 3 inches maximum from insulation end joints, and 16 inches o.c. in both directions.
   c. Do not over compress insulation during installation.
   d. Cut and miter insulation segments to fit curved sides and dome heads of tanks and vessels.

5. Impale insulation over anchor pins and attach speed washers.
6. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing
7. Secure each layer of insulation with stainless-steel bands.
8. Stagger joints between insulation layers at least 3 inches.
9. Apply insulation in removable segments on equipment access doors and other elements that require frequent removal for service.
10. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.

11. Apply vapor-retarder mastic to open joints, breaks, and punctures for insulation indicated to receive vapor retarder.

B. Flexible Elastomeric Thermal Insulation Applications for Tanks and Vessels: Apply insulation over entire surface of tanks and vessels according to the manufacturer's written instructions.

1. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
2. Seal longitudinal seams and end joints.

3.5 FIELD-APPLIED JACKET APPLICATION

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

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

B. Foil and Paper Jackets: Apply foil and paper jackets where indicated.

1. Draw jacket material smooth and tight.
2. Apply lap or joint strips with the same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Apply jackets with 1-1/2-inch laps at longitudinal seams and 3-inch- wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-retarder mastic.

C. PVC Jackets: Apply jacket with longitudinal seams along top and bottom of tanks and vessels for horizontal applications. Secure and seal seams and end joints with manufacturer's welding adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along the seam and joint edge.

D. Aluminum Jackets: Secure jackets according to jacket manufacturer's written instructions.

3.6 FINISHES

A. Glass-Cloth Jacketed Insulation: Paint insulation finished with glass-cloth jacket as specified in Division 9 Section "Painting."

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

3.7 FIELD QUALITY CONTROL

A. Inspection: Perform the following field quality-control inspections, after installing insulation materials, jackets, and finishes, to determine compliance with requirements:

   1. Inspect pumps and tanks randomly selected by Architect.

B. Insulation applications will be considered defective if sample inspection reveals noncompliance with requirements. Remove defective Work and replace with new materials according to these Specifications.

C. Reinstall insulation and covers on pumps and tanks uncovered for inspection according to these Specifications.

3.8 EQUIPMENT APPLICATIONS

A. Insulation materials and thicknesses are specified in schedules at the end of this Section.

B. Materials and thicknesses for systems listed below are specified in schedules at the end of this Section.

3.9 INTERIOR TANK AND VESSEL INSULATION APPLICATION SCHEDULE

A. Equipment: Chilled-water air separators and compression tanks.

   1. Operating Temperature: 35 to 75 deg F.
   2. Insulation Material: Flexible elastomeric.
   3. Insulation Thickness: 2”
   4. Field-Applied Jacket: Glass cloth.
   5. Vapor Retarder Required: Yes.

B. Equipment: Domestic hot-water storage tanks, not factory insulated.

   1. Operating Temperature: 55 to 140 deg F.
   2. Insulation Material: Mineral fiber.
   3. Insulation Thickness: 1-1/2”
   4. Field-Applied Jacket: Aluminum.

      a. Aluminum Thickness: 0.024 inch.

   5. Vapor Retarder Required: Yes.

C. Equipment: Heating hot-water air separators and compression tanks.

   1. Operating Temperature: 100 to 200 deg F.
   2. Insulation Material: Mineral fiber.
   3. Insulation Thickness: 2”
   4. Field-Applied Jacket: Foil and paper.
   5. Vapor Retarder Required: No.

D. Equipment: Heating hot-water heat exchangers and steam-to-water converters.

1. Operating Temperature: 100 to 450 deg F.
2. Insulation Material: Mineral fiber.
3. Insulation Thickness: 2"
4. Field-Applied Jacket: Glass cloth.
5. Vapor Retarder Required: No.
6. Finish: None.

3.10 INTERIOR FLAT-SURFACE EQUIPMENT INSULATION APPLICATION SCHEDULE

A. Equipment: Steam condensate receivers, not factory insulated.

1. Operating Temperature: 100 to 450 deg F.
2. Insulation Material: Mineral fiber.
3. Insulation Thickness: 2"
4. Field-Applied Jacket: Glass cloth
5. Vapor Retarder Required: No.
6. Finish: None.

3.11 PUMPS

A. Equipment: Chilled Water Pump Housing

1. Operating temperature 35 to 75 degrees F.
2. Insulation Material: Mineral-fiber board thermal insulation.
3. Insulation Thickness: 2".

END OF SECTION 230716

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SECTION 230719 – PIPE INSULATION

SECTION 230719 - PIPE INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes preformed, rigid and flexible pipe insulation; insulating cements; field-applied jackets; accessories and attachments; and sealing compounds.

B. Related Sections include the following:

1. Division 23 Section "Duct Insulation" for insulation for ducts and plenums.
2. Division 23 Section "Equipment Insulation" for insulation materials and application for pumps, tanks, hydronic specialties, and other equipment.
3. Division 15 Section "Hangers and Supports" for pipe insulation shields and protection saddles.

1.3 SUBMITTALS

A. Product Data: Identify thermal conductivity, thickness, and jackets (both factory and field applied, if any), for each type of product indicated.

B. Shop Drawings: Show fabrication and installation details for the following:

1. Application of protective shields, saddles, and inserts at pipe hangers for each type of insulation and hanger.
2. Attachment and covering of heat trace inside insulation.
3. Insulation application at pipe expansion joints for each type of insulation.
4. Insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
5. Removable insulation at piping specialties and equipment connections.
6. Application of field-applied jackets.

1.4 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of mechanical insulation products, of types and sizes required, whose products have been in satisfactory use in similar services for not less than 10 years.

B. Installer's Qualifications: Firms with at least 5 years successful installation experience on projects with mechanical insulation systems similar to that required for this project.

C. Flame/Smoke Ratings: Provide composite mechanical insulation (insulation, jackets, coverings, sealers, mastics and adhesives) with flame-spread index of 25 or less, and smoke developed index of 50 or less, as tested by ASTM E 84 (NFPA 255) method.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Ship insulation materials in containers marked by manufacturer with appropriate ASTM specification designation, type and grade, and maximum use temperature.

1.6 COORDINATION

A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 15 Section "Hangers and Supports."

B. Coordinate clearance requirements with piping Installer for insulation application.

C. Coordinate installation and testing of steam or electric heat tracing.

1.7 SCHEDULING

A. Schedule insulation application after testing piping systems and, where required, after installing and testing heat-trace tape. Insulation application may begin on segments of piping that have satisfactory test results.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Armacell LLC
2. Certainteed Corp.
3. Foster Products Corp.
4. IMCOA
5. Johns Manville Products Corp.
6. Knauf Fiber Glass GmbH.
7. Owens-Corning Fiberglas Corp.
8. Pittsburgh Corning Corp.

2.2 FIELD-APPLIED JACKETS

A. General: ASTM C 921, Type 1, unless otherwise indicated.

B. PVC Jacket: High-impact, ultraviolet-resistant PVC; 20 mils thick; roll stock ready for shop or field cutting and forming.

1. Adhesive: As recommended by insulation material manufacturer.
2. PVC Jacket Color:

a. In Penthouses (Room 462 and 467) and Mechanical Room 066 PVC jacket shall be colored. For color-coding comply with ASME A13.1.
b. For the rest of the piping: White or gray.

C. Standard PVC Fitting Covers: Factory-fabricated fitting covers manufactured from 20-mil-thick, high-impact, ultraviolet-resistant PVC.

1. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories for the disabled.
2. Adhesive: As recommended by insulation material manufacturer.

D. Aluminum Jacket: Factory cut and rolled to required sizes. Comply with ASTM B 209, 3003 alloy, H-14 temper.

1. Finish and Thickness: Smooth finish, 0.010 inch thick.
2. Finish and Thickness: Stucco-embossed finish, 0.016 inch thick.
3. Moisture Barrier: 1-mil-thick, heat-bonded polyethylene and kraft paper.
4. Elbows: Preformed, 45- and 90-degree, short- and long-radius elbows; same material, finish, and thickness as jacket.

2.3 VAPOR RETARDERS

A. Mastics: Materials recommended by insulation material manufacturer that are compatible with insulation materials, jackets, and substrates.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry pipe and fitting surfaces. Remove materials that will adversely affect insulation application.

3.3 GENERAL APPLICATION REQUIREMENTS

A. Apply insulation materials, accessories, and finishes according to the manufacturer's written instructions; with smooth, straight, and even surfaces; free of voids throughout the length of piping, including fittings, valves, and specialties.

B. Refer to schedules at the end of this Section for materials, forms, jackets, and thicknesses required for each piping system.

C. Use accessories compatible with insulation materials and suitable for the service. Use accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Apply insulation with longitudinal seams at top and bottom of horizontal pipe runs.

E. Apply multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Seal joints and seams with vapor-retarder mastic on insulation indicated to receive a vapor retarder.

H. Keep insulation materials dry during application and finishing.

I. Apply insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by the insulation material manufacturer.

J. Apply insulation with the least number of joints practical.

K. Apply insulation over fittings, valves, and specialties, with continuous thermal and vapor-retarder integrity, unless otherwise indicated. Refer to special instructions for applying insulation over fittings, valves, and specialties.

L. Hangers and Anchors: Where vapor retarder is indicated, seal penetrations in insulation at hangers, supports, anchors, and other projections with vapor-retarder mastic.

1. Apply insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor retarders are indicated, extend insulation on anchor legs at least 12 inches from point of attachment to pipe and taper insulation ends. Seal tapered ends with a compound recommended by the insulation material manufacturer to maintain vapor retarder.
3. Install insert materials and apply insulation to tightly join the insert. Seal insulation-to-insulation inserts with adhesive or sealing compound recommended by the insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect the jacket from tear or puncture by the hanger, support, and shield.

M. Insulation Terminations: For insulation application where vapor retarders are indicated, taper insulation ends. Seal tapered ends with a compound recommended by the insulation material manufacturer to maintain vapor retarder.

N. Apply adhesives and mastics at the manufacturer's recommended coverage rate.

O. Apply insulation with integral jackets as follows:

1. Pull jacket tight and smooth.
2. Circumferential Joints: Cover with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip and spaced 4 inches o.c.
3. Longitudinal Seams: Overlap jacket seams at least 1-1/2 inches. Apply insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4 inches o.c.

   a. Exception: Do not staple longitudinal laps on insulation having a vapor retarder.

4. Vapor-Retarder Mastics: Where vapor retarders are indicated, apply mastic on seams and joints and at ends adjacent to flanges, unions, valves, and fittings.
5. At penetrations in jackets for thermometers and pressure gages, fill and seal voids with vapor-retarder mastic.

P. Roof Penetrations: Apply insulation for interior applications to a point even with top of roof flashing.

1. Seal penetrations with vapor-retarder mastic.
2. Apply insulation for exterior applications tightly joined to interior insulation ends.
3. Extend metal jacket of exterior insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal metal jacket to roof flashing with vapor-retarder mastic.

Q. Exterior Wall Penetrations: For penetrations of below-grade exterior walls, terminate insulation flush with mechanical sleeve seal. Seal terminations with vapor-retarder mastic.

R. Interior Wall and Partition Penetrations: Apply insulation continuously through walls and floors.

S. Fire-Rated Wall and Partition Penetrations: Apply insulation continuously through penetrations of fire-rated walls and partitions.

1. Firestopping and fire-resistive joint sealers are specified in Division 7 Section "Firestopping."

T. Floor Penetrations: Apply insulation continuously through floor assembly.

1. For insulation with vapor retarders, seal insulation with vapor-retarder mastic where floor supports penetrate vapor retarder.

3.4 MINERAL-FIBER INSULATION APPLICATION

A. Apply insulation to straight pipes and tubes as follows:

1. Secure each layer of preformed pipe insulation to pipe with wire, tape, or bands without deforming insulation materials.

2. Where vapor retarders are indicated, seal longitudinal seams and end joints with vapor-retarder mastic. Apply vapor retarder to ends of insulation at intervals of 15 to 20 feet to form a vapor retarder between pipe insulation segments.
3. For insulation with factory-applied jackets, secure laps with outward clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets with vapor retarders, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by the insulation material manufacturer and seal with vapor-retarder mastic.

B. Apply insulation to flanges as follows:

1. Apply preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation segment the same as overall width of the flange and bolts, plus twice the thickness of the pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Apply canvas jacket material with manufacturer's recommended adhesive, overlapping seams at least 1 inch, and seal joints with vapor-retarder mastic.

C. Apply insulation to fittings and elbows as follows:

1. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When premolded insulation elbows and fittings are not available, apply mitered sections of pipe insulation, or glass-fiber blanket insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire, tape, or bands.
3. Cover fittings with standard PVC fitting covers.

D. Apply insulation to valves and specialties as follows:

1. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When premolded insulation sections are not available, apply glass-fiber blanket insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation. For check valves, arrange insulation for access to stainer basket without disturbing insulation.
3. Apply insulation to flanges as specified for flange insulation application.
4. Use preformed standard PVC fitting covers for valve sizes where available. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.
5. For larger sizes where PVC fitting covers are not available, seal insulation with canvas jacket and sealing compound recommended by the insulation material manufacturer.

3.5 FLEXIBLE ELASTOMERIC THERMAL INSULATION APPLICATION

A. Apply insulation to straight pipes and tubes as follows:

1. Follow manufacturer's written instructions for applying insulation.

2. Seal longitudinal seams and end joints with manufacturer's recommended adhesive. Cement to avoid openings in insulation that will allow passage of air to the pipe surface.

B. Apply insulation to flanges as follows:

1. Apply pipe insulation to outer diameter of pipe flange.
2. Make width of insulation segment the same as overall width of the flange and bolts, plus twice the thickness of the pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of the same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive. Cement to avoid openings in insulation that will allow passage of air to the pipe surface.

C. Apply insulation to fittings and elbows as follows:

1. Apply mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive. Cement to avoid openings in insulation that will allow passage of air to the pipe surface.

D. Apply insulation to valves and specialties as follows:

1. Apply preformed valve covers manufactured of the same material as pipe insulation and attached according to the manufacturer's written instructions.
2. Apply cut segments of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation. For check valves, fabricate removable sections of insulation arranged to allow access to strainer basket.
3. Apply insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive. Cement to avoid openings in insulation that will allow passage of air to the pipe surface.

3.6 FIELD-APPLIED JACKET APPLICATION

A. Apply PVC jacket where required, with 1-inch overlap at longitudinal seams and end joints. Seal with manufacturer's recommended adhesive.

B. Apply metal jacket where required, with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.7 FINISHES

A. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of the insulation manufacturer's recommended protective coating.

3.8 PIPING SYSTEM APPLICATIONS

A. Insulation materials and thicknesses are specified in schedules at the end of this Section.

B. Items Not Insulated: Unless otherwise indicated, do not apply insulation to the following systems, materials, and equipment:

1. Flexible connectors.
2. Vibration-control devices.
3. Fire-suppression piping.
4. Drainage piping located in crawl spaces, unless otherwise indicated.
5. Below-grade piping, unless otherwise indicated.
6. Chrome-plated pipes and fittings, unless potential for personnel injury.
7. Air chambers, unions, strainers, check valves, plug valves, and flow regulators.

3.9 FIELD QUALITY CONTROL

A. Inspection: Owner will engage a qualified inspection agency to perform the following field quality-control inspections, after installing insulation materials, jackets, and finishes, to determine compliance with requirements:

B. Insulation applications will be considered defective if sample inspection reveals noncompliance with requirements. Remove defective Work and replace with new materials according to these Specifications.

C. Reinstall insulation and covers on fittings and valves uncovered for inspection according to these Specifications.

3.10 INSULATION APPLICATION SCHEDULE, GENERAL

A. Refer to insulation application schedules for required insulation materials, vapor retarders, and field-applied jackets.

B. Application schedules identify piping system and indicate pipe size ranges and material, thickness, and jacket requirements.

3.11 HVAC AND PLUMBING PIPING INSULATION

A. The International Energy Conservation Code 2000 permits energy conservation using the IEC parameters or the parameters in ASHRAE 90.1 – 2001. For the purpose of pipe insulation thickness, Dartmouth College has chosen to adhere to the requirements of ASHRAE 90.1. If this is part of a project that requires a compliant statement from the designer, the IEC parameters may need to be followed depending if the designer is using the IEC for compliance measures. Insulate HVAC and plumbing piping systems with insulation according to the following schedules:

Pipe Insulation Systems			
Pipe Service	Location	Insulation Type	Insulation Cover
Steam	Building	Fiberglass	ASJ
Steam Condensate	Building	Fiberglass	ASJ
Chilled Water	Building	Fiberglass	ASJ
Condenser Water	Building	Fiberglass	ASJ
Domestic Hot Water	Building	Fiberglass	ASJ
City Water	Building	Fiberglass	ASJ
Refrigeration Piping	Building	Elastomeric	None
	Exterior	Elastomeric	Paint
Storm Water	Building	Fiberglass	ASJ
Cooling tower make-up water	Exterior above grade	Fiberglass	Aluminum Jacket and heat trace

Minimum Pipe Insulation Thickness - Fiberglass or Polyurethane							
Fluid Design Operating Temperature, °F	Conductivity Range (k) (Btu*in/(h*cf*°F)	*Nominal Pipe Diameter (inches)*					
		Runouts <2 diameter & 12' long	<1	1 -> <1-1/2	1-1/2-> <4	4 -> <8	≥8
251 -> 350	0.29-0.31	1.5	1.5	2.5	3.0	3.0	3.0
201 -> 250	0.27-0.30	1.5	1.5	1.5	2.0	2.0	2.0
141 -> 200	0.25-0.29	0.5	1.0	1.0	1.0	1.5	1.5
105 -> 140	0.24-0.28	0.5	0.5	0.5	1.0	1.0	1.0
61 -> 104		0	0	0	0	0	0
40 -> 60	0.23-0.27	0.5	1.0	1.0	1.0	1.0	1.0
<40	0.23-0.27	1.0	1.0	1.5	1.5	1.5	1.5

1. The Minimum Pipe Thickness chart shall be used for insulations with the scheduled 'k' values. Insulation thickness of insulation with 'k' values outside of the schedule (i.e. calcium silicate) shall be computed via the formula noted in ASHRAE Standard 90.1 - 2001.

B. Plumbing piping system insulation omitted on chrome plated exposed piping (except for handicapped fixtures), air chambers, unions, etc.

1. Special Application Requirements: Insulate interior above-ground horizontal storm water piping, 1" thickness.
2. Insulate all exposed piping under ADA compliant lavatories with a white, fitted anti-microbial pipe cover. Cover shall be designed to allow access to the stop valves. Lav Guard; Truebro, Inc

C. HVAC piping system insulation omitted on steam traps, on condensate piping between steam trap and union, hot piping within radiation enclosures or unit cabinets; on cold piping within unit cabinets provided piping is located over drain pan; and on unions, flanges, flexible connections, expansion joints and medium temperature chilled water branch piping to chilled beams where PEX piping is used.

1. Insulate low temperature refrigerant piping (liquid line) with 11/2" thick elastomeric insulation and cold condensate drains from refrigeration and air conditioning drain pans with 1" thick fiberglass insulation.

END OF SECTION 230719

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SECTION 230752 – HUMIDIFIERS

SECTION 230752 - HUMIDIFIERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following types of humidifiers:

1. Heat-exchanger humidifiers for application on ducted HVAC systems.

1.3 SUBMITTALS

A. Product Data: Include rated capacities, operating weights, furnished specialties, and accessories.

B. Shop Drawings: Detail fabrication and installation of humidifiers. Include piping details, plans, elevations, sections, details of components, and dispersion tubes.

1. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.
2. Coordination Drawings: Detail humidifiers and adjacent equipment. Show support locations, type of support, weight on each support, and required clearances.

C. Maintenance Data: For humidifiers to include in maintenance manuals specified in Division 1.

1.4 QUALITY ASSURANCE

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

B. Comply with ARI 610, "Standard for Central System Humidifiers for Residential Applications."

C. Comply with ARI 620, "Standard for Self-Contained Humidifiers for Residential Applications."

D. Comply with ARI 640, "Standard for Commercial and Industrial Humidifiers."

1.5 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Supply one replacement cylinder with each humidifier.

1.6 COORDINATION

A. Coordinate location and installation of humidifiers in ducts and air-handling units. Revise locations and elevations to suit field conditions and to ensure proper humidifier operation.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Heat-Exchanger Humidifiers:

a. Dri Steam
b. Armstrong International, Inc.
c. Nortec Industries, Inc.
d. Pure Humidifier Co.

2.2 GAS FIRED HUMIDIFIERS

A. Fabrication requirements:

1. Tank: 14–gauge 304–stainless steel with Heli–arc welded seams
2. Removable cover allowing easy access to probe assembly in the tank.
3. Easily accessible cleanout plate
4. Steam outlet on top of tank configured to connect to hose or pipe (GTS Models 100–200) or a flange (GTS Models 300–800).
5. Stainless steel round flue outlet to vent products of combustion. Humidifier shall be certified to use Class B flue materials.
6. Painted aluminum enclosure to protect all humidifier components. Enclosure shall have integral base with openings designed for moving with a fork lift or pallet jack.
7. Stainless steel heat exchanger with welded joints
8. Factory insulation: Humidifier shall be covered with 1"–thick (25 mm), rigid, foil–faced fiberglass insulation. All surfaces except front face panel shall have insulation.
9. Size: Units with capacities of 300 lbs/hr (136 kg/hr) or less shall be capable of fitting through a 36" (91 mm) door.

B. Water requirements: The humidifier shall be capable of generating steam from tap, softened or DI/RO water.

C. Drain: An electric drain valve shall be mounted on humidifier assembly to allow tank to drain automatically at the end of a humidification season (standard water models only).

D. Burner assembly:

1. Humidifier and burner assembly shall be CSA/AGA/CGA certified and tested to support natural or LP gas.
2. Gas train assembly shall be complete with burner/mixing tube assembly, igniter, sight glass, flame rod electrode, gas manifold, integral gas valve and venturi.
3. Each burner shall freely modulate or time proportion with a gas input turndown ratio of up to 4:1, and shall time–proportion below that threshold.

E. Integral water tempering device: A factory-installed thermostatically controlled water valve shall meter an amount of cold water into a stainless steel mixing chamber to temper 212 °F (100 °C) water with a 6 gpm (0.38 l/s) in-flow rate to a 140 °F (60 °C) discharge temperature to sanitary system.

2.3 HUMIDIFIER CONTROLS

A. Control sub-panel: Control sub-panel shall be factory attached to humidifier with all wiring between sub-panel and humidifier completed at factory. A wiring diagram shall be included.

B. Vapor-Logic3 microprocessor controller with the following features or functions:

1. Makeup water switch control and low water safety shutdown
2. Fully modulating (0% to100%) control of humidifier outputs
3. PID control capability
4. Self–diagnostic test at start–up
5. Integral fault relay for remote signaling of alarms
6. A keypad, capable of either unit or remote mounting with a 5' (1.5 m) cable, and able to operate within a temperature range of 32 °F to 122 °F (0 °C to 50 °C)
7. A keypad that provides text backlighting and allows personal password codes
8. A keypad capable of monitoring and/or controlling the following parameters:

   a. Relative humidity (RH) set point and actual conditions in the space (from humidity transmitter)
   b. Relative humidity (RH) set point and actual conditions in the duct for variable air volume applications (from duct humidity transmitter)
   c. Relative humidity (RH) high limit set point and actual conditions
   d. Total system demand in % of humidifier capacity
   e. Total system output in lbs/hour (kg/h)
   f. Drain/flush frequency interval and duration
   g. End–of–season drain status (on standard water systems and if ordered as a DI water option)
   h. Window glass surface temperature (in % RH offset application and if ordered as an option)

i. System alarms
j. Previous fault messages
k. Up to 20 humidifier functions, depending on programming
l. Operating temperature

9. User–adjustable water surface skim duration
10. Water level control for softened or hard water:

a. System shall provide for automatic refill, low water cutoff, field adjustable skimmer bleedoff functions and automatic drain–down of humidifier. System shall consist of:

1) A water level sensing unit comprised of three metallic probes screwed into a threaded probe head. Probe head shall incorporate probe isolation chamber to elminiate short-circuiting between probes caused by mineral coating of probe head. Probe heads shall be mounted on the humidifier assembly.
2) A solenoid operated fill valve factory mounted on the humidifier assembly
3) End–of–season drain

C. Temperature sensor: A factory mounted sensor, with a temperature range of –40 °F to 248 °F (–40°C to 120°C) shall be mounted on the humidifier to enable the following functions:

1. Maintain the evaporating chamber water temperature above freezing
2. Maintain a user–defined preset evaporating chamber water temperature
3. Allow rapid warm–up of water in evaporating chamber after a call for humidity, providing 100% operation until steam production occurs

2.4 HUMIDIFIER CONTROL OPTIONS

A. Control input accessory options:

1. Humidity transmitter, duct: Humidity transmitter shall be a duct–mounted device that measures from 0% to 100% RH range and provides a linear output (10% RH to 90% RH) from 4 mA to 20 mA. Accuracy ± 2% RH. Supply voltage 21 VDC. Operating temperature range: –4 °F to 140 °F (–20 °C to 60 °C).
2. Humidistat, on–off, high limit: Electric humidistat control shall be an off–on style, duct mounted with a control range of 15% to 95% RH. Compatible with 24, 120, 240 VAC. Operating temperature range 40 °F to 125 °F (4 °C to 52 °C).
3. Airflow proving switch, pressure type: Airflow proving switch shall be diaphragm–operated with pitot tube for field installation. Switch shall have an adjustable control point range of 0.05" wc to 12" wc (12.5 Pa to 2988 Pa) Operating temperature range –40 °F to 180 °F (–40 °C to 82 °C). Compatible with 24, 120 and 240 VAC.

2.5 HUMIDIFIER DISPERSION OPTIONS

A. Ultra–sorb® steam dispersion panel:

1. The factory assembled steam dispersion panel shall include the following components:

   a. Steam supply header/separator
   b. Condensate collection header
   c. Closely spaced steam dispersion tubes spanning the distance between the two headers

2. Each dispersion tube shall be fitted with two rows of steam discharge tubelets inserted into the tube wall, centered on the diametric line, and spaced 1 1/2" (38 mm) apart. Each tubelet shall be made of a thermal–resin material designed for high steam temperatures. The two rows of tubelets in each dispersion tube shall discharge steam in diametrically opposite directions, perpendicular to airflow.
3. Each tubelet shall extend through the wall of and into the center of the dispersion tube and contain a steam orifice sized for its required steam capacity.
4. The humidifier shall provide absorption characteristics that preclude water accumulation on any in–duct surface within 9" (229 mm) of the humidifier tube panel while maintaining conditions of 80% maximum relative humidity at a minimum of 55°F (13°C) in the duct airstream.
5. Air pressure loss across the humidifier panel shall not exceed 0.086" water column (21 Pa) at a duct air velocity of 1200 fpm (6 m/s).
6. Each packaged humidifier panel assembly of tubes and headers shall be contained within a galvanized metal casing to allow convenient duct mounting, or to facilitate the stacking of and/or the end–to–end mounting of multiple humidifier panels in ducts or air handler casings. When so designated, the humidifier panel shall be shipped unassembled.
7. All tubes and headers shall be 304 stainless steel and be Heli–arc welded.
8. Tubes shall be joined to headers with slip–fit couplings.

2.6 HEAT-EXCHANGER HUMIDIFIERS-STEAM TO STEAM

A. Description: Steam-to-steam heat exchanger, directly mounted under the duct or remotely mounted with connecting hose.

B. Housing: ASTM A 666, Type 316 stainless steel with stainless-steel lid, overflow fitting, and drain fitting.

C. Controls: Solenoid-fill and automatic drain valves shall maintain water level and temper hot drain water; field-adjustable timer shall control drain cycle for flush duration and interval.

1. Water-Level Controller: Mechanical float.

D. Dispersion Tube: Duct-mounting, single- or manifold-grid tube extending across entire width of duct; connected to heat-exchanger housing with flexible hose and equipped with mounting brackets for both ends of tube.

E. Dispersion Tube: Inverted U-tube when humidifier is directly mounted under the duct.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine ducts, air-handling units, and conditions for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before humidifier installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 HUMIDIFIER INSTALLATION

A. Install with required clearance for service and maintenance.

B. Seal humidifier dispersion-tube duct penetrations with flange.

C. Install dispersion tubes pitched to drain condensate back to housing.

D. Install drip leg upstream from steam trap, a minimum of 12 inches for proper operation of trap.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

1. Install piping adjacent to machine to allow service and maintenance.
2. Install shutoff valve and strainer in humidifier supply line.
3. Install backflow prevention device in humidifier supply line.
4. Connect piping with a minimum of 1-inch air gap in fill line to prevent backflow into supply line.

B. Install electrical devices furnished by manufacturer but not specified to be factory mounted.

C. Ground equipment.

1. 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 UL 486B.

3.4 FIELD QUALITY CONTROL

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

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove malfunctioning units, replace with new units, and retest.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.5 DEMONSTRATION

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

1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.
2. Review data in maintenance manuals. Refer to Division 1 Section "Contract Closeout."
3. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
4. Schedule training with Owner, through Architect, with at least seven days' advance notice.

END OF SECTION 230752

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SECTION 230861 – AIR FILTERS

SECTION 230861 - AIR FILTERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes factory-fabricated air-filter devices and media used to remove particulate matter from air for HVAC applications.

1.3 DEFINITIONS

A. DOP: Dioctyl phthalate or bis-(2-ethylhexyl) phthalate.

B. HEPA: High-efficiency particulate air.

C. ULPA: Ultra low penetration air.

1.4 SUBMITTALS

A. Product Data: Include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; furnished specialties; and accessories for each model indicated.

B. Shop Drawings: Include plans, elevations, sections, and details to illustrate component assemblies and attachments.

1. Show filter rack assembly, dimensions, materials, and methods of assembly of components.
2. Include setting drawings, templates, and requirements for installing anchor bolts and anchorages.
3. Wiring Diagrams: Power, signal, and control wiring.

C. Operation and Maintenance Data: For each type of filter and rack to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of air filters and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."

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

C. Comply with ARI 850.

D. Comply with ASHRAE 52. and ASHRAE 52.2 for method of testing and rating air-filter units.

E. Comply with NFPA 70 for installing electrical components.

F. Comply with NFPA 90A and NFPA 90B.

1.6 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

1.7 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Provide one complete set of clean filters for each filter bank upon substantial completion as well as a complete change for Owner's attic stock.
2. Provide one container of red oil for inclined manometer filter gage.
3. Provide matrix of project equipment and related filter size and type for inclusion in the Operation and Maintenance Manual.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

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

1. Air Filters and Filter-Holding Systems:
   a. AAF International.

b. Farr C0
c. Filtration Group.
d. Flanders Filters, Inc.
e. General Filters Inc.
f. International Air Filtration Corporation.
g. Koch Filter Corporation.

2. Filter Gages:

a. Airguard Industries, Inc.
b. Dwyer Instruments, Inc.

2.2 EXTENDED-SURFACE, DISPOSABLE PANEL FILTERS

A. Description: Factory-fabricated, dry, extended-surface filters with holding frames.

B. Media: Fibrous material formed into deep-V-shaped pleats with anti-microbial agent and held by self-supporting wire grid.

C. Media and Media-Grid Frame: Nonflammable cardboard

D. Duct-Mounting Frames: Welded, galvanized steel with gaskets and fasteners, and suitable for bolting together into built-up filter banks.

2.3 HIGH-EFFICIENCY FILTERS

A. Description: Factory-fabricated 95 percent DOP and HEPA filters with holding casing.

B. Media: UL 586, fibrous glass, constructed of continuous sheets with closely spaced pleats with vinyl-coated aluminum separators.

C. Frame Material: 3/4-inch- Aluminum.

D. Media to Frame Side Bond: Thermosetting sealant.

E. Face Gasket: Silicone.

2.4 SIDE-SERVICE HOUSINGS

A. Description: Factory-assembled, side-service housings, constructed of galvanized steel, with flanges to connect to duct system.

B. Prefilters: Integral tracks to accommodate 2-inch disposable.

C. Access Doors: Continuous gaskets on perimeter and positive-locking devices. Arrange so filter cartridges can be loaded from either access door.

D. Sealing: Incorporate positive-sealing gasket material on channels to seal top and bottom of filter cartridge frames to prevent bypass of unfiltered air.

2.5 FILTER GAGES

A. Description: Diaphragm type with dial and pointer in metal case, vent valves, black figures on white background, and front recalibration adjustment.

1. Diameter: 4-1/2 inches.
2. Range: Pressure range of each gauge shall be such that the operating pressure shall fall within the middle sector of the dial.

B. Manometer-Type Filter Gage: Molded plastic with epoxy-coated aluminum scale, logarithmic-curve tube gage with integral leveling gage, graduated to read from 0- to 3.0-inch wg, and accurate within 3 percent of full scale range.

C. Accessories: Static-pressure tips, tubing, gage connections, and mounting bracket.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install filter frames according to manufacturer's written instructions.

B. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.

C. Install filters in position to prevent passage of unfiltered air.

D. Install filter gage for each filter bank.

E. Install filter gage static-pressure tips upstream and downstream from filters to measure pressure drop through filter. Mount filter gages on outside of filter housing or filter plenum in an accessible position. Adjust and level inclined gages.

F. Coordinate filter installations with duct and air-handling unit installations.

3.2 FIELD QUALITY CONTROL

A. HEPA Filters: Pressurize housing to a minimum of 3.0-inch wg or to designed operating pressure, whichever is higher; and test housing joints, door seals, and sealing edges of filter for air leaks according to ASME N510 pressure-decay method.

3.3 CLEANING

A. After completing system installation and testing, adjusting, and balancing air-handling and air-distribution systems, clean filter housings and install new filter media.

END OF SECTION 230861

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SECTION 230913 – HVAC INSTRUMENTATION AND CONTRLS

SECTION 230913 - HVAC INSTRUMENTATION AND CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and General Provisions of the Contract, including General and Supplementary Conditions Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes control sequences for HVAC systems, subsystems and equipment.

B. Manufacturers:

1. Acceptable manufacturers of electronic and DDC controls are Honeywell and Johnson Controls.

1.3 SCOPE

A. Provide labor, materials, services, equipment and transportation necessary for complete and operational system of automatic temperature control and building management (i.e., DDC system), as indicated on Contract Drawings and specified herein.

B. This section covers the specification of control systems for heating, ventilating and air conditioning systems based on using DDC controls and electric actuators for all valve and damper operators, central fans and for temperature control of terminal equipment in non-laboratory spaces. All room temperature & volume control for laboratories will use Phoenix electric digital controls with electric actuators (LAC – Lab Air Controls).

C. Provide labor, materials, services, equipment and transportation necessary for complete and operational system of automatic temperature control and building management, as indicated on the Contract Drawings and specified herein, including but NOT limited to the following:

1. Controls for air systems including supply fans, heating coils, heat recovery devices, cooling coils, humidifiers, return fans, exhaust fans, and dampers.
2. Controls for variable volume air supply regulators (Lecture Hall).
3. Interface with lab supply air and fume hood exhaust volume and temperature control system so that all lab air flow data, temperatures, humidities and room equipment alarms are readable on the system workstation and system graphics.
4. Controls for inclusion of new chiller within existing chiller plant located at Proctor Hall including but not limited to new cooling tower, economizer heat exchanger, chilled water pumps, valves, sensors and meters.
5. Controls for hot water boiler plant and associated pumps, valves, sensors and meters.
6. Controls for building low temperature and medium temperature chilled water pumping.
7. Controls for space heating systems including, chilled beams, fan coil units and unit heaters.
8. Controls for space cooling systems including chilled beams and fan coil units.
9. Controls for air handling/heat recovery systems (other than those provided by fan mfg)

10. Control wiring and power wiring to control panels, actuators, and temperature controls by this section and interface wiring between BMS and LAC systems.
11. Equipment necessary to interface with existing Campus chilled water distribution including chilled water pumps, valves, meters and differential pressure sensors.
12. Furnishing of automatic control valves and dampers, pressure sensors, and sensor wells to be installed under SECTION 232113 PIPING.
13. Building Management System (BMS) including:

    a. Control of mechanical systems
    b. Monitoring
    c. Alarm
    d. Energy management
    e. Energy use reporting (ADD ALT)
    f. Calculation of data for custom reports (ADD ALT)
    g. Color graphics of floor plans and mechanical systems (ADD ALT)
    h. Totalization logs (ADD ALT)
    i. Historical trend logs

14. Control dampers
15. Motorized smoke dampers
16. Motorized combination fire/smoke dampers
17. Sleeves, escutcheons, seals, waterproofing, and similar devices
18. Hangers, anchors, guides, bases, and other supports
19. Access panels and access doors at duct mounted devices
20. System identification, including valve tags
21. Noise and vibration control
22. Seismic restraints, including equipment bolts and welding
23. Cleaning, lubrication, testing and adjusting, to satisfy this specification and to support balancing contract.
24. Coordination drawings
25. Record drawings
26. Operating and maintenance manuals
27. Instructions

1.4 SHOP DRAWINGS AND OTHER SUBMITTALS

A. Make preliminary submittal of two sets of control drawings to Engineer for review before shop drawings are submitted through normal channels. The purpose of this preliminary submittal is to save time. Include following information:

    1. Temperature control ranges
    2. Instrument zero and span ranges
    3. Transducer ranges
    4. Method of control
    5. Control devices selected
    6. Description of operation

B. Submit for review shop drawings for each item of material, equipment, and system component furnished or installed as part of the work of this Section.

C. Shop drawings shall include control layout and data on sensitivity, ranges, means of adjustment, means of calibration, and other data necessary for review of each device, its function and its intended application.

D. Devices on shop drawings shall be identified by numbers and letters. These identifiers shall also be used in description of operation, in control layouts, and on data sheets for ease in cross-referencing.

E. Shop drawings shall include motor efficiency data for three-phase motors 1 HP and larger, and power consumption data for all actuators.

F. Submit circuit coordination information for review by Engineer and Contractor, indicating circuit requirements by electrical panel, i.e., panel identification and maximum load of each circuit required for control system. Submittal will be returned indicating Engineer's final determination of panels and circuits to be used.

1. Furnish copy of final circuit determinations to DIVISION 16 contractor, for use in preparing panel directories. Information on circuits shall include control component and area served.

G. Furnish certificate from manufacturer of control system that expansion hardware and software shall be available for next 10 years.

H. Furnish drawing showing location plans and elevations of:

1. Building level controllers
2. Field and terminal unit controllers
3. Digital data cable
4. Connection to campus Ethernet

I. Furnish point schedule for each controller. Schedule shall include point designation, point description, system location, location of device being controlled, device manufacturer and model number.

J. Furnish instruction manual for review. Manual shall describe function and operation of all control and management system components and shall include trouble-shooting and operating procedures. Manual shall be easily understood, for use by Owner's personnel; shall show the total integrated control system; and shall include:

1. System description.
2. Control devices, including number, system, service, location, and normal position of each.
3. Information on sequencing of related devices.
4. Calibration charts and instructions.

K. Submit software manual to Owner, for review. Software manual shall describe programming and testing, including:

1. System overview, and detailed description of each software feature.

2. Instructions for user operation, including verifying status and errors, changing passwords, and initiating or disabling control programs.
3. Description of programming language including commands, editing and writing control programs, algorithms, printouts and logs, mathematical calculations and passwords.
4. Copies of application program software and documentation necessary for Owner to interpret program and make any changes desired.
5. Instructions for user programming or reprogramming any portion of DDC system including control programs, algorithms, mathematical equations, variables, setpoints, time periods, messages, and other information necessary to load, alter, test and execute DDC system.
6. Reference summary sheets that compare control programs with pertinent information about hardware and field wiring information.
7. Point identification including terminal number, symbol, engineering units and control program reference number.
8. Field information including DDC system control hardware and locations, device type and function, electrical parameters, and record drawing reference numbers.

L. Submit data summary forms to Owner for review. Forms shall define following information, for inclusion into DDC system, for each point in DDC system.

1. Description of each piece of equipment and the functions to be controlled.
2. For each DDC function, a listing of digital and/or analog hardware required to interface DDC system to equipment.
3. Listing of digital and analog alarms.
4. Listing of DDC system application programs associated with each piece of equipment. This listing shall include control algorithms and mathematical equations and shall be in easy-to-understand English format.

M. Upon completion of project, submit for review electric control shop drawings corrected for "as-built" conditions. Shop drawings shall include final pressure settings, temperature ranges, throttling ranges and temperature control settings. Three copies of accepted "record" shop drawings shall be furnished to Architect.

N. Submit a VHS-format videotape or DVD of instruction training. Videotape shall include training instructions given to Owner's personnel on their systems.

1.5 COORDINATION DRAWINGS

A. Before materials are purchased or work is begun, prepare Coordination Drawings showing size and location of mechanical pipes, ducts, equipment and appurtenances, relative to work of other trades.

B. Submit for review coordination drawings signed by following trades: sheet metal, plumbing, fire protection, electrical, and other HVAC trades. Drawings shall be composite construction floor plans, on mylar sepia transparencies.

C. Preliminary coordination drawings shall be prepared as follows:

1. First: Sheet metal trade shall prepare coordination drawings, minimum 1/4"=1' scale, to be used as composite construction floor plans for coordination of trades. Plans shall

show floor and ductwork layouts in detail, including ceiling heights, duct heights and sizes (including insulation), registers and diffusers, and light fixtures.

2. Second: As part of work of DIVISION 21, fire protection trade shall draw fire protection piping, etc., on coordination drawings prepared by sheet metal trade.
3. Third: As part of DIVISION 26, ELECTRICAL WORK, electrical trade shall draw electrical distribution conduits, wires, panels, and other electrical work which must be coordinated with other trades; on coordination drawings which have been prepared by fire protection trade.
4. Fourth: As part of work of DIVISION 22, plumbing trade shall draw waste piping, vent piping, water piping, risers and other plumbing work which must be coordinated with other trades; on coordination drawings which have been prepared by electrical trade.
5. Fifth: As part of work of DIVISION 23, HVAC trades shall draw HVAC piping work which must be coordinated with other trades; on coordination drawings which have been prepared by plumbing trade.
6. Each trade shall use a different color code.

D. Coordination Meeting and Drawing Revisions

1. Sixth: Contractor shall hold a coordination meeting with sheet metal, HVAC, fire protection, electrical and plumbing trades and shall resolve conflicts between trades. Coordination drawings are to assist in identifying trade conflicts.
2. Seventh: Sheet metal trade shall revise coordination drawings to reflect revisions to the various trade work (including sheet metal, HVAC, fire protection, electrical and plumbing trades), as determined by coordination meeting.
3. Eighth: Sheet metal, HVAC, fire protection, electrical and plumbing trades shall sign the revised coordination drawings as indication of their acceptance of the construction layout shown thereon.

E. Sheet metal trade shall submit the revised coordination drawings to Architect for review.

F. Coordination Drawings are for Contractor's and Engineer's use during construction and shall not be construed as replacing shop, "as-built" or record drawings required elsewhere in the Contract Documents.

1.6 CONTRACTOR QUALIFICATION REQUIREMENTS

A. Systems design and installation shall be by factory employees or by sub-contractors working under the supervision of factory representatives.

B. Bids from contractor purchasing equipment from wholesalers are NOT acceptable.

C. As requested, submit catalog data and letters or certificates from Owners of other buildings in which similar control systems have operated successfully as intended.

1.7 SERVICE

A. Provide necessary service, adjusting and checking of control and management systems, at no additional cost to the Owner, during 12-month period of guarantee.

1. This shall include service required to correct space temperature alarms and equipment control problems that are the result of control component malfunctions.
2. This shall include full system checkout and calibration during the 12th month of guarantee period.

B. Furnish service contract for Owner's consideration, which continues systems' service beyond the guarantee period. This is NOT part of the Construction Contract and is an extra cost to the Owner, at Owner's option.

1.8 INSTRUCTION TRAINING

A. Competent technicians shall provide 40 hours of instruction to the Owner's personnel (four technicians). Instructions shall include, but are NOT limited to, the following:

1. Familiarization with HVAC Control system, hardware and operation procedures.
2. Familiarization with Management System Hardware.
3. Use of management system.
4. Modifications of software packages.
5. Trouble-shooting and service procedures.
6. Operation of the Workstation software

PART 2 - PRODUCTS

2.1 CONTROL SYSTEM - GENERAL REQUIREMENTS

A. This project will be an interoperable combination of a Lab Air Control (LAC) system and a Building Management System (BMS) for non-lab areas. The LAC system will be completely visible to the BMS workstation or server provided for the College of Pharmacy project in this division. See specification section 230915 Lab Air Control System.

B. The LAC system will provide lab air pressure control in response to VAV hood use and temperature controls via reheat coils or increased exhaust flow to force more supply flow and match cooling loads. *In addition the LAC will provide 3 future control points in each lab (total six labs). In rooms with environmental chambers or freezers, these inputs will be furnished with a temperature sensor.* The LAC will connect digitally, or with discrete outputs to BMS for reporting these alarms.

C. The successful BMS bidder must provide a router or gateway to the successful LAC bidder, whether by means of a national standard interface such as BACnet (to Phoenix) or a custom gateway. This interface will occur in the MDF room, where the BMS workstation is located (known herein as the CMT or central monitoring terminal), or in some cases, on a campus HVAC server in the Boiler Plant (see below).

D. The points in the LAC to be *visible* in the BMS are: room setpoint and actual temperatures; room volume flows, offsets, and setpoints as well as supply, hood and general exhaust valve actuator signal (% open); room alarm inputs, air flow alarms and hood status (emergency hi-flow, standard flow, standby reduced flow, below design flow, energy waste flow - sash up with lights off). Room temperature and equipment alarm setpoints are to be adjustable, as well as the night override time and range of the room temperature adjuster.

E. Contract Drawings do NOT show every control device and every location. It shall be understood that Specifications are the primary guide to control requirements and that, unless specifically excluded, every piece of heating and cooling equipment shown on Contract Drawings requires controlling device controlled through the BMS.

F. Control system shall be complete in all respects including:

1. Room, insert and immersion thermostats and sensors.
2. Transmitters.
3. Relays.
4. Valves.
5. Dampers.
6. Control panels.
7. Electronic analog sensors: temperature, humidity, pressure, flow and/or others as required.
8. Digital controllers.
9. Central File Server (CFS).
10. Transmission power supply.
11. Operators' terminal and printers (existing vendors).
12. Control wiring.
13. Auxiliary devices and accessories.
14. Interface with fire alarm system.
15. Modem/telephone interface and associated software
16. Campus network interface

G. Electronic monitoring system shall be UL listed or ETL approved.

H. Expansion capabilities

1. As provided, system shall be capable of being expanded as follows. (This is not spare capacity to be provided, but is capability of adding points.) L1Cs are building level controllers. L2Cs are field equipment controllers:

   a. Number of L1Cs may be doubled.
   b. Number of L2Cs may be doubled.
   c. Number of L2Cs served by each L1C location may be increased 25%.
   d. Number of fieldbus channels on each L1C may be increased by one.

2. Expansion shall be possible without replacing or physically modifying CMT/CFS.

I. Sequencing shall be accomplished by selection and adjustment of proper actuator span and zero ranges for damper and valve operators or separate outputs for sequenced control outputs.

J. Provide power and control wiring, conduit, junction boxes, fittings and other electrical appurtenances that are required for complete and operational control and monitoring systems; conform to electrical standards, codes and requirements specified under DIVISION 26, ELECTRICAL WORK. Power for control system will be obtained from "standby" power panels only. This work shall include:

1. Wiring of control and monitoring devices and circuits carrying voltages up to and including 120 V, unless otherwise indicated.
2. Wiring of 120 VAC power feeds to temperature control panels, CPU, digital controllers, printer, and other control system equipment.
3. Wiring required for interfacing with building fire alarm, security and emergency generator systems; including wiring between DDC panels and fire alarm system panels.
4. Wiring of control system including wiring from sensors to panels, wiring from panels to CPU, and wiring from CPU to operator's terminal.
5. Wiring to "Auto" side of hand-off-auto switches on units being controlled as part of work of this Division.
6. Wiring of devices controlled as part of the work of this Division, whether furnished under this Division or another Division. Examples of devices include: alarm device, relay, solenoid valve, actuator, and electro-mechanical device at control cabinet.
7. Wiring of devices providing control inputs, whether furnished under this Division or another Division. Examples of devices include: smoke detector contact; fire alarm relay contact; pressure, temperature, limit level, and motion switches; PE switch; and analog sensor.
8. Wiring from temperature control panel to terminal strips.
9. Wiring between panel terminal strips and field-mounted devices.

K. For bidding purposes, unless otherwise indicated, closest appropriate emergency electrical panel shall be assumed to have circuit(s) available for control system use. Coordinate selection of circuits for control system use, by special submittal; refer to paragraph.

L. Provide standby power to control and monitoring devices as indicated in drawings and as specified herein; coordinate with work of Division 23 to ensure that all power feeds to control system components come from standby power panels.

M. Power wiring installed and terminated as part of the work of DIVISION 26, ELECTRICAL WORK, shall include:

1. Wiring of devices and circuits carrying voltages GREATER than 120 V, unless otherwise indicated.
2. Wiring of power feeds to disconnects, starters and electric motors.
3. Wiring from disconnects to equipment motor starters.
4. Wiring from equipment motor starters to equipment motors.

N. All wiring provided under this section shall be installed in conduit. No exception allowed.

2.2 TRANSMISSION NETWORK

A. Automatic system shall have multi-drop digital transmission network that provides communication link between operator's terminal and all DDC panels.

B. System shall have error-checking feature to ensure signal reliability and shall identify signal transmission network failures. System shall ensure signal quality and strength. System shall support multiple multi-drop trunks.

C. All multi-drop trunks shall be interfaced to the system via standard EIA interface.

D. Transmission network shall be run in conduit or shall be shielded cable. Wiring shall NOT be run in same conduit with fire alarm, security, lighting, building power or other dedicated systems. Where exposed and for ceiling to wall sensor drops within walls, cable will be in conduit.

E. High-level transmission network between L1C panels shall be minimum 10 megabit/sec. rate.

2.3 ISOLATION AND SEISMIC RESTRAINT

A. Seismic restraint shall be provided on following piping systems at turns of more than 4 feet and throughout entire run; where piping is supported by hangers longer than 12", as measured from top of pipe to bottom of supporting structure. Restraint type and maximum spacing of restraints shall be as noted in Pipe Seismic Restraint Schedule in SECTION 230548.

B. Seismic restraint shall be provided on control equipment. Vibration isolation shall be provided on control equipment where indicated. Isolation and restraint device types and minimum deflection shall be as noted in Equipment Seismic Restraint & Vibration Isolation Schedule in SECTION 230548.

2.4 DAMPERS

A. Provide control dampers not furnished with each fan system, to allow effective modulation or close-off of airflow as required.

1. Dampers shall be low leakage design, with seals along both edges and ends of damper blades to provide tight closure. Air leakage of damper when in closed position shall NOT exceed 4.5 cfm/sf in 4'x4' size at 4" w.g. differential pressure.
2. Modulating dampers shall be sized for design velocities of 1500 fpm through free area of damper at maximum system air flows.
3. Two-position dampers shall have parallel blade linkage; modulating dampers shall have opposed blade linkage. Dampers shall be arranged for normally open or normally closed operation as required. Linkage shall be serviceable without removal of entire damper.
4. Damper construction shall be suitable for damper operation at maximum fan pressure, without failure, binding or distortion.
5. Dampers for outdoor air shall be insulated. Insulated dampers shall be constructed of aluminum with expanded polyurethane in blades (R=2.2 min.) and a thermally broken, polystyrene filled frame. Blade & frame seals shall be extruded silicone. AMCA certified air leakage rate shall not exceed 4.1 cfm @ 4" wg (standard air). Dampers shall be manufactured to the actual opening, do not safe off the opening to use stock sizes. Subject to compliance with requirements, provide dampers of one of the following: Tamco series 9000 BF.

B. Damper frames shall be either galvanized steel or aluminum, constructed to facilitate field assembly. Frames shall have openings or mounting clips which allow secure fastening of frame to surrounding ductwork, duct collar or fan housing.

C. Damper blades shall be airfoil style, either galvanized steel or aluminum, with maximum blade length of 48□ in any section unless specifically listed by the manufacturer for the applicable duct pressure class and velocity. Blades shall have suitable bearings for smooth operation and shall be interconnected to provide unison operation.

D. Provide stiffening or bracing for frame sections over 48" high.

E. Dampers in air handling units shall be provided by Unit manufacturer, actuators shall be provided under this section.

2.5 DAMPER ACTUATORS

A. Electric actuators shall have non-overloading motors, shall meet the selection requirements specified for the damper size and type, and shall be direct drive by Belimo or acceptable equivalent.

B. Actuators associated with outdoor air shall have fail-closed devices and reversible rotation.

C. Actuators shall be furnished with end switches and adjustable zero and span where required.

D. Actuator sizing and quantity shall be determined by control manufacturer:

1. As needed to meet system requirements.
2. As needed to provide sufficient power for smooth modulation over entire range.
3. As needed to be able to open or close damper without binding or damage, at pressure differential up to 4" w.g. for low pressure systems and up to 8" w.g. for medium and high pressure systems.

E. Provide actuator for each damper over four feet in length or height.

F. Assembly shall include necessary mounting hardware and brackets.

2.6 AUTOMATIC CONTROL VALVES - GLOBE/BALL TYPE

A. Provide automatic temperature control valves for services as indicated on Contract Drawings. Valves shall be normally open, normally closed two-way or mixing type, as required. Unless otherwise noted, valves shall be as follows:

1. Valves 2" and smaller: Characterized ball valve, 400# WOG, bronze body, stainless ball and stem, pressure and temperature ports, reinforced PTFE seats & seals, screwed ends, 250 °F rating, 200 psig close-off pressure, and a max DP rating of not less than 50 psig: Belimo CCV or Delta SoftTouch up to 3" size.
2. Valves 4" and larger: ANSI Class 150, globe type, steel body, bronze trim, flanged ends.

B. Valve design shall allow disassembly of valve top, inspection, and replacement of packing without system shutdown or valve body removal.

C. Provide following accessories:

1. Valve stem packing: low friction, tight sealing, of material and pressure rating suitable for service.
2. Valve stems and balls of stainless steel up to 3"
3. Valve stems of polished stainless steel or Monel, for valves 4" and larger.
4. Valve actuators: suitable and sized for closing against system differential pressure.

D. Provide hot water coil valves & chilled water coil valves:

1. In general, valves shall be two-way modulating ball type, equal percentage valves with characterized equal percentage throttling ball, selected to have pressure drop between 4 psig and 6 psig at maximum design flow (approximately equal to coil pressure drop).
2. Where indicated, valve shall be three-way modulating type, equal percentage valve with throttling ball, selected to have pressure drop between 2 psig and 5 psig at maximum design flow.
3. Valves shall have close-off rating suitable for minimum differential pressure of 50 psig. Insofar as possible, valves on same pump system shall have approximately same pressure drop. Higher-pressure drops are permitted on valves nearest to pump (up to 50% of system pressure drop on systems with total pump head over 45 feet).
4. Hot water coil valves and Chilled water coil valves shall fail in their current position.

E. Hot water valves serving perimeter heating shall fail open; chilled water terminal valves will fail to current position.

F. Reheat water valves shall be normally closed to coil or shall be floating control type that remains at last position.

G. Provide steam valves; normally closed for humidifiers and reheat coils, normally open for other applications. Valves shall be single seated, modulating type with lineal characteristics.

1. When full load steam requirement exceeds 400 lbs/hr, provide two valves in parallel, sized for one-third and two-thirds of total unit load capacity or a single high turndown, industrial quality characterized ball valve.

2.7 AUTOMATIC CONTROL VALVES - BUTTERFLY TYPE

A. Automatic butterfly style control valves shall be industrial grade control valves, supplied by control manufacturer. Valves for chilled water and high-pressure hot water systems shall have 285 psi pressure rating; valves for low pressure chilled or hot water systems shall have 200 psi pressure rating. Two-position valves shall be line size.

B. Valves for standard service shall be lug type, for use with weld neck ANSI 125/150# flanges, with ductile iron body, ductile iron or aluminum bronze disc, stainless steel stem, EPDM seat, and elastomer parts: MCC-Centerline "Series LT" or acceptable equivalent by Jamesbury, DeZurick, Fairbanks, Keystone, Posi-Seal, Belimo, Johnson or Honeywell.

C. Valves for modulating service shall be Norris "R Series" or Alpha-Laval Saunders Type "RS" with wide-open Cv low enough to produce a 3-5 psi pressure drop at full design flow or as needed for the particular application.

D. Actuators for valves shall fail to existing position, electrically operated, quarter turn type. Actuator shall be sized to provide tight shutoff against differential pressure of 60 psig.

E. Valve control switches:

1. For each modulating control valve, provide manual control station with "auto-manual" selector switch and with valve position control potentiometer, to regulate branch signal to valve operator.
2. For each two-position control valve, provide remote-mounted "auto-open-closed" selector switch.
3. Switches shall be in enclosed panel boxes with lockable-hinged covers. Control boxes shall be located within controller panels.

2.8 LOW TEMPERATURE DETECTION (MANUAL RESET)

A. Provide low temperature protection thermostats in air systems for each hot water coil, and chilled water coil. Thermostats shall be non-averaging type, and either manual or automatic reset as indicated.

B. Thermostat capillary shall have minimum sensitive length of 20 feet, and shall be installed in serpentine fashion downstream from heating coil or upstream of cooling coil it is protecting.

1. Each square foot of coil shall be protected by a section of thermostat capillary.
2. Where large coil size or multiple coil construction exceeds the limit of coverage of one unit, provide additional units placed in series so that coil area coverage is maintained.

C. Upon detecting a coil leaving temperature below its setpoint, thermostat shall stop fan, close outside air damper and enable heating valves to associated coil to maintain minimum MAT.

2.9 ELECTRONIC TRANSMITTERS AND SENSORS

A. Sensors or switches cannot contain mercury.

B. Electronic Temperature Transmitters: shall be solid state; RTD, thermistor or IC type which transmit electric analog signal to DDC panel; shall have proper range and accessories to transmit temperature value to DDC panel with accuracy of ±1°F; shall be field calibrated, wired between point of sensing and DDC panel.

C. Space Temperature Sensors: shall have cover of brushed aluminum or plastic, as accepted by Architect; with PC data ports and temperature readouts on all models.

1. Offices and Prep rooms and research labs will have a ±4 °F adjustment range and night override switch.
2. Classrooms, conference areas, teaching labs and other areas occupied by students will have a ± 2 degree adjustment range and night override switch.
3. Sensors in public unoccupied spaces such as lobbies and corridors will have no adjustment or override control.
4. Rooms with occupancy sensors that input to BMS, will use them for night override control.

D. Duct Temperature Sensors: shall be mounted in main airstream as required for best temperature control; with cover with hole and plug to permit insertion of 1/8" test thermometer; of length appropriate to situation. Sensors used on coils shall have extended length.

E. Pipe Immersion Temperature Sensors: shall have stainless steel immersion well and accessories. When installed on inlet and outlet of heat exchanger or supply-return for BTU monitoring, sensors shall be selected from the same manufacturing run, certified to read within ±0.1°F of each other.

F. Space or Duct Relative Humidity Sensors: shall be accurate to ±3% when compared to accurate reference psychrometer, from 20% RH to 80% RH (higher or lower precision may be required in some locations). Sensors by Mamac or Vaisala.

G. Space or Duct Dew Point Temperature Sensors: CO_2 based moisture sensor directly reading dew point or Humidity Ratio, with In-field NIST calibration capability, 15 year life, 32-120°F operating dry bulb range, 0 to 80°F dew point range, +/-3.6°F accuracy to a certified reference. Teleaire Vaporstat, M/N 9002, by GEsensing.com.

H. High Pressure Transducers for water or air shall have analog signal transmitter, temperature compensated, with integral signal conditioning, full range span and offset adjustments; Ashcroft K1, Setra 206/207, Mamac PR-264 or acceptable equivalent with ±0.5% accuracy.

I. Differential Pressure Transmitters for AIR differential pressure (such as air velocity pressure in ducts) and for air static pressure (such as pressure in ducts up to 3" w.g.) shall be a dedicated DP sensor. Using two pressure sensors and calculating the pressure differential will not be accepted:

1. Transmitters shall be sized for the application range. Combined static error (RMS of non-linearity, non-repeatability and hysteresis) shall be less than ±1% of full range output.
2. Transmitter shall be Modus #T40, Ashcroft #XLDP, Setra #C-264, Robinson-Halpern #157, Mamac #PR-274, or acceptable equivalent; mounted on surface isolated from fan vibrations.

J. Low Pressure Transmitters for Liquid differential pressure:

1. Transmitters shall have accuracy of ±0.25%; shall be capable of withstanding system pressure applied to one port with no pressure on other port; shall be Setra #230, Mamac #PR-284, or Robinson-Halpern 250C.
2. Provide three-valve manifold to simplify calibration. Provide mounting suitable to relieve stress on tubing and sensing transducer.

K. Liquid Flow Switch: shall be vane- or disc-operated flow switch with SPDT contacts; W.E. Anderson "Model V6 Flotect" or Thomas Products "Model 1100". Switch shall be sealed from liquid with magnetic linkage; components exposed to liquid shall be non-corrosive. Switch shall be full pipe size.

L. Liquid Level Sensor:

1. Sensor shall provide continuous output signal indicating liquid level. Sensor shall have appropriate range, zero, and materials suited to the application. Sensor shall be accurate to ±0.75 inch and shall be temperature compensated from 32°F to 110°F. Sensor shall have programmer/calibrator unit if unit is required to set zero and span.

2. Sensor may be submersible pressure type, ultrasonic type, RF type, capacitive probe type, or other type acceptable to Engineer.

M. Occupancy Sensors: (Provided under Division 26 except as noted)

1. Sensor shall be ceiling-mounted low voltage, ultrasonic or infrared occupancy sensor; with sensitivity control to compensate for installation conditions.
2. Vendor shall determine, and Contractor shall provide, adequate quantity and distribution of sensors to ensure entire space is covered per manufacturer's recommendations.
3. Sensors within a control zone shall report as one input to DDC system. BMS will use the delay logic in the occupancy sensor but be capable of adding an adjustable delay before changing the HVAC setpoints to the night values.

N. Air Quality Sensor (Carbon Dioxide Sensor): shall be carbon dioxide concentration sensor with 0-2000 ppm range and 4-20 mA output: Telaire #8002W wall-mounted sensor with display, Telaire #8001D duct-mounted sensor, Teleaire 2051 outdoor air sensor or equal by Alta Labs, MSA, or General Eastern with a sensing range of 0-2500 ppm (max) and an accuracy of ±50 ppm and 5 year drift warranty. Include 1 calibration kit.

O. Liquid Flow Meters, for chilled water, hot water systems: Furnish meters for installation under SECTION 15500, HVAC TRADE WORK. All meters shall be same type and shall be mounted as recommended by manufacturer. Unless otherwise specified, meters shall be one of following types:

1. Paddlewheel flow sensor of "wet tap" type; suitable for application pressure and temperature; with insertion tool and appropriate transmitter to DDC panel; with accuracy of ±1.5% of full scale, ±1% linearity, ±0.3% repeatability: Data Industrial #SDI, Great Lakes Instruments #1172FO, Flow Research #TR-500, or George Fischer/Signet #MK1500.

P. AC Watt Transducer: Provide three-phase transducer with input current transformer, suitable voltage current and power ratings, and output suitable for connection to DDC system. Accuracy shall be ±0.5% at rated output including power factor, linearity, repeatability, calibration, and current sensor. Unit shall be Ohio Semitronics #PC-5, Load Controls #PH3A or #PH-1000, or acceptable equivalent.

Q. Water Differential Pressure Switch: shall be rated for working pressure range of 10-350 psig; with adjustable setpoint on increasing differential of 10-300 psi: Honeywell #P606A, Whitman #P845, or acceptable equivalent.

R. Water Condensation Switch will be a pipe-bottom mounded device to detect the formation of condensed liquid water on the bottom of the supply line to cooling radiant ceiling panels (RCPs). Flakt Woods Model QF2C-08-01 or equivalent by others.

S. AC Current Sensor & Switch: Current transformer with built in 4-20 ma/ 0-10 vdc transducer for variable speed motor loads or switch with setpoint adjustment for constant speed loads with ±2.0% accuracy. Veris Industries Inc, Hawkeye H-721/H-921 sensor, H-708/H-908 switch or acceptable equivalent.

T. Airflow Measurement Sensor:

1. Provide probe-type multi-point electronic sensors for high turn down applications or pitot tube sensors where 3:1 turndown is adequate, with spacing as required in ASHRAE duct traverse standard. Multiple probe pitot type sensors shall be manifolded to provide a single total pressure and a single static pressure to a differential pressure transmitter specified under paragraph.
2. Flow probes for fan inlets shall be Ebtron Gold series or Tek Air Vortek VT-7000 series with minimum of a 5:1 turndown and Air Monitor "Voluprobe FI", Paragon #FE-1050, or acceptable equivalent where 3:1 turndown is adequate. Flow probes for duct mounting shall be same manufacturers duct models with proper turndown range.
3. Flow probes for minimum outdoor air dampers and shall be Ruskin IAQ-50 (integrated with damper), Trane Traq, Air Monitor OAM, Tek-Air IAQ-Tek or Ebtron Gold series.
4. Flow probes for main fume hood exhaust system will be Air Monitor Voluprobe 3 or equal stainless steel pitot-type flow station, by Tek-Air or Ultratech Industries.

U. Duct Static Pressure Probe: shall be Air Monitor "Stat-Probe I", Paragon #PE-5000, or acceptable equivalent. Space Static Pressure Sensors: shall be Air Monitor "Type S.A.P./3" or acceptable equivalent, designed for recessed ceiling mounting. Elements shall have multiple sensing ports, pressure impulse suppression chamber, air velocity shielding and 12-gauge stainless steel casing. Sensor shall be capable of sensing pressure in sensor's vicinity to within 1% of actual pressure value, when subjected to airflow rate of 1000 fpm from 360° radial source.

V. Outdoor Static Pressure Probe: shall be accurate to 1% when subjected to 360° radial wind velocities of up to 80 mph; Air Monitor #SOAP, Ultratech #ORS, or acceptable equivalent. Probe will serve as a reference for space static pressure sensors.

W. Analog sensors shall be compatible with systems specified, carefully selected for the required span.

X. All sensor wiring - analog or digital, input or output - shall be capable of sharing single conduit runs without affecting signal performance. Sensor wiring shall be capable of sharing single conduit runs with switched 120 VAC or 240 VAC. If this is NOT possible, provide separate conduits for sensor wiring, to ensure signal integrity.

Y. Steam Meters: Insertion vortex meter with no moving parts and transmitter for 0-10 vdc or 4-20 ma input to BMS. For 8" main LP steam line meter will have a range of 2200-16,00 pounds per hour with an accuracy of 1.5% of rate. Hot tap type, EMCO Insertion Vortex Model V-Bar, or equal.

Z. Steam Condensate Meters: In-line vortex meter with no moving parts and transmitter for 0-10 vdc or 4-20 ma input to BMS. Pressure rating 75 psig, temperature rating 325°F. EMCO Inline vortex meter, Type PhD with reduced line size for 110% of expected flow (approx 1").

2.10 ELECTRIC VAV BOX ACTUATORS

A. Quarter turn operators using floating control signal for the VAV box volume damper, with torque required by the box manufacturer by Belimo or equal.

B. Provide power and control wiring, as necessary, to operate the VAV box air volume controllers and actuators.

C. Minimum stop adjustments shall be set or reset via software.

2.11 SMOKE DETECTION

A. As part of work of DIVISION 26, ELECTRICAL WORK: Two smoke detectors shall be furnished and wired for each air system rated above 15,000 cfm and for each air system so indicated on Contract Drawings. One smoke detector shall be furnished and wired for each air system rated between 2,000 cfm and 15,000 cfm.

B. Installation of smoke detectors in the air systems, (first) one on discharge side of supply fan and (second) one in return/exhaust airstream, shall be done as part of work of DIVISION 23.

C. As part of work of this Section, provide wiring from smoke detectors to DDC system so that, when a detector serving a particular system senses smoke, DDC system shall:

1. Indicate alarm condition at DDC system console.
2. Stop that system's supply, return and exhaust fans.
3. Close that system's outside air intake and exhaust dampers.
4. For systems with supply air quantity of 15,000 cfm or more: Close that systems return and discharge fire/smoke damper.

D. Detector installation and control action shall be strictly in accordance with NFPA 90A.

2.12 FLOW MONITOR DEVICES

A. For Air Systems: Provide airflow measuring devices, for each Lab Exhaust system duct as required to accomplish Sequence of Operation and monitoring, as shown.

B. Refer to paragraph 2.9 ELECTRONIC TRANSMITTERS AND SENSORS.

2.13 CONTROL CABINETS

A. Control cabinets shall be fully enclosed, all metal construction. Cabinets shall have hinged door with full piano hinges or heavy duty concealed hinges, with locking latch or bolt-on cover plate, and with work light and switch. All cabinet locks shall be common keyed. Cabinets shall be finished with two coats of enamel paint.

B. Indicating devices and manual adjustment devices required for routine operation of system shall be located on cabinet door or cover plate. Other devices shall be located on sub-panel within cabinet.

C. Cabinets shall have ample room for control device mounting and wiring.

D. Cabinets shall house control apparatus, relays, I-P transducers, EP and PE switches, gauges and other items specified.

2.14 SYSTEM ARCHITECTURE

A. Field Bus:

1. The Field Bus supports local control units of modular size for operation of the building's HVAC system. This RS485 (or ARCnet) bus shall operate at a minimum speed of 19200 baud, with a minimum length of 4000 feet or 32 nodes before requiring a network repeater. A minimum of 127 HVAC controllers shall be configurable on the Field Bus. Manufacturers with baud rates of less than 19200 shall be limited to 64 controllers to insure adequate global data and alarm response times.
2. The Field Bus shall permit peer-to-peer communications among all local controllers and allow simultaneous communications with laptop computer service tools that are connected to a controller. Failure of the controller will not impair the operation of its associated Field Bus. All space temperature sensors will have ports for laptop computer service tools.

B. Network Transparency: All points contained in controllers shall be considered global points. Any program in any controller on the network shall be able to reference any point in any controller regardless of its location on the network.

C. System Communications

1. Workstation Communications: Workstations shall be connected directly to the Ethernet LAN TCP/IP or through a communications port on a Level 1 Controller. Workstations shall also be able to communicate via modems to remote network devices by RS232 connection. Telephone communications shall operate simultaneously with communication to any controllers connected on the Ethernet LAN.
2. Laptop Service Tool Communications: The laptop computer service tool shall communicate with either Level 1 or Level 2 Controllers. Through the laptop, operators shall be able to view points and change parameters on any Level 1 or Level 2 controller on the network.
3. Dial-Up Communications: It shall be possible to access the network remotely through a standard dial-up modem. This modem shall permit direct access to the Ethernet LAN via a Level 1 network controller. It shall be possible to configure multiple modems in Level 1 network controllers to enable multi-user communications when more than 1 telephone line is available.
4. Third Party Driver Communications: The RS232C or RS485 ports on the Level 1 Network Controllers shall be optionally configurable for communication to third party controllers such as EPA certified leak detection probes, fire panels, boiler and chiller controllers, or other microprocessor based devices. Where third party communications are required, reference the network drawing and Section 17300 of this specification.

2.15 CENTRAL MONITORING TERMINAL (CMT)

A. Provide a laptop computer to allow building operator to view and acknowledge alarms, to access and edit system database information, to view system displays and reports, to customize the system, and to allow communication with remote systems via internet, Ethernet, and modem plus voice-grade telephone line. Interface shall be capable of displaying dynamic real-time point data on color graphic displays.

B. Portable service tool will be a laptop PC; 1.66 GHz, 1 GB RAM, 140GB hard disk, DVD+/-RW Optical and 15" diagonal XGA screen and integrated 802.11g wireless LAN transceiver.

C. Provide a secure 802.11g wireless router in the penthouse for access to the campus network with the laptop workstation. [Even if owner provides Wi-Fi, this will be needed for construction and commissioning]

D. The CMT (or a level 1 controller) will have digital interfaces to other building digital control systems (MDF room), including: Lighting Controls (BACnet), Square-D electrical switchgear (KW pulse and ATS BI alarms); Phoenix Lab Air Controls (BACnet).

E. NOTE: Owner will NOT accept deviations from this specification unless noted by Bidder and accepted by Owner prior to Contract Award.

2.16 DIRECT DIGITAL CONTROL (DDC) PANELS

A. DDC system shall have one or more stand-alone microprocessor-based DDC panels: L1C, or L2C. Note: These types of DDC panels differ mainly in processing power, memory, and input/output point count.

B. DDC panels shall be interconnected by communications bus that permits sharing of data between DDC panels and CMT.

C. DDC panel shall have ample memory to support its operating system, database and programming requirements.

D. Operating system of DDC panel shall manage the input and output communications signals to allow distributed controllers to share real and virtual point information and to allow central monitoring and alarms.

E. Data shall automatically be shared between DDC panels when they are networked together.

F. Database and custom programming routines of remote DDC panel shall be editable from an operator station.

G. DDC panel shall be capable of being remotely monitored over telephone modem or campus network; of automatically dialing out / networking alarms; and of gathering alarm, reports and logs.

H. DDC panel shall continually check the status of its processor and memory circuits. If failure is detected: DDC panel shall assume a predetermined failure mode, send an alarm to the CMT, and display the card failure identification locally.

I. DDC panel shall be bottom- or side-wired so as to prevent entrance of water through conduits.

J. Application programs shall be retained in permanent memory. Upon restoration of power after an extended power outage, operation shall be resumed in the scheduled mode. Equipment related to Atrium smoke exhaust shall have a UPS to provide continuous operation until emergency power is available.

K. Where specified, DDC panel shall have keypad and LCD display for local interface with mechanical equipment. Security password shall prevent unauthorized use of keypad and display, unless otherwise requested by Owner. Keypad and display shall be mounted on the associated mechanical equipment. *The penthouse mechanical room shall have one keypad w/ LCD display.*

L. Hardware shall be suitable for anticipated ambient conditions. DDC panels installed in outdoor and wet areas shall be rated for operation at temperatures between -40°F and 155°F, mounted within waterproof enclosures. DDC panels used in other areas shall be rated for operation at temperatures between 32°F and 120°F, mounted in dust-proof enclosures.

M. DDC panel shall be configured so that operator interface can be plugged directly into DDC panel or can be connected to DDC system sensor within sight of DDC panel or can connect wirelessly over the 801.11g Wi-Fi net; for programming, editing and other operator functions.

2.17 INPUT/OUTPUT POINT TYPES

A. Hardwired inputs and outputs shall be tied into DDC system via DDC panels. Critical points requiring immediate reaction (e.g., differential pressure control of variable flow pumps) shall be tied directly into controller hosting the control software algorithm for the critical function.

B. Binary Input (BI) points shall allow monitoring of on/off signals from remote devices. BI points shall provide current source to monitor dry contacts. Status points shown on control diagrams on shall be positive-proof differential pressure switches or current-sensing binary switches, as required.

C. Analog Input (AI) points shall allow monitoring of low voltage, current, or resistance signals; with minimum resolution of 0.1% of sensing range. AI points shall be compatible with, and field configurable to, commonly available sensing devices; e.g., 4-20 mA or 0-10 VDC.

D. Binary Output (BO) points shall provide continuous low voltage signal for on/off control of remote devices. BO points shall have three-position on/off/auto override switches and status lights and shall report to CMT when not in Auto position. BO points shall be selectable for either normally open or normally closed position.

E. Analog Output (AO) points shall provide modulating signal for control of end devices. AO points shall provide either 0-10 VDC signal or 4-20 mA signal, as required to provide proper control of output device. Where 3-15 psi and 0-80 psi pneumatic outputs are needed, provide high quality, stable, durable transducer acceptable equivalent to Bellophram 1000, mounted in controller or auxiliary cabinet. L2Cs using floating control algorithm with open/off/close contacts may be used as an alternative form of AO. AO points in DDC panels shall have on/off/auto switches with manual output signal adjustment and with alarm report when not in Auto position.

2.18 BUILDING AUTOMATION SYSTEM SOFTWARE - GENERAL

A. Provide software required for efficient operation of automation system functions. Software shall be modular in design, for flexibility in expansion or revision of system.

B. Real-time Operating System shall be general purpose, capable of supporting following features:

1. Multi-Tasking, with event-driven task scheduling.
2. Real-time clock routines.
3. Input/output control.
4. Power-fail and automatic restart.
5. Multiple CMT support

C. The intent of this specification is provide Data Base Creation and Support Software that will allow Owner to do his own programming for point additions and point modifications to the system. All changes must be possible while system is ON-LINE and operational. System must have standard procedures to do following:

1. Communicate with system, in English, for day-to-day operations.
2. Request displays on real-time data, assigned limit, current value, status, report or message.
3. Command selected equipment.
4. Change time/event schedules.
5. Add and delete points.
6. Modify any point parameter.
7. Add, change or delete English language descriptors for print input, print output, status, alarm or engineering unit.
8. Select analog alarm limits.
9. Change analog setpoints.
10. Initiate printout of report or information displayed.
11. Generate and modify color schematics of building equipment or areas being monitored.
12. Characterize each function card to accept different analog inputs, or pulsed or steady state digital signals.
13. Create custom relationships between points, by use of general-purpose user language, so that operator can implement software interlocks, master/slave relationships, virtual points and calculations.
14. Switch over hard copy reporting of alarms from the event printer to another user-designated printer.

D. It shall be possible to display or command any collection of points as a group, regardless of the controller to which the points are physically connected.

E. Automatic restart: Restart of field equipment after field power failure shall be user-definable, staggered to limit electric demand, and shall be either:

1. "Static nature" restart which places equipment in operational state which is previously designated by operator; OR
2. "Appropriate state" restart which places equipment in operational state which is based on time of restart and interior temperatures.

F. Printer interface

1. All change-of-state reports, system logs, information summaries, system malfunction messages and alarms shall be printed out on main (event) printer.
2. Alarms shall be printed out on dedicated alarm printer. [in this building or centrally??]

G. Substitutes which will NOT be accepted:

1. Systems which exclusively use numeric codes for address descriptors will NOT be acceptable.
2. Systems which do not automatically download latest database information to controllers when controller reboots will NOT be acceptable.

2.19 SYSTEM ACCESS

A. System shall support minimum of two operator terminals. Operator terminal shall be understood to be a station which allows operator input and output and which may include several and various devices. Following devices shall be capable of being used as terminals:

1. Personal computer with workstation software.
2. LCD display panel with keypad.
3. Portable personal computer (laptop) with workstation software.
4. Hand-held service tool.
5. Any PC with internet browser software to access the system database server.

B. Each terminal shall be able to be operated independently of and concurrently with other terminal(s). It shall be possible to limit the capabilities of any terminal to specific functions, specific points or specific buildings. It shall be possible for terminals to have equal capabilities.

C. Terminals shall be connected to the system via standard EIA interface at controller panels and by any means that allows connection to the campus Ethernet.

D. User access shall be secured using individual security passwords, minimum of 12 users. Passwords shall have minimum three levels of user access with data entry restrictions being assignable by password. User logon/logoff shall be recorded.

E. System shall protect itself from unauthorized use by automatically logging a user off if user's delay time expires without another keystroke. Delay time for each user shall be definable.

2.20 SYSTEM PROCESSING FEATURES

A. Alarm processing features shall include:

1. Display of each alarm, including: appropriate alarm message, date and time of alarm report, system descriptor, point descriptor, and alarm condition.
2. Printout of alarm and change-of-state messages, on printer selected by operator.
3. Capability for selection by operator, at any time, of changes-of-state that shall be considered alarms.
4. Critical and non-critical designations for each alarm point for alarm reporting.

5. Automatic time delay of alarms during equipment startup and shutdown, to prevent nuisance and false alarms.
6. Protection against false alarms due to noise transients on the data networks.
7. Annunciation of DDC panel failure or databus failure, including failure condition and location.

B. Event Processing Features:

1. Automation system software shall include ability to automatically initiate commands, user-defined messages, logs, application programs, and graphic displays as a result of an event condition.
2. Event conditions shall include change-of-state occurrence, alarm, hardware failure, software failure, return-to-normal or any logical combination of these.

C. Graphic Processing features shall include:

1. Display of a group of points on color graphic CRT.
2. Display of associated graphics on color graphic CRT.
3. Simultaneous display of dynamic alphanumeric data and associated graphics on color graphic CRT.
4. Capability to create, modify or delete graphic display while automation system is operational and on-line.
5. Capability to edit control parameters displayed on color graphic CRT.
6. Capability to show the extent that a point on a graphic deviates from setpoint by means of text or color.
7. Display of up to 60 small analog bar graphs for analog points, on one screen (e.g. room temps, room air flow, hood sash position).

2.21 MESSAGES

A. System shall be capable of automatically displaying or printing a user-defined message subsequent to a selected event. Operator shall be able to:

1. Insert, change or delete any message.
2. Display or log messages at any time.
3. Assign any message to any event.

B. Minimum of 300 independent messages, with up to 256 characters each, shall be simultaneously possible.

2.22 GRAPHICS

A. Provide following graphic screens showing setpoints and actual point readings: [ADD ALTERNATE]

1. Each mechanical system, as shown on Drawings.
2. Each floor of the facility, showing mechanical systems serving the floor and locations of controlled devices.
3. Composite bar graph of airflow delivered by VAV terminals (0-100%) for a group of rooms. Use color to indicate operation of fan-coils, reheat VAV units or chilled beams.

4. Composite bar graphs showing hood sash positions for all fume hoods (up to 30 per screen).
5. Summary screens showing instantaneous, monthly and annual energy use for heating, cooling, lighting and HVAC power.

B. System diagrams should be simplified one-line schematics with the minimum necessary to show control input devices, control output devices, controlled equipment, and their relationships; as well as information on setpoints and variables.

2.23 REPORT CAPABILITY

A. Reports shall be produced on automatic schedule and upon manual request. Reports shall include time, date and initials of operator who requested report. Reports shall be in English and in logical format that is easily understood.

B. Following reports shall be included in software:

1. All Point Summary
2. Building or Unit Summary
3. Alarm Summary
4. Motor Status Summary (on/off)
5. Historical Trend Log
6. Alarm Limit Summary
7. Totalization Logs (motor run time; analog values)
8. Point Lock-Out Summary
9. Status Summary
10. Operator Access Report (report on identity, time and date of each operator signing on and off; for time period which is input with report request)
11. System Hardware Performance Report (periodic report on operational status of central hardware and transmission network)
12. Database Management Report (report on current data-base of included points)
13. Operator Access Level Report (report on access level assignments for operators)
14. Time-of-day Start/Stop Schedules
15. Messages Summary (report on all messages and on events that triggered each message)
16. Graphic Listings Report (report listing each color graphic defined)
17. Chilled or Hot Water Usage Profile Log for a selected period

C. If alarm printer experiences a detectable fault, DDC system shall either (1) automatically report alarms on other user-designated printer, or (2) save alarm reports to disc file for later printing.

2.24 TOTALIZATION AND DATA LOGGING

A. Automation system software shall support both motor run-time (MRT) totalization and analog totalization. Operator shall be able to:

1. Add or delete points from totalization program.
2. Set, change or reset current totals.
3. Display or log totalized point(s).
4. Display totalized values as part of unit/system display.

5. Initiate totalized printouts automatically by week or month, or manually upon request.
6. Download to a spreadsheet file for off-line analysis.

B. Provide data logging software to record system analog values at operator-selected intervals. Data stored in local controllers shall be automatically transferred to the CMT or BFS as necessary. Data transferred to CMT / BFS shall be saved on hard disk and/or archive CD. Data files shall be saved in format accessible to an Excel spreadsheet.

2.25 ENERGY MANAGEMENT ROUTINES

A. Automation system shall include software for energy management applications. Application routines shall be compatible with, and capable of simultaneous use in, system. Use of any routine shall NOT cause other software to malfunction.

B. Provide following application routines for energy management:

1. Time of Day
2. Start/Stop Time Optimization
3. Demand Limiting
4. Timed Override
5. BTU Calculation

C. Time of Day

1. Automation system software shall include automatic start and stop of equipment according to stored time schedules which can be modified by the operator. DDC system shall have minimum of three schedules for each mechanical system being controlled.
2. Each schedule shall be capable of controlling minimum of 50 pieces of equipment according to time delay scheduled between successive starts or stops.
3. Each start, stop and time delay period shall be individually defined and shall be re-definable by operator.
4. Automatic and manual override of each schedule shall be possible.
5. Daylight savings time adjustment shall be automatic on dates selected by operator.

D. Optimal Start/Stop (OSS) program shall perform optimized start-up and shutdown of selected equipment.

1. OSS program shall start HVAC equipment at latest possible time that will still allow equipment to achieve the desired zone conditions by occupancy time. OSS shall include earlier startup on days following an unoccupied day.
2. OSS program shall shut down HVAC equipment at earliest possible time before end of occupancy period that will still maintain desired comfort conditions.
3. OSS program shall meet local code requirements for minimum outside air while building is occupied. When building is unoccupied, OSS shall use 0% outside air if use of outside air requires heating or cooling of same, i.e., increasing total building energy consumption.
4. OSS program shall perform optimized start/stop either as function of both outside and inside conditions, or as function of outside conditions only.

5. OSS program shall include purge cycle which takes advantage of free cooling available at night, during summer cooling periods.

    a. Purge cycle shall run prior to occupancy, if enthalpy of outside air is lower than enthalpy of return air, such that energy consumption is lowered by operation of purge cycle.
    b. Purge cycle shall open outside air dampers, shall exhaust inside air, and shall bring in outside air.

6. Operator shall be able to establish and modify following parameters, for each building under OSS control:

    a. Occupancy period.
    b. Empirical factor which relates outside temperature, required supply water temperature, and time period for advance startup of heating and cooling.

7. Optimum Start: Program shall calculate proper start time in order to reach space temperature setpoint by occupancy time based upon: current space and outdoor temperature; previous day's performance; and full or partial occupancy, as selected by operator. If system did not operate yesterday, program shall adjust by calculating an earlier start time.
8. Warm-Up: If average space temperature is below heating setpoint and if outdoor temperature is more than 2°F below this setpoint, fan system shall operate in Standby Mode (no outdoor air) until scheduled occupancy time. If fan system has no heating coils, this program shall not be implemented. Heating shall be by perimeter units only. Central fan system startup shall be delayed until occupancy time.
9. Pre-Cool: If average space temperature is above cooling setpoint and if outdoor air is above economizer switchover point, fan system shall operate in Standby Mode until scheduled occupancy time. Otherwise, outdoor air shall be used as needed for "free" cooling.

E. Demand Limiting (DL) program

1. DL shall monitor the building power consumption from signals generated at building power meter or by a watts transducer attached to the building feeder lines. Pulse generator or watts transducer shall be provided as part of work of this Section.
2. DL shall be based on predictive sliding window algorithm. DL shall be self-adjusting and shall control minimum two independent demand limiting applications.
3. To ensure that indoor air quality and occupant comfort are not compromised, DL shall include following parameters:

    a. 15-minute or 30-minute demand intervals, as selected
    b. Shed/restore deadband width
    c. Maximum off-time, for each load
    d. Temperature limits, for each load

4. Demand limiting in VAV systems shall be accomplished by resetting individual VAV box temperature setpoints to reduce load while maintaining indoor air quality and occupant comfort.

5. Ventilation system demand will be reduced at times when outdoor air temperatures are 90°F or above, by reducing the ventilation rate down to 10 cfm / person (indoor-outdoor CO_2 differential reset up to 1,050 ppm)
6. Mechanical equipment shall be protected by anti-recycle timer.
7. DL shall have capability for inputting the end-of-billing-period indication.

F. Timed Override (TOR) program

1. TOR shall enable operator to set up groups of devices to be temporarily turned on for a defined period of time, based on DI, AI or operator inputs.
2. Override time period shall be adjustable from 1 minute to 720 minutes.
3. TOR shall have standard weekly and monthly reports documenting TOR operation.
4. Typical TOR application will be from switches on temperature sensors in areas with limited public access.

G. Direct Digital Control (DDC) program

1. DDC shall provide modulating control of remote devices based on sensed data.
2. DDC shall have capability to use standard control strategies including proportional control, proportional plus integral control (default), and proportional plus integral plus derivative control.
3. Control routines shall be flexible enough to allow operator to set parameters and make adjustments.
4. DDC loop setup and modification shall be done through preformatted edit screen with parameters shown in English.
5. DDC shall provide graphic display of control loop functions, self-tuning control loops, or other method for remote tuning of control loops.

H. Other energy management routine programs shall be based on data outlined in SEQUENCE OF OPERATION paragraphs and shall include:

1. Supply air reset
2. Hot water supply temperature reset
3. Space temperature reset for demand limiting
4. Chilled water reset to highest temperature possible while satisfying air system needs
5. Pressure optimization on variable flow systems (air and water) so that at least some users are not throttling flow

2.26 SEQUENCE OF OPERATION: LAB EXHAUST FANS

2.27 SEQUENCE OF OPERATION : VIVARIUM AHU-1

A. Vivarium AHU-1 (dedicated heat recovery VAV outdoor air unit with air control valves, hot water reheat coils and chilled beam terminal units). Add Alternate

2.28 SEQUENCE OF OPERATION: NON-LAB SPACES

A. Non-lab Spaces AHU-2 (dedicated heat recovery VAV outdoor air unit with chilled beam terminal units)

2.29 SEQUENCE OF OPERATION: LAB SPACES AHU-3

A. Lab Spaces AHU-3 (dedicated heat recovery VAV outdoor air unit with air control valves, hot water reheat coils and chilled beam terminal units)

2.30 SEQUENCE OF OPERATION: GAS FIRED HOT WATER BOILERS AND HOT WATER PUMPS

2.31 SEQUENCE OF OPERATION: GAS FIRED STEAM BOILER

2.32 SEQUENCE OF OPERATION: AIR COOLED CHILLER

2.33 SEQUENCE OF OPERATION: CHILLED WATER PUMPS

2.34 SEQUENCE OF OPERATION: WATER COOLED CHILLER, CONDENSER WATER PUMPS, COOLING TOWER AND CONDENSER WATER PLATE HEAT EXCHANGER

2.35 SEQUENCE OF OPERATION: GENERAL EXHAUST FANS

2.36 SEQUENCE OF OPERATION: CHILLED BEAMS

2.37 SEQUENCE OF OPERATION: FAN COIL UNITS

2.38 SEQUENCE OF OPERATION: VAV TERMINAL UNITS WITH HOT WATER RE-HEAT COILS

2.39 BMS INTERFACE WITH OTHER SYSTEMS:

A. Laboratory Air Control: successful LAC bidder will provide a Modbus gateway for interface with the BMS system. Control Contractor shall provide an O-link controller on the C-bus communication level in the building for the Modbus interface. All the points from the LAC system shall be visible in the BMS. A BACnet interface is also acceptable as well as a system in which the LAC software runs on BMS hardware controllers

B. Energy Use Display: the successful bidder will provide a BACnet gateway for interface with BMS. Control Contractor shall provide a BACnet router on the LAN for this interface. BMS shall provide any data required from the system trend logs for the Energy Use Display system.

2.40 SEQUENCE OF OPERATION: LAB EXHAUST FANS (LEF-1 through 5)

A. Overview: There are total of five laboratory exhaust fans located within the Mezzanine Mechanical Room. Two laboratory exhaust fans are associated with the Vivarium AHU-1 (Alternate Bid) and three laboratory exhaust fans associated with the lab system AHU-3. The laboratory exhaust is gathered by risers and connects to the inlet of the heat recovery wheel for AHUs, located within the Mezzanine Mechanical Room. After giving up energy to the heat recovery wheel (HRW) the exhaust air enters the exhaust suction plenums and is expelled to the atmosphere by lab exhaust fans LEF-1 through LEF-5.

B. Lab Exhaust System Duct Pressure Control Loop:

1. Laboratory exhaust system fans (LEF-1 to 5) will be staged On and Off at required speed to continuously maintain the measured duct system static pressure at set point and a high exhaust stack velocity. BMS will monitor fan status.
2. When the static pressure in the fan's suction plenum falls below setpoint, bypass dampers will modulate closed.
3. After 10 seconds with the bypass damper in fully closed position, fan with the least run-time will begin opening its isolation damper. The fan will start and his speed will be ramped up so that the full speed will be reached with when the isolation damper will be fully open. Bypass dampers will then modulate open as needed to maintain the plenum pressure. Report failure of isolation damper to fully open after 120 seconds.
4. If the bypass dampers are fully open and the plenum static pressure rises 0.2" w.c. above set point for 10 seconds the fan with the most run-time will Stop, and bypass dampers modulated closed to maintain proper plenum pressure.
5. If an exhaust fan does not start when called for, report alarm and start fan with the next least run-time.

C. Lab Exhaust System Duct Pressure Reset:

1. The duct system static pressure as determined by TAB contractor for system normal operation will be reset based on a Trim and Respond logic between a minimum (0.50") and maximum (1.25") pressure.
2. Trim and Respond Logic: with the fans operating, every two minutes trim the static pressure set point by 0.04" w.c. if there are two or fewer zone pressure request. If there are more than two zone pressure requests, respond by increasing the set point by 0.06" w.c.
3. A zone pressure request can be: zone airflow (more than 90% of required CFM for more than two minutes) or damper position (damper 90% or more open).

D. Exhaust Fans Speed Reset Control Loop (wind reset):

1. Fan speed for all operating fans will modulate based on the calculated wind speed from 100% (at 15 mph wind) down to 70% (at 0 mph wind).
2. Wind speed shall be measured every minute at penthouse level and an average for 15 minutes period shall be recorded. The calculated wind speed as mean of the last 4 recordings will be used for the fans speed reset.
3. BMS shall produce a graphic display indicating the fan speed reset and the wind calculated speed.
4. If the lab exhaust fan speed is reset and the duct static pressure cannot be maintained with all the fans operating the fan speed reset shall be overridden and the fan speed shall be modulated up to 100% to maintain the current static pressure setpoint.

E. Every week BMS shall designate a new lead fan for each exhaust system through rotation all fans. The lead fan shall be first to start and last to stop.

F. Bypass and fan inlet dampers will have electric actuators by this Division with NEMA 4 weather protection enclosures (if required) and alarms for any damper that does not fully open. Fan inlet damper shall be furnished with exhaust fans, actuators provided under this section. Bypass dampers and actuators will be provided under this section.

G. Fan staging and damper activation speed shall be sequenced such that the addition or deletion of operating fans does not result in fluctuation of exhaust system static pressure.

H. Separation Damper:
1. The damper between Vivarium Exhausts and Hood Exhausts will be normally closed and fans operate as two independent systems, as above.
2. If either system cannot maintain its current static pressure setpoint, the separation damper will open and the system fans staged to maintain current setpoints in both exhaust risers so that neither riser is below the current setpoint.

I. Alarms:

1. A fume hood air valve CFM is below its required control range.
2. A laboratory exhaust fan has failed.
3. An LEF isolation damper has not opened fully after 120 seconds of operation.
4. An exhaust fan is OFF but its isolation damper is "not closed"
5. Exhaust plenum pressure has dropped below setpoint for 30 seconds

J. Trend Setups:

1. Number of LEFs on.
2. Total LEF kW.
3. Exhaust plenum inlet duct pressure.
4. Exhaust duct riser pressure.
5. Bypass damper (A & B) position
6. Total exhaust fan flow.

2.41 SEQUENCE OF OPERATION: AHU-1 & 3 (VAV Supply Air System for LABORATORIES)

A. Overview: Each unit is a large VAV makeup air system with a total (latent and sensible) energy recovery wheel that provides all the laboratory make-up and conditioning air. The unit consists of outdoor air dampers, outdoor air pre and final filters, hot water preheat coils with freeze protection pump, draw-through supply fans, enthalpy wheel with purge, steam humidifier, chilled water coil with future sound attenuators (supply & exhaust air streams) and exhaust filters (suction side of the wheel). There are five control loops for each section of this system:

1. Supply Fan Start / Stop: System runs continuously.
2. Supply Air Temperature: Modulate coil fluid flows to maintain SAT reset schedule of 55-60°F.
3. Heat Recovery Wheel: Modulate wheel speed to maintain supply air temperature setpoint.
4. Space Humidity: Modulate steam to humidifier to maintain the space (return air) humidity set point.
5. Fan Speed Control: Maintain supply air pressure setpoint, with reset based on Trim and Respond logic to satisfy air valves.

B. Supply Fan Start/Stop Control Loop:

1. Discharge smoke dampers and outdoor air dampers are commanded open and series end switches confirm that both have opened and enable fan.

2. Energy Recovery Wheel is enabled if outdoor conditions are within setpoint range (see ERW sequence).
3. Continued fan operation is contingent on high-pressure discharge switch contacts remaining closed.
4. Operating Schedule is continuous, 24 hours/day.
5. If the unit is stopped, HW valve continues to modulate to maintain 40°F at either adjacent duct sensor (night watchman controller).

C. Supply Air Temperature Control Loop:

1. All temperature control elements will modulate in sequence to maintain the discharge temperature setpoint. The supply air temperature will be allowed to float between 55°F and 60°F (dead band) but will be reset downward as required to satisfy space humidity set point of 56° DP as measured by humidistat in any lab area.
2. Heating: On a call for heating supply air (i.e. at full wheel speed ERW LAT < SAT setpoint), the two-way HW valve modulates open to maintain supply air set point (Provide 1/3-2/3 valves or high turndown characterized ball control valve to handle low loads with ERW in operation).
3. Cooling: On a call for cooling supply air (i.e. at full wheel speed ERW LAT > SAT setpoint), CHW pressure independent valve modulates open to maintain discharge air temperature set point.
4. Note that to minimize fan energy all coil bypass dampers (if provided) are open when the coil is not in use and fully closed when coil is in use.
5. BMS shall not allow simultaneous operation of heating and cooling valves.

D. Energy Recovery Wheel Speed Control Loop (provided by BMS contractor):

1. When the supply fan runs, the ERW VFD is enabled *if the OAT drops 2°F below the discharge air temperature setpoint (heat required) OR if the OAT exceeds the RA temperature by 2°F (cooling is possible & needed)*

2. The energy wheel speed increases until the leaving air temperature equals the supply air temperature setpoint (heating or cooling, as appropriate) and modulates to maintain it.

3. If the exhaust leaving air dew point temperature approaches 32°F, the wheel slows to keep the exhaust stream moisture from freezing.

4. A proximity sensor shall be installed for monitoring the wheel rotation. The sensor will close the contact once per revolution under normal running conditions. An alarm is generated if the ERW is On and contact closure has not been detected in 9 minutes.

E. Space Humidity Control Loop:

1. The BMS system will read space humidity in specific locations (as indicated in drawings).
2. The BMS will average the space humidity readings and use the average to modulate the humidifier steam valve to maintain the space humidity average of all floors at setpoint.

3. Normal humidity setpoint is 30% when OAT is above 30°F, resetting down to 20% at -20°F and below.
4. The discharge humidity sensor will limit the humidifier valve so that the leaving air relative humidity does not exceed 80% at its current supply air temperature.
5. Two-position humidifier steam isolation valve will close if space humidity is above 35%, or mechanical cooling is being used, or fan stops.

F. Supply Fan Speed Control Loop

1. Speed of fan varies to maintain the discharge static pressure set point required to operate the lab supply air valves.

The following reset logic will not be useable with the Phoenix air valve because their control logic assumes adequate pressure all the time (open loop control of valve position):

2. The maximum duct static pressure setpoint determined by TAB contractor for system design operation will be reset downward between (max and 0.25") based on a Trim and Respond logic to satisfy actual air valve needs.
3. Trim and Respond Logic: with the fan operating, every two minutes trim the static pressure set point by 0.04" w.c. if there are two or fewer zone pressure requests. If there are more than two zone pressure requests, respond by increasing the setpoint by 0.06" w.c.
4. A zone pressure request can be: zone airflow (more than 90% of required CFM for more than two minutes) or damper position (damper 90% or more open).
5. A high limit pressure switch ahead of smoke dampers will stop fan if its high-pressure setpoint is exceeded.
6. If the VFD fails and cannot start the fan, BMS enable the bypass and reset supply air temperature upward so that duct static does not exceed 3".

G. Freeze Protection:

1. If the HW coil leaving air temperature drops to 38°F, a Potential Freeze Warning will be sent to the system alarm workstation and on-call maintenance pager requesting immediate response.
2. If the air temperature at cooling coil inlet falls below 34°F, auto-reset freeze protection thermostat will:

   a. Shut down supply fans.
   b. Close outside air dampers.
   c. Report critical alarm at BMS and dial out alarm to maintenance on-call pager number.
   d. Modulate HW valve to maintain 45°F at heating coil discharge (night watchman).
   e. Open chilled water cooling control valve completely and start building lead CHW pump.

3. Final Freeze Protection fan sequence will be via hard-wired control contacts, not through BMS software. If the freeze-stat trips, the fan's start contact is disabled until an operator enters his password and BMS system logs the entry.

H. Smoke Detection and Control: Supply Duct: Upon sensing smoke in the supply airstream by smoke detector (provided under DIVISION 16, ELECTRICAL WORK) BMS hard-wiring stops the supply fans, closes the outdoor air dampers, and indicates an alarm condition.

I. Alarms:

1. Supply Air: 63°F < SAT <52°F for more than 3 minutes.
2. Filters Dirty: Filter DP >1.75" w.c. (AI).
3. Heat Recovery Wheel LAT < 25°F.
4. Heat Recovery Wheel not rotating when commanded On.
5. Temperature rise through heating coil with valve closed.
6. Freeze T-stat has tripped unit off (auto reset t-stat with software restart required).
7. Temperature drop through the cooling coil with valve closed.
8. Fan failure (drive current)
9. OA, or fan's smoke damper not open when commanded On.
10. Duct high/low static pressure.
11. Fan smoke detector has tripped, stopping fan.

J. Trends of Measured Data (hourly values arranged as a spreadsheet with date, time and data in columns):

1. Fan percent speed
2. Supply air temperature
3. Supply air temperature setpoint
4. End of duct pressure
5. Supply duct pressure setpoint
6. Space average humidity
7. Supply air humidity.

2.42 SEQUENCE OF OPERATION: AHU-2 (VAV Supply Air System with Energy Recovery)

A. Overview: This is a dedicated outdoor air system (DOAS), variable volume air system with a total (latent and sensible) energy recovery wheel that supplies ventilation air to offices, the auditorium and two large classrooms. The supply side includes pre & final filters, total energy wheel (HRW), HW heating coil with freeze pump, steam grid humidifier, CHW cooling coil ~~with bypass damper~~ and draw-through variable speed supply fan. The exhaust side includes pre-filters, HRW and variable speed exhaust fan. There are seven control loops:

1. Fan start-stop from schedule and occupancy sensors.
2. Total Energy Wheel Speed control loop from SA setpoint.
3. Supply Fan Speed control loop from duct pressure.
4. Exhaust Fan Speed control loop from supply cfm
5. Supply Air Temperature control.
6. Space humidity control loop.

B. Fan Start - Stop Control Loop

1. Unit starts upon occupancy detection in any of the three spaces served by the unit.
2. Units stops 10 minutes after occupancy is not detected in any of the three spaces.

3. Outdoor air damper and exhaust air damper are commanded open and series end switches enable fan VFDs when both are confirmed open.
4. Total Energy Recovery Wheel is enabled if outdoor conditions are within setpoint range (see ERW sequence).

C. Total Energy Wheel Speed Control Loop:

1. When occupancy begins, the total energy wheel starts rotating, increasing speed to capture more energy from the exhaust air.
2. The total energy wheel speed increases until the leaving air temperature equals the supply air temperature setpoint (heating or cooling, as appropriate).
3. In normal operation mode the discharge duct probe measures supply air temperature. During dehumidification mode the supply air temperature is measured from the sensor after the cooling coil but before the sensible only wheel.
4. The wheel speed modulates to maintain the heating or cooling setpoint. As the LAT after the ERW approaches the supply air temperature setpoint the wheel speed will gradually slow down.
5. If the outdoor air temperature rises to 2°F of the discharge air temperature the wheel stops. If the outdoor air temperature exceeds the RA temperature by 2°F, the wheel restarts.
6. If the exhaust leaving air dew point temperature approaches 32°F, the wheel slows to keep the exhaust stream moisture from freezing.
7. A proximity sensor shall be installed for monitoring the wheel operation. The sensor will close the contact once per revolution under normal running conditions. An alarm shall be generated if the ERW is On and contact closure has not been detected in 9 minutes.

D. Sensible-only Energy Wheel Speed Control Loop:

1. During AHU's normal operation the sensible only wheel will be Off (not rotating) and bypass damper open.
2. When dehumidification mode begins, the energy wheel starts rotating, increasing speed to capture more energy from the exhaust air.
3. The energy wheel speed increases until the leaving air temperature equals the supply air temperature setpoint measured in the discharge duct probe (heating or cooling, as appropriate).
4. The wheel speed modulates to maintain the heating or cooling setpoint. As the LAT after the ERW approaches the supply air temperature setpoint the wheel speed will gradually slow down.
5. A proximity sensor shall be installed for monitoring the wheel operation. The sensor will close the contact once per revolution under normal running conditions. An alarm shall be generated if the ERW is On and contact closure has not been detected in 9 minutes.

E. Supply and Exhaust Fan Speed Control loop:

1. Supply fan starts at 20% speed.
2. Supply fan speed varies to maintain the discharge static pressure set point. The static pressure will be reset so that at least one of the VAV boxes will be 85-90% open.
3. Exhaust fan speed is reset so that exhaust CFM is 5% less than outside air CFM.

4. If VFD fails and cannot start one fan, BMS will shut down the unit down and report an alarm. Outside air and exhaust dampers shall be closed.
5. Note that to minimize fan energy all coil bypass dampers are open when the coil is not in use and fully closed when coil is in use.

F. Supply Air Temperature Control Loop:

1. Overview: Heating or Cooling control valves will modulate open to maintain discharge temperature if the total energy wheel cannot. BMS shall not allow simultaneous operation of heating and cooling valves.
2. Heating: Discharge air temperature setpoint: 70°F. Total energy recovery wheel speed modulates until supply air temperature reaches the setpoint. If supply air temperature falls below heating setpoint, HW coil valve modulates to bring supply air temperature back to setpoint.
3. Cooling: Discharge air temperature setpoint: 63°F. Total energy recovery wheel speed modulates until supply air temperature reaches the setpoint. If supply air temperature rises above cooling setpoint, CHW coil valve modulates to bring supply air temperature back to setpoint.

G. Outdoor Air Demand Control reset by space CO2 level: CO2 levels will be measured by Aircuity system in all 3 zones (auditorium and two large classroom) with wall-mounted sensors. The space CO2 levels will be compared with the OA levels. If the CO2 differential for any of the monitored zones exceed 700 ppm, the VAV box serving that space will modulate open increasing the room airflow until the CO2 level is satisfied. As the differential CO2 levels in all the monitored spaces drops below 600 ppm the VAV box will modulate closed downwards to minimum position. Outdoor CO_2 level will be read from the building outdoor sensor located at penthouse level.

H. Cooling Mode Space Humidity Control Loop (Dehumidification Mode):

1. There is no humidity control for heating mode.
2. In cooling mode, if dewpoint level in any of the three spaces as measured by Aircuity system rises at setpoint (57°F –adjustable), supply air temperature after CHW coil resets downward to 53°F. Discharge air temperature set point as measured by the discharge duct probe shall be maintain at 63°F by the sensible only heat recovery wheel.
3. As the dewpoint in all the three spaces falls 1°F below setpoint, supply air temperature after CHW coil resets upward to 63°F.
4. Dehumidification Mode is Off when discharge air temperature after CHW coil equals the cooling set point (63°F).

I. Freeze Protection Controls:

1. If the HW coil leaving air temperature drops to 38°F, a Potential Freeze Warning will be sent to the system alarm workstation and on-call maintenance pager requesting immediate response.
2. If air temperature at cooling coil inlet falls below 34°F, auto-reset freeze protection thermostat will:
   a. Shut down supply and exhaust fans.
   b. Close outside air and exhaust dampers.

c. Report critical alarm at BMS and dial out alarm to maintenance on-call pager number.

d. Modulate HW valve to maintain 45°F at heating coil discharge (night watchman).

3. Final Freeze Protection fan sequence will be via hard-wired control contacts, not through BMS software. If the freeze-stat trips, the fan's start contacts is disabled until an operator enters his password and system logs the entry.

J. Smoke Detection and Control:

1. Supply Duct: Upon sensing smoke in supply airstream by smoke detector (provided under DIVISION 16, ELECTRICAL WORK) BMS hard-wiring stops the fans, closes the dampers, and indicates an alarm condition.

K. **Auditorium and Large Classroom Control:** These spaces have three control loops: temperature, dew point and ventilation rate.

1. Temperature control: radiant ceiling panels are the primary temperature control system with air system as secondary system.
   a. In heating mode: room temperature set points are occupied 70°F, unoccupied 65 degF.
   b. During heating, unoccupied mode starts 30 minutes after occupancy is not detected in that space. During unoccupied periods space dedicated VAV box shall be fully closed.
   c. Perimeter heating radiant panel's control valve modulates to maintain space temperature set point. In occupied mode if the space temperature falls below setpoint with control valve fully open (5 minutes delay) the space reheat coil's valve shall modulate open to satisfy the temperature setpoint.
   d. In cooling mode: room temperature set points are occupied 75°F, unoccupied 80°F.
   e. During cooling, unoccupied mode starts 10 minutes after occupancy is not detected in that space. During unoccupied periods space dedicated VAV box shall be fully closed.
   f. Radiant cooling panel's control valve modulates to maintain space temperature set point. In occupied mode if the space temperature rises above setpoint with control valve fully open (5 minutes delay), space dedicated VAV box will modulate open to satisfy room set point.
2. Dew Point Control: If the room DP rises at room setpoint level, the dehumidification mode shall be initialized (see the Dehumidification Mode sequence). If the room DP does not drop after SA temperature is reset downwards to 53°F (measured after cooling coil), room's VAV box shall modulate open to satisfy room DP setpoint. The radiant cooling panel control valve shall remain open subject to a condensation sensor on the room chilled water supply line.
3. Ventilation Rate Control: during occupied periods VAV box shall deliver minimum OA required for the space (20% of the maximum CFM). If the space measured (by Aircuity sensors) CO_2 level exceeds outside air levels by 700ppm Outdoor Air Demand Control sequence shall be initiated.
4. DP control and temperature control shall override ventilation rate control.

L. Alarms:

1. Supply Air: SAT > +/- 5°F from discharge air setpoint for more than 2 minutes.
2. Filters Dirty: Filter DP >1.75" wc (AI).
3. Heat recovery wheel supply air LAT <25°F.
4. Air temperature rise through HW coil with valve closed.
5. Freeze T-stat has tripped unit off (auto reset t-stat with software restart required).
6. Air temperature drop through the cooling coil with valve closed.
7. Fan failure (drive current or kW))
8. Fan VFD failure (drive fault)
9. Supply or exhaust fan airflow differs by more than 10% from setpoint.
10. Smoke detector has tripped, stopping both S&E fans.
11. Cooling coil LAT >70°F with coil valve open
12. Heating coil LAT <50°F with coil valve open.

M. Trends of Measured Data (hourly values arranged as a spread sheet with date, time and data in columns):

1. Fan speed percent (Sup & Exh)
2. Supply air temperature.
3. Supply air temperature setpoint
4. End of duct pressure
5. Supply duct pressure setpoint
6. Space humidity

2.43 SEQUENCE OF OPERATION: AHU-2 (VAV Supply Air System with Energy Recovery and with Unocc. Recirculation)

A. Overview: This is a dedicated outdoor air system (DOAS) with a total (latent and sensible) energy recovery wheel that supplies ventilation air to the offices and general spaces. Supply air path has pre & final filters, blow-through supply fan with VFD, total energy wheel, HW coil and CHW cooling coil. The exhaust side includes pre-filters, energy wheel and variable speed exhaust fan. It provides 100% outdoor air to occupied rooms only, when it runs. There are five control loops:

1. Fan start-stop from schedule or occupancy sensors.
2. Energy Wheel Speed Control loop.
3. Supply and Exhaust Fan Speed Control loop.
4. Supply Air Temperature reset.
5. Cooling Space Humidity Control loop.

B. Fan Start-Stop Control loop

1. Unit Starts 20 minutes prior to scheduled occupancy, and during un-scheduled hours when sensor detects that occupants are present. For morning warm-up all room ventilation dampers shall be open.
2. Outdoor air damper and exhaust air damper are commanded open and series end switches enable fan VFDs when both are confirmed open.
3. During start-up time, the energy wheel operation will be enabled, while supply and exhaust fans will be at 100% speed. AHU's HW/CHW valves will modulate to achieve the space temperature and humidity (only in cooling mode) setpoint.
4. Five minutes prior to scheduled occupancy, if the space high dew point is at 57°F or less, the supply fan speed will reduce to 20%, and enable the Supply Fan Speed control loop.
5. Unit Stops 10 minutes after the last occupant sensor detects an occupant in the office area, but modulates HW coil flow as needed to maintain 40°F at the sensors on either side of the coil (night watchman).

C. Total Energy Wheel Speed Control loop:

1. During startup mode when space T & H are adjusted to their occupied values, fan runs at 100% speed the energy wheel will modulate to maintain supply air temperature setpoint.
2. When occupancy begins, the total energy wheel starts rotating, increasing speed to capture more energy from the exhaust air.
3. The total energy wheel speed increases until the leaving air temperature equals the supply air temperature setpoint (heating or cooling, as appropriate).

4. The wheel speed modulates to maintain the heating or cooling setpoint. As the LAT after the ERW approaches the supply air temperature setpoint the wheel speed will gradually slow down.
5. If the outdoor air temperature rises to 2°F of the discharge air temperature the wheel stops. If the outdoor air temperature exceeds the RA temperature by 2°F, the wheel restarts.
6. If the exhaust leaving air dew point temperature approaches 32°F, the wheel slows to keep the exhaust stream moisture from freezing.
7. A proximity sensor shall be installed for monitoring the wheel operation. The sensor will close the contact once per revolution under normal running conditions. An alarm shall be generated if the ERW is On and contact closure has not been detected in 9 minutes.

D. Supply and Exhaust Fan Speed Control Loop:

1. Supply fan speed is 100% during start up mode when space temperature and humidity are approaching setpoints.
2. Supply fan speed reduces to 20% when the outdoor air damper opens and then varies to maintain the duct static pressure setpoint (reset w/ hi-limit setpoint determined by air balancer to get design flow).
3. Exhaust fan speed is reset so that exhaust CFM is 1000 CFM less than supply fan CFM.
4. If VFD fails and cannot start one fan, BMS will shut the unit down and report an alarm. Outside air and exhaust dampers shall be closed.
5. Note that to minimize fan energy all coil bypass dampers are open when the coil is not in use and fully closed when coil is in use.

E. Supply Air Temperature Control Loop:

1. Overview: Heating or Cooling control valves will modulate open to maintain discharge temperature if the energy wheel cannot. BMS shall not allow simultaneous operation of heating and cooling valves.
2. Heating: Discharge air temperature setpoint: 70°F. Total energy recovery wheel speed modulates until supply air temperature reaches the setpoint. If supply air temperature falls below heating setpoint, HW coil valve modulates to bring supply air temperature back to setpoint.
3. Cooling: Discharge air setpoint will be allowed to float between 53°F and 60°F (deadband) when outdoor air temperature rises above 53°F. Total energy recovery wheel speed modulates until supply air temperature reaches the setpoint. If supply air temperature rises above cooling setpoint, CHW coil valve modulates to bring supply air temperature back to setpoint.

F. Cooling Mode Space Humidity Control Loop (Dehumidification Mode):

1. There is no humidity control for heating mode.
2. In cooling mode, if dewpoint level in any of the spaces as measured by Aircuity system rises at setpoint (57°F –adjustable), supply air temperature resets downward to 53°F.
3. As the dewpoint in all the spaces falls 1°F below setpoint, supply air temperature resets upward to 60°F.

G. Freeze Protection Controls:

1. If the HW coil leaving air temperature drops to 38°F, a Potential Freeze Warning will be sent to the system alarm workstation and on-call maintenance pager requesting immediate response.
2. If air temperature at cooling coil inlet falls below 34°F, auto-reset freeze protection thermostat will:
   a. Shut down supply and exhaust fans.
   b. Close outside air and exhaust dampers.
   c. Report critical alarm at BMS and dial out alarm to maintenance on-call pager number.
   d. Modulate HW valve to maintain 45°F at heating coil discharge (night watchman).
3. Final Freeze Protection fan sequence will be via hard-wired control contacts, not through BMS software. If the freeze-stat trips, the fan's start contacts is disabled until an operator enters his password and system logs the entry.

H. Smoke Detection and Control:

1. Supply Duct: Upon sensing smoke in supply airstream by smoke detector (provided under DIVISION 16, ELECTRICAL WORK) BMS hard-wiring stops the fans, closes the dampers, and indicates an alarm condition.

I. Office Room Control: Offices have two control loops: temperature and dew point. In order to prevent condensation on the cooling radiant ceiling panels, the ventilation system must first bring the space dew point down below 57 °F before the room chilled water valves are opened. The Aircuity system will measure the air dew point levels in the spaces (as mean reading in the return duct). In any room cooling valve will be closed if the water sensor on the supply line senses condensation and an alarm is reported. This may occur if occupants leave door open and outdoor humidity rises. Such rooms will get no cooling, but continue to get ventilation if occupancy in the room is detected.

1. If a room sensor detects occupants or at building start up 2-position room ventilation damper opens fully.
2. If room temperature is below the heating setpoint, room heating valve is modulated open to enable the ceiling radiant heating panels.
3. If the room temperature is above the cooling setpoint AND highest floor dew point reading is 57°F or below, the room cooling valve is enabled and modulates to satisfy the cooling setpoint, subject to a condensation sensor on the supply line to the ceiling panels.
4. During unoccupied normal hours, heating setpoint will be allowed to fall to an intermediate value of 68°F and cooling setpoint to rise to 80°F.
5. During nighttime unoccupied hours heating setpoint will drop to 65°F and cooling will be Off.

J. Conference Room Control: Conferences have three control loops: temperature, dew point and ventilation rate. In order to prevent condensation on the cooling radiant ceiling panels, the ventilation system must first bring the space dew point down below 57 °F before the room chilled water valves are opened. The Aircuity system will measure the air dew point levels in the spaces. In any room cooling valve will be closed if the water sensor on the supply line senses condensation and an alarm is reported.

1. If a conference room sensor detects occupants or at building start up the room VAV box opens to its minimum position.
2. If room temperature is below the heating setpoint, room heating valve is modulated open to enable the ceiling radiant heating panels.
3. If the room temperature is above the cooling setpoint AND room dew point reading is 57°F or below, the room cooling valve is enabled and modulates to satisfy the cooling setpoint, subject to a condensation sensor on the supply line to the ceiling panels.
4. During unoccupied normal hours, heating setpoint will be allowed to fall to an intermediate value of 68°F and cooling setpoint to rise to 80°F.
5. During nighttime unoccupied hours heating setpoint will drop to 65°F and cooling will be Off.
6. If the room DP rises to the setpoint VAV box will modulate open to maintain space DP setpoint.
7. If the room CO_2 readings exceeds outside air levels by 700 ppm, VAV box will modulate open to maintain the CO_2 required levels.

K. Alarms:

1. Supply Air: SAT > +/- 5 °F from SA setpoint for more than 2 minutes.
2. Filters Dirty: Filter DP >1.75" wc (AI).
3. Heat recovery wheel supply air LAT <25°F.
4. Air temperature rise through preheat coil with valve closed.
5. Freeze T-stat has tripped unit off (auto reset t-stat with software restart required).
6. Air temperature drop through the cooling coil with valve closed.
7. Fan failure (drive current or kW))
8. Fan VFD failure (drive fault)
9. Supply or return fan airflow differs by more than 10% from setpoint.
10. Smoke detector has tripped, stopping both S&R fans.
11. Cooling coil LAT >65°F with coil valve open
12. Heating coil LAT <50°F with coil valve open.

L. Trends of Measured Data (hourly values arranged as a spread sheet with date, time and data in columns):

1. Fan speed percent (Sup & Ret)
2. Supply air temperature.
3. Supply air temperature setpoint
4. End of duct pressure
5. Supply duct pressure setpoint
6. Space average humidity (return air)

2.44 SEQUENCE OF OPERATION: LABORATORY AREA (with Fume Hood)

A. Overview: The control below is provided by the Laboratory Air Control system (LAC) and summarized here for reference. The LAC system will do all lab control (temperature and airflow control). There are to be no BMS controllers in the labs. The LAC's room data object present values will be visible to the BMS via the BACnet protocol. Space temperature and humidity setpoint objects in the LAC will be adjustable from the BMS. Room heating will be provided by a duct-mounted HW coil and active (hot water) beams, supplemental cooling by sensible only active chilled beams.

B. The Lab Controller will modulate supply, fume hood and general exhaust airflow valves to maintain required CFM differential.

C. The Fume Hood Controller through the sash sensor signal will control the fume hood exhaust airflow valve to maintain a specified constant average face velocity at the fume hood opening. The Vortek airflow sensor will read the true airflow value of the individual fume hood exhaust. The Fume Hood Controller will control as a stand-alone unit, modulating the hood exhaust valves as required via the factory-mounted high speed actuators. The FHC will have local displays and alarms.

1. The FHC will measure the fume hood exhaust airflow and compare it to the current exhaust airflow setpoint. The setpoint will be based on the sash position and status of the "Emergency" switch.
2. The fume hood display shall report the calculated face velocity in FPM and hood exhaust volume in CFM on its 4-digit LCD. The display shall provide the option to read in "Alpha" mode (NORM/ALERT) instead of numeric. The "Parameters" button on the face of the display shall allow the operator to scroll through all operating parameters and alarm setpoints, which shall be displayed on the LCD.
3. Should the hood exhaust volume remain off setpoint for a prescribed period of time, the fume hood controller shall initiate a local alarm. The local alarm shall consist of a flashing red LED and a beeper on the fume hood display. The beeper shall be temporarily silenced by pushing a Mute button on the fume hood display. The alarm light shall be de-energized when the alarm condition is rectified.
4. The Fume Hood Controller will transmit a true airflow signal to the Lab Room Controller.

D. The total exhaust airflow volume from the lab (fume hood and general exhaust) will be measured through the Vortek airflow sensors. The controller will compare this value to the lab total exhaust setpoint and modulate its general exhaust air valve to supplement the exhaust airflow volume as required to maintain the required lab ventilation rate.

E. The Lab Room Controller will control the supply airflow required to maintain the required space airflow differential.

F. Lab Ventilation Rate:

1. Lab air system shall provide 6 ACPH for occupied periods and 3 ACPH for unoccupied periods. Occupied/unoccupied period will be scheduled through BMS.
2. Provided that room design conditions are met the ventilation rate shall be further reduce downward to 4 ACPH for occupied periods and to 2 ACPH for unoccupied periods.
3. Room parameters will be constantly monitored by LAC (temperature and fume hood make-up) and by Aircuity system (room DP and air contaminants). Any changes outside of room parameter setpoints shall reset the ventilation rate upward. There will be one Aircuity sensor per two labs bays. The adjustments required by Aircuity system readings will take place in both lab bays.
4. During unoccupied periods isolation control air damper (D1) will shut the air to the lab interior 4 active chilled beams. Ventilation air will be supplied to the space through the two perimeter active beams and alcoves active beams. This will insure the air rates to an acceptable range for active beam operation.

G. Lab Temperature Control:

1. There are four temperature sensors in a typical lab layout: a perimeter sensor (S1) installed on the outside wall and used only for heating, a lab sensor (S2) and two alcove sensors (S3 & S4), one per alcove.
2. There are 5 control valves for a typical lab layout: a HW valve (V1) for the two perimeter (4-pipe) active beams, a HW valve (V2) for the reheat coil, a MCHW valve (V3) for the lab active beams and two alcove MCHW valves (V4&5), one per alcove, for the alcove's active chilled beams.
3. Lab temperature setpoints are: heating 70°F occupied and 65°F unoccupied; cooling 75°F occupied and 80°F unoccupied.
4. Heating:

   a. Perimeter heating: Lab Room Controller will modulate the HW valve V1 to maintain space temperature setpoint for sensor S1. When control valve V1 modulates open the lab MCHW control valve (V3) shall be close.
   b. Lab Room Controller will modulate the reheat coil's HW valve (V2) to maintain space temperature setpoint for S2, 3 or 4.

5. Cooling: If zone temperature rises with minimum zone airflow, chilled beam's MCHW valves (V3, 4 or 5) modulates as required to maintain setpoint. On a continued rise in zone temperature above cooling setpoint, the LAC will modulate the supply airflow valve to the required cooling CFM.
6. DP control: if the space DP rises to 57°F supply air valve shall modulate open to maintain space DP setpoint.

H. In the event of a spill (the fume hood "Emergency" purge button pushed or contaminants level as measure by Aircuity system exceeds high limit setpoint) LAC shall override airflow control and force a full-flow purge mode. In this mode fume hood and general exhaust air valves shall modulate fully open, while the supply air valve shall modulate to maintain space airflow differential. A red LED on the face of the display shall light to alert the operator that the hood is in the purge mode. The controller will remain in "Purge" mode and the LED shall remain lit until the button is pushed again. When purge mode is initialized an alarm shall be submitted through BMS.

I. Fail Safe Condition: Under loss of power, the hood exhaust valve, the general exhaust valve and supply air valves will fail to their current position.

J. Daytime unoccupied setbacks: starts 15 minutes after occupant sensor does not detect an occupant in the area.

1. Fume hood shall reset face velocity from 100 fpm to 60 fpm.
2. Heating setpoint 68°F, cooling setpoint 78°F.

2.45 SEQUENCE OF OPERATION: LABORATORY AREA (Support Areas with NO Fume Hood)

A. Overview: The control below is provided by the Laboratory Air Control system (LAC) and summarized here for reference. The LAC system will do all lab control (temperature and airflow control). There are to be no BMS controllers in the labs. The LAC's room data object present values will be visible to the BMS via the BACnet protocol. Space temperature and humidity setpoint objects in the LAC will be adjustable from the BMS. Room heating will be provided by a duct-mounted HW coil, where provided (refer to the drawings) supplemental cooling by sensible only active chilled beams.

B. The Lab Controller will modulate supply and exhaust airflow valves to maintain required CFM differential.

C. The total exhaust airflow volume from the space will be measured through the Vortek airflow sensors. The controller will compare this value to the lab total exhaust setpoint and modulate the exhaust air valve as required to maintain the required lab ventilation rate.

D. The Lab Room Controller will control the supply airflow required to maintain the required space airflow differential.

E. Space Ventilation Rate:

1. Lab air system shall provide occupied and unoccupied ventilation rates (ACPH) as scheduled in the drawings. Occupied/unoccupied period will be scheduled through BMS.
2. Provided that room design conditions are met the ventilation rate shall be further reduce downward as scheduled (refer to the drawings).
3. Room parameters will be constantly monitored by LAC (temperature) and by Aircuity system (room DP and air contaminants). Any changes outside of room parameter setpoints shall reset the ventilation rate upward.

F. Space Temperature Control:

1. Temperature setpoints are: heating 70°F occupied and 65°F unoccupied; cooling 75°F occupied and 80°F unoccupied.
2. Heating: Lab Room Controller will modulate the reheat coil to maintain space temperature setpoint.
3. Cooling: Lab Room Controller will modulate the supply air valve to maintain space temperature setpoint in spaces without active chilled beams. Where active chilled beams are provided, if zone temperature rises with minimum zone airflow, chilled beam's MCHW valve modulates as required to maintain setpoint. On a continued rise in zone temperature above cooling setpoint, the LAC will modulate the supply airflow valve to the required cooling CFM.
4. DP control in room with active chilled beams: if the space DP rises to 57°F supply air valve shall modulate open to maintain space DP setpoint.

G. Fail Safe Condition: Under loss of power, the exhaust valve and supply air valves will fail to their current position.

H. Daytime unoccupied setbacks: starts 15 minutes after occupant sensor does not detect an occupant in the area.

1. Heating setpoint 68°F, cooling setpoint 78°F.

2.46 SEQUENCE OF OPERATION: EMERGENCY GENERATOR SYSTEM

A. Overview: Generator control panel will have dry auxiliary alarm contacts, provided under DIVISION 16, ELECTRICAL WORK. Provide BACnet or Modbus connection to DDC system for common digital alarm signal (BI), engine cranking (BI) and running contacts (BI) and at least 3 other parameters from generator, as well as fuel tank level high, low and leak alarms (3-BI). Refer to DIVISION 16, ELECTRICAL WORK, for further information. BMS controls generator room temperatures: exhausting for cooling, and heating with engine heat bypass damper or unit heater. Generator intake and exhaust damper (PBDs) are held closed but spring open on loss of power to fully open in < 20 seconds. Provide interface to the tank gauging module RS232 comm-link to monitor fuel level and alarms, and BACnet or Modbus link to generator controls. There are two control loops: Engine start and room temperature control.

B. Emergency Start Sequence:

1. When BMS detects engine cranking contact closure, combustion and cooling air intake (D-4) and engine exhaust dampers (D-1) will open fully on stored energy, within 20 seconds (dampers have normally open actuators, and are powered closed).
2. Intake and 2-position engine exhaust dampers will be airfoil parallel blade type and engine bypass (D-3) and modulating exhaust (D-2) are opposed blade type. All outdoor / exhaust air dampers will have insulated airfoil blades (R-2.29), silicone seals with less than 5 cfm/sf leakage at 4" DP (e.g. TAMCO 9000 series w/ thermally broken frame).
3. If any of makeup dampers fail to open, report an alarm.

C. Room Temperature Control Loop:

1. Bypass damper (D-3) modulates open as exhaust damper D-2 modulates closed to force re-circulation of hot exhaust air and maintain 60°F room temperature when engine is running.
2. Unit heater HW valve opens whenever room air is less than 45°F and end switch runs fan as required until room temperature reaches 50°F, ***unless generator is on.***
3. Generator intake and exhaust dampers remain open whenever outdoor air temperature is above 60 degrees *and* after generator stops for at least 2 minutes, or until room temperature drops to the higher of 60°F or the outdoor temperature.
4. If OAT > 65°F, OA will open and remain open until room temperature drops to OA temperature.
5. If generator is OFF and room temperature exceeds 78°F, OA damper opens, exhaust fan damper opens and end switch runs exhaust fan EF-9 at variable speed until room is cooled to higher of 75°F or outdoor temperature. If generator is running exhaust is by generator fan and EF-9 remains OFF.

D. Alarms: Monitor and totalize by month the annual fuel flow by reading the RS232 communications port of the tank gauging panel.

1. The generator graphic will display the current fuel tank level and alarm when it drops to 10% full.
2. Room temperature exceeds 100°F.

3. Interpret the RS-232 data signal to monitor the tank level, overfill, low level alarm and interstitial leak alarms.
4. If RS-232 monitoring is not feasible, provide optional tank gauge analog output module for tank level and program standard relays for alarm conditions.

E. Trend Logs: Set up trend logs for the following:

1. Generator kW / kvar
2. OAT (°F)
3. Room temperature (°F)
4. Intake & exhaust damper status (open /closed)
5. Fuel level (%)

F. Energy Report

1. Provide a report screen that tabulates electrical data about building power and generated power, as follows:

    a. Generator average kW output by hour (if any).
    b. Average building kW use by hour
    c. Peak building kW demand for each hour.
    d. Total building demand peak & date-time for the last 12 months.
    e. OAT
    f. Daily use totals for a & b above.

2. Retain daily electric data in an archive to produce daily, monthly or annual reports as needed.
3. Transmit above data to the Greentouchscreen display system

2.47 SEQUENCE OF OPERATION: BASEMENT MECHANICAL EQUIPMENT ROOM VENTILATION

A. Overview: This sequence includes the Mechanical room as well as the Electric room, Transformer room and Fire Pump room. Each room has a connection to an outdoor air source and a supply fan (Mech room) or exhaust fan (other rooms) to move ventilation air for cooling. The Mech room has a recirculation arrangement to provide continuous air movement with its VFD fan at minimum speed. Other room exhaust fans have VFDs that are controlled at varying speed to maintain room temperature setpoints. There are 5 control loops:

1. Electric room cooling by variable speed exhaust fan and heat by electric unit heater
2. Fire Pump room cooling by variable speed exhaust fan.
3. Transformer room temperature control loop by variable speed exhaust fan and electric unit heater.
4. Mech room temperature control with HW unit heater, recirc fan and economizer cooling.
5. Mech room refrigerant emergency purging system.

B. Electric Room (0066B) Temperature Control Loop:

1. Outdoor air damper opens when outdoor temperature rises to 65°F and closes if room drops below 60°F.
2. Room variable speed exhaust fan starts and varies its speed from 20-100% to maintain a room setpoint of 76 °F or the outdoor temperature, whichever is higher.
3. If room drops to 45°F electric unit heater is energized until room reaches 50°F.

C. Fire Pump Room (0066D) Temperature Control Loop:

1. Outdoor air damper opens when outdoor temperature rises to 65°F and closes if room drops below 60°F.
2. Room variable speed exhaust fan starts and varies its speed from 20-100% to maintain a room setpoint of 76 °F or the outdoor temperature, whichever is higher.

D. Transformer Room (0066A) Temperature Control Loop:

1. Outdoor air damper opens when outdoor temperature rises to 65°F and closes if room drops below 60°F.
2. Room variable speed exhaust fan starts and varies its speed from 20-100% to maintain a room setpoint of 76 °F or the outdoor temperature, whichever is higher.
3. If room drops to 45°F electric unit heater is energized until room reaches 50°F.

E. Mechanical Room (066)

1. Supply Fan SF-1 supplies 250 cfm of Outdoor Air (set by balancer) at its minimum speed (20% = 1000 cfm), but reduces OA if needed with a low limit supply air temperature (SAT) of 50°F.
2. As room temperature rises, OA damper modulates open (return closed) to maintain room cooling setpoint of 74°F or outdoor temperature, whichever is higher.
3. As OA damper reaches 100% open (1000 cfm), Mech room exhaust fan EF-1 starts at minimum speed (20% = 1200 cfm).
4. As room temperature rises further, SF speed ramps up and EF speed ramps up to track it (250 cfm less), as set by the air balancer at 20%, 60% & 100% SF speed.
5. If room temperature drops to 55°F unit heater valve opens and end switch starts fan motor until temperature rises to 60°F.

F. Mechanical Room Emergency Purging System (066)

1. If refrigerant leak is detected the room shall go in emergency purge mode. .
2. OA damper opens, RA damper close.
3. SF-1 full speed, emergency purge fan (EF-11) at full speed and Mech room EF-1 at 20% speed.
4. An alarm shall be generated through BMS.
5. Emergency purge mode shall continue until an operator enters his password and system logs the entry.

2.48 SEQUENCE OF OPERATION: PENTHOUSE MECHANICAL EQUIPMENT ROOM VENTILATION.

A. Overview: There is one ventilation system for the North and one for the East penthouse. Each room has a variable speed supply fan with outdoor air and recirculation (economizer) and a matched exhaust fan. The supply runs continuously at minimum speed and minimum outdoor air. When room temp rises, the OA damper modulates to 100% open, and the exhaust fan starts. As room temp increases supply and exhaust speed up together to maintain room temperature. When the room temperature drops to 60°F the unit heater(s) are started to maintain the room between 60 and 65°F. Start / stop and speed are the only control loops for these systems.

B. Start / Stop:

1. Unit heaters start when room temperature drops to 60°F and Stop when it reaches 65°F.
2. Ventilation supply fans run continuously at minimum speed (20%=1600 cfm), with OA damper open to 400 cfm starting at 7 am and stopping at 5 pm, and full recirculation at other times.
3. Room exhaust damper opens whenever the OA temperature exceeds 65°F. Exhaust Fan starts at minimum speed (20% = 1600 cfm) when supply OA damper opens fully (1600 cfm).

C. Temperature Control Loop

1. Unit heater starts by commanding control valve open; actuator end switch will enable fan motor. The opposite happens when the room reaches setpoint (60-65°F).
2. As room temperature rises, supply and exhaust fans increase speed in a linear fashion with exhaust trailing supply by 400-500 cfm (as determined by the air-balancing contractor at 20%, 60% and 100% speed) to maintain a room setpoint of 75°F or the outdoor temperature, whichever is higher.
3. Override OA damper closed to maintain a minimum MAT of 45°F and report an alarm

2.49 SEQUENCE OF OPERATION: HOT WATER CONVERTERS AND HW PUMPS (BUILDING HW HEATING LOOP)

A. Overview: There are 2 steam-to-hot water converters (one standby) providing hot water for building heating via AHU-5, 6 and 7 HW coils, room RCPs, perimeter active beams, duct-mounted HW coils, UH, CUH, FCUs. There are 2 hot water pumps with 100% standby capacity. The system has 4 control loops:

1. Pump Start / Stop control loop by demand for hot water.
2. Hot water pump speed from top of riser DP, reset to optimize DP.
3. Hot Water Supply temperature, reset.
4. Equipment Lead/Lag control.

B. Hot Water Pumps Start / Stop Control Loop: HW system is On for all hours of the year unless all lab reheat valves are closed (data from LAC). A 5 minutes time delay shall be provided for pump shut down. If a pump fails to start, BMS shall start the standby pump and an alarm shall be generated.

C. Pump Speed Control Loop: Pumps modulate from 20-100% to maintain the differential pressure setpoint, with pressure setpoint optimized by resetting so that the hot water valve with the greatest demand is always between 94- 98% open (above 98%, pressure reset upward, below 94% pressure reset downward).

D. Hot Water Supply Temperature: Reset from 160°F at 10°F OAT to 140°F at 60°F OAT.

E. Equipment Lead/Lag control:

1. Lead and Lag pumps are interchanged when Lead run time exceeds Lag by 96 hours.
2. Lead and Lag converters are interchanged when Lead run time exceeds Lag by 168 hours.

F. Provide flow meter and matched supply and return temperature sensors. Provide software to calculate MBtu use for reports for each hot water system.

1. Tabulate Btu use on annual basis in ten "bins" corresponding to 10% increments of maximum demand; i.e., Bin 10 accumulates the number of hours that the building hot water demand is between 90% and 100% of the design maximum.
2. Tabulate HWS & R temp, GPM and MBtu's for hour with total for the day in a spreadsheet form (data in columns) that includes equivalent pump Btu's (3413 Btu / kWh) from the VFD KW output. Include max, min and average hourly use.
3. Tabulate HWS & R temp, GPM and MBtu's for each day with total for the month in a spreadsheet form (data in columns) that includes equivalent pump Btu's (3413 Btu/kWh) from the VFD KW. Include max, min and average hourly use for each day, for the month and the average for weekends and weekdays. Include a day of week column next to date.
4. Tabulate HWS & R temp, GPM and MBtu's for each month with total for the year in a spreadsheet form (data in columns) that includes equivalent pump Btu's (3413 Btu/kWh) from the VFD KW output. Show a running total for this year of Mbtu's, as well as monthly average, max & min MBtu's and equivalent pounds of steam (870 Btu/lb @ 125 psig) along the with the last 12 months running total and the calendar year total for comparison.
5. Show hot water use and paste a graph to the page showing the Mbtu and equivalent steam use.
6. Pass data to Total Building Energy Use Report.

G. Trended Points:

1. GPM, HWS temperature, pump kW, pump %, HW delta-T, steam valve % open.

H. Alarms:

1. HWP-1 (2) Failure: Commanded on, but the status is off.
2. HWP-1 (2) Running in Hand: Commanded off, but the status is on.
3. Runtime Exceeded: Status runtime exceeds a user definable limit.
4. High temperature: HWS if greater than 170°F (adj.)
5. Low temperature: HWS if less than 130°F (adj.) with OAT < 65°F.
6. High DP: If 25% (adj.) greater than setpoint for 5 minutes.
7. Low DP: If 25% (adj.) less than setpoint for 5 minutes.
8. HWP-1-(2) VFD fault.

9. System static pressure has dropped by 20% from normal level.
10. System static pressure has dropped to 5 psig - System flow in danger of stopping. Possible leak.
11. Pumped condensate temperature > 220 °F. Traps leaking! (Insulated strap-on sensor is adequate for this alarm).
12. Condensate receiver level is HIGH.

2.50 SEQUENCE OF OPERATION: HOT GLYCOL CONVERTER AND HG PUMPS FOR LAB AIR SYSTEM HEATING COILS (AHU-1, 2, 3 & 4)

A. Overview: There is a steam-to-glycol converter providing hot glycol (30% P.G) for AHU-1, 2 , 3 & 4 heating coils and 2 hot glycol pumps with 100% standby. The system has 4 control loops:

1. Pump Start / Stop control loop by demand for hot water.
2. Pump speed from top of riser DP, reset to optimize DP.
3. Glycol heating supply temperature, reset.
4. Pumps Lead/Lag control.

B. Glycol Heating Pumps Start / Stop Control Loop: HG system will operate only seasonally (winter). If all the AHU's heating coil control valves are closed pumps shall be Off. A 5 minutes time delay shall be provided for pump shut down. If a pump fails to start, BMS shall start the standby pump and an alarm shall be generated

C. Pump Speed Control Loop: Pumps modulate from 20-100% to maintain the differential pressure setpoint, with pressure setpoint optimized by resetting so that the hot glycol valve with the greatest demand is always between 94- 98% open (above 98%, pressure reset upward, below 94% pressure reset downward).

D. Glycol Heating Supply Temperature: Reset from 200°F at 10°F OAT to 140°F at 60°F OAT.

E. Equipment Lead/Lag control: Lead and Lag pumps are interchanged when Lead run time exceeds Lag by 96 hours.

F. The system will provide backup for the Greenhouse heating system. In the backup mode the manual isolation valves will be open, GHT-HX-1 will reset glycol heating supply temperature per Greenhouse reset schedule and HWP-GHT-1 (2) will modulate speed to maintain the differential pressure setpoint in the greenhouse heating loop.

G. Provide flow meter and matched supply and return temperature sensors. Provide software to calculate MBtu use for reports for each hot water system.

1. Tabulate Btu use on annual basis in ten "bins" corresponding to 10% increments of maximum demand; i.e., Bin 10 accumulates the number of hours that the building hot water demand is between 90% and 100% of the design maximum.
2. Tabulate GHTS & R temp, GPM and MBtu's for hour with total for the day in a spreadsheet form (data in columns) that includes equivalent pump Btu's (3413 Btu / kWh) from the VFD KW output. Include max, min and average hourly use.
3. Tabulate GHTS & R temp, GPM and MBtu's for each day with total for the month in a spreadsheet form (data in columns) that includes equivalent pump Btu's (3413 Btu/kWh)

from the VFD KW. Include max, min and average hourly use for each day, for the month and the average for weekends and weekdays. Include a day of week column next to date.

4. Tabulate GHTS & R temp, GPM and MBtu's for each month with total for the year in a spreadsheet form (data in columns) that includes equivalent pump Btu's (3413 Btu/kWh) from the VFD KW output. Show a running total for this year of Mbtu's, as well as monthly average, max & min MBtu's and equivalent pounds of steam (870 Btu/lb @ 125 psig) along the with the last 12 months running total and the calendar year total for comparison.
5. Show hot glycol use and paste a graph to the page showing the Mbtu and equivalent steam use.
6. Pass data to Total Building Energy Use Report.

H. Trended Points:

1. GPM, GHTS temperature, pump kW, pump %, GHT delta-T, steam valve % open.

I. Alarms:

1. HWP-GHT-1-(2) Failure: Commanded on, but the status is off.
2. HWP-GHT-1-(2) Running in Hand: Commanded off, but the status is on.
3. Runtime Exceeded: Status runtime exceeds a user definable limit.
4. High temperature: GHTS if greater than 210°F (adj.)
5. Low temperature: GHTR if less than 140°F (adj.) with OAT < 65°F.
6. High DP: If 25% (adj.) greater than setpoint for 5 minutes.
7. Low DP: If 25% (adj.) less than setpoint for 5 minutes.
8. HWP-GHT-1-(2) VFD fault.
9. System static pressure has dropped by 20% from normal level.
10. System static pressure has dropped to 5 psig - System flow in danger of stopping. Possible leak.
11. Pumped condensate temperature > 220 °F. Traps leaking! (Insulated strap-on sensor is adequate for this alarm).
12. Condensate receiver level is HIGH.

2.51 SEQUENCE OF OPERATION: LOW TEMPERATURE CHILLED LOOP

A. Overview: This loop serves the entire building and loop is supplied from campus CHW distribution. Low temperature CHW loop is served by has a pair of pumps with 100% standby capacity. If campus CHW differential is not sufficient to maintain the end of riser DP, lead building CHW pump will do so.

B. There are 4 control loops for the low temperature CHW pumps:

1. Start/stop control from CHW demand (any valve) and low campus DP, as well as pump lead-lag rotation.
2. Speed control from end-of-riser DP, reset to keep one AHU CHW valve 98% open (optimized DP).
3. Delta-T Control: Return CHW valve modulated closed to raise CHW return temperature to 58°F (only enabled if pump is running).
4. CHW backup operation from medium temperature loop.

C. CHWP Start Control Loop:

1. Low temperature CHW pumps will start when minimum riser differential on monitored riser drops below the required DP setpoint and there is a demand for chilled water (open CHW valve in AHU). If external distribution pumping is adequate to maintain required riser differential setpoint, pumps will remain Off.
2. Lead and Lag pumps will exchange when Lead run time exceeds Lag run time by 60 hours or lead pump fails to operate.

D. Pump Speed Control Loop: Modulates as required to maintain the differential pressure setpoint, which is reset low enough so that one of the main AHU chilled water valves is always between 94 - 98% open. (Poll valves no more than every 10 minutes). If all the CHW valves are closed pumps shall be commanded Off (a delay of 15 minutes).

E. Building CHW Temperature Differential Control Loop (Only when pumps are running): Modulate building supply throttling valve to maintain return temperature at setpoint of 58°F (12°F temperature differential).

F. Chiller Operation for Low Temperature Loop Backup (Refer to CHW Loop Backup Control Detail in Mechanical drawings): If campus chilled water is not available; CH-1 can be use for low temperature backup. The connection between the two loops shall be automatically achieved through BMS after an authorized operator enters his password and system logs the entry.

1. Medium CHW pumps shall be stopped.
2. The chiller discharge temperature shall be reset down to 46°F from BMS input.
3. Two-way isolation valves V1 and V2 shall open.
4. CHWP-1(2) and MCHWP-1(2) shall start. MCHWP will operate as primary pump tracking flow of CHWPs.
5. When low temperature backup operation ends, MCHWP and chiller stops, isolation valve V1 and V2 will close, chiller discharge temperature is reset to 58°F. MCHW pump will start with medium temperature CHW loop operating in "free cooling" mode (condenser water diverted to lab AHUs intake glycol coils) until MCHWS reaches the loop operation set point. When the set point is achieve the MCHW loop will resume to normal operation.

G. Trend logs of Utility Data: Provide flow meters and matched supply and return temperature sensors and software to calculate Btu use (i.e., Mbtus & Tons of refrigeration) for reports for low temperature and medium temperature systems. In a spreadsheet format, with date and time in columns A & B and the following data in succeeding columns, report data each time interval and total for report period.

1. Low temperature CHW flow.
2. CHWS & R temperatures to low temperature loop.
3. Tabulate MBtu's & Tons on an hourly basis for All Bldg low temperature CHW (Mbtu= GPM /2 x (Tret-Tsup; Tons = MBtus/12).
4. Total the ton-hours for each day and calculate average and peak hour Tons for the day.
5. Calculate the enthalpy-hours for each hour of the day, by: finding the average outdoor enthalpy for the hour, and subtracting the typical indoor enthalpy of 28.4 Btu/pound at space setpoint (76 db, 55 dew point). Total the enthalpy-hours for each day.
6. Calculate a performance index of Building Ton-hours of refrigeration per enthalpy hour.

7. Transfer the Daily totals to a Monthly sheet showing 31 lines of daily totals, the monthly total of MBtu's and tons, monthly average, weekday average and weekend average and monthly peak.
8. Transfer monthly totals (MBtu's and Tons) to an annual summary sheet with 12 lines of monthly totals, averages and peaks, and totals or averages for the year.

H. Alarms:

1. CHWP-1 (2) Failure: Commanded on, but the status is off.
2. CHWP-1 (2) Running in Hand: Commanded off, but the status is on.
3. Runtime Exceeded: Status runtime exceeds a user definable limit.
4. High DP: If 25% (adj.) greater than setpoint for 5 minutes.
5. Low DP: If 25% (adj.) less than setpoint for 5 minutes.
6. CHWP-1 (2) VFD fault.
7. System static pressure has dropped by 20% from normal level.
8. System static pressure has dropped to 5 psig - System flow in danger of stopping. Possible leak.

2.52 SEQUENCE OF OPERATION: MEDIUM TEMPERATURE CHILLED WATER LOOP

A. Overview: This loop serves the radiant cooling panel/chilled beams loop. This loop has a dedicated chiller (CH-1) for MCHW production. Whenever room panel/beam valve opens, lead MCHW pump must run to maintain the end of riser.

B. There are 3 control loops for medium CHW pumps:

1. Start / stop control from MCHW RCP/chilled beams valve demand, as well as pump lead-lag rotation.
2. Speed control from end-of-riser DP, reset to keep one RCP/chilled beams CHW valve 98% open (optimized DP).
3. MCHW supply temperature.

C. MCHWP Start Control Loop:

1. Medium temperature CHW pumps will start when any RCP/chilled beams or condenser water heat recovery (CTR) valve opens for cooling.
2. Lead and Lag pumps will exchange when Lead run time exceeds Lag run time by 60 hours or lead pump fails to operate.

D. Pump Speed Control Loop: Modulates as required to maintain the differential pressure setpoint, which is reset low enough so that one of the room RCP/chilled beams valve is always between 94 - 98% open. (Poll valves no more than every 15 minute).

E. MCHW supply temperature:

1. Medium temperature CHW setpoint is 58°F (6°F temperature differential).
2. MCHW is produced by:
   a. Chiller (CH-1). As the MCHW flow approaches the manufacturer recommended minimum flow the loop bypass valve shall modulate open to maintain this flow.

b. Economizer mode "free-cooling" (CT-1 and MCHW-HX-1). See condenser water sequence of operation.

c. Campus CHW (backup operation). If MCHW cannot be produce by either CH-1 or free-cooling operation; low temperature chilled water shall be used to mix with MCHWR for the 58°F set point. In this mode (refer to CHW Loop Backup Control Detail in Mechanical drawings) the chiller isolation valve will be closed while MCHW-HX-1 isolation valve opened. The backup isolation valve V1 will be closed and valve V2 will modulate to maintain MCHWS at set point.

F. Trend logs of Utility Data: Provide flow meters and matched supply and return temperature sensors and software to calculate Btu use (i.e., Mbtus & Tons of refrigeration) for reports for low temperature and medium temperature systems. In a spreadsheet format, with date and time in columns A & B and the following data in succeeding columns, report data each time interval and total for report period.

1. Medium temperature CHW flow.
2. MCHWS & R temperatures to low temperature loop.
3. Tabulate MBtu's & Tons on an hourly basis for All Bldg low temperature MCHW (Mbtu= GPM /2 x (Tret-Tsup; Tons = MBtus/12).
4. Total the ton-hours for each day and calculate average and peak hour Tons for the day.
5. Calculate the enthalpy-hours for each hour of the day, by: finding the average outdoor enthalpy for the hour, and subtracting the typical indoor enthalpy of 28.4 Btu/pound at space setpoint (76 db, 55 dew point). Total the enthalpy-hours for each day.
6. Calculate a performance index of Building Ton-hours of refrigeration per enthalpy hour.
7. Transfer the Daily totals to a Monthly sheet showing 31 lines of daily totals, the monthly total of MBtu's and tons, monthly average, weekday average and weekend average and monthly peak.
8. Transfer monthly totals (MBtu's and Tons) to an annual summary sheet with 12 lines of monthly totals, averages and peaks, and totals or averages for the year.

G. Alarms:

1. MCHWP-1 (2) Failure: Commanded on, but the status is off.
2. MCHWP-1 (2) Running in Hand: Commanded off, but the status is on.
3. Runtime Exceeded: Status runtime exceeds a user definable limit.
4. High DP: If 25% (adj.) greater than setpoint for 5 minutes.
5. Low DP: If 25% (adj.) less than setpoint for 5 minutes.
6. MCHWP-1 (2) VFD fault.
7. System static pressure has dropped by 20% from normal level.
8. System static pressure has dropped to 5 psig - System flow in danger of stopping. Possible leak.

2.53 SEQUENCE OF OPERATION: CONDENSER WATER PUMPS, COOLING TOWER AND FREE COOLING

A. Overview: There are two condenser water pumps with 100% standby capacity. The condenser water will be pumped through a close circuit Cooling Tower with spray pump or the outside air intake preheat glycol coils (AHU-1, 2, 3 &4). When the outside air conditions will allow it the production of medium temperature CHW will be "assigned" to a plate heat exchanger (free cooling).

There are 4 control loops for the condenser water loop:

1. Start/Stop control for condenser water pump.
2. Start/stop control for Cooling Tower spray pump.
3. Condenser Water temperature: reset on outside air conditions.
4. Economizer/Free cooling control.

B. Condenser water pumps CWP-1(2) start/stop control: On for all hours of the year unless MCHW pumps are Off.

C. Cooling tower spray pump start/stop control: will start only if Condenser Water pump is On and if outside air temperature > 40°F. The spray pump can be enable/disabled from BMS (manually switched from winter to summer operation).

D. Condenser water temperature: with chiller operating the condenser water will be reset from 85°F at outside air 78°F WB to 60°F (adjustable) at outside air 45°F WB and lower. In economizer/free cooling mode the condenser water temperature will be reset to 55°F. Condenser water temperature will be maintain as follows:

1. Condenser water pumps speed will modulate between 25% and 100% to maintain condenser water temperature setpoint.
2. When condenser water pump reaches 75% speed, enable tower fan at minimum speed (20%) and modulate his speed up to 100% to maintain condenser water temperature setpoint.
3. If tower fan reaches 100% and the condenser water temperature cannot be maintained, start the cooling tower spray pump and reduce tower fan speed to 20% and modulate up to 100% to maintain condenser water setpoint.

E. Economizer/Free Cooling: This operation mode will be automatically selected through BMS when outside air conditions are below 53°F (adj). In this mode the cooling tower spray pump and chiller will be Off. The cooling tower fan will modulate its speed to maintain condenser water at setpoint. The two-position valve for the chiller will be closed isolating the equipment from the loop. The flow will be diverted to the plate and heat exchanger. If the temperature in the tower basin drops to 34°F (adjustable) the tower three-way bypass valve will divert condenser water thru basin coil to prevent basin freezing. As the outside air temperature drops below 20°F (adj, the condenser water will be diverted from the closed circuit tower to the AHU-1, 2, 3 & 4 intake preheat coils. Condenser water pump will modulate the speed to maintain the condenser water temperature at 55°F (adjustable).

F. Alarms:

1. CWP-1 (2) Failure: Commanded on, but the status is off.
2. CWP-1 (2) Running in Hand: Commanded off, but the status is on.
3. Spray pump Failure: Commanded on, but the status is off.
4. Spray pump Running in Hand: Commanded off, but the status is on.
5. Cooling tower Failure: Commanded on, but the status is off.
6. High CW temperature: If 5°F (adj.) greater than setpoint for 5 minutes.

7. Low CW temperature: If 5°F (adj.) less than setpoint for 5 minutes.
8. CHWP-1 (2) or MCHWP-1(2) VFD fault.
9. System static pressure has dropped by 20% from normal level.
10. System static pressure has dropped to 5 psig - System flow in danger of stopping. Possible leak.

G. **ENERGY MONITORING:**

1. Record the CW flow and the temperature drop across the DWH preheat tank and calculate the heat recovered (as QREC = CW GPM x 500 x TiN - TOUT), each hour and totalize by day. Record minutes of MCHW use and minutes of DHW emergency dump valve use each hour as Unused heat and Lost heat
2. Calculate the total heat collected from the condensers, QTOTAL, using condenser supply and return temperatures and gpm and record monthly and annually.
3. Calculate the Recovery Effectiveness = QREC / QTOTAL in percent and report daily, monthly and annually.

2.54 ADDITIONALLY MONITORING/ALARM POINT

A. Additionally monitoring/alarming points shall be included for the equipment installed by other trades. The equipment list shall include:

1. Research sensitive equipment: refrigerators, coolers, freezers, incubators, etc.
2. Emergency power.
3. Sump pumps.
4. Elevator pumps.
5. Sewage ejector.
6. RO/DI system.
7. STMH84 sump pump.
8. STMH84 steam condensate pump.
9. Domestic hot water heaters.
10. Storm water system.
11. PH monitoring.

PART 3 - EXECUTION

PART 4 - EXECUTION

A. Thermostats, hygrostats and space sensors shall be mounted 6 feet above finished floors in corridors or stairs; elsewhere, they shall be mounted 66 inches above finished floors. Exact locations shall be coordinated with adjacent light switches and other wall-mounted devices.

B. Provide air pressure indication gauges for indication of supply and control pressures at following locations.

1. At controller inputs.
2. At controller outputs.
3. At devices where associated controller gauge is not readable from device location.

4. At relays and other points where visual indication of air pressure is required to verify operation.

C. Field mounted gauges will be located to be readable by Owner's staff person when standing on the floor below the device.

D. Control valves will be installed in true vertical position with operator on top.

4.2 ADJUSTMENT AND CALIBRATION

A. Calibrate, test and adjust controls and control system including pneumatic and electric controls, thermostats, valves, damper motors and relays until system is properly adjusted, and ready for use. Management system's hardware and software will be completely checked, test run, and modified as required.

B. Be present for functional tests on systems. Before Engineer is asked to witness functional tests, ensure that:

1. Entire control and management system is complete.
2. Controls are calibrated.
3. Controlled devices and equipment have been physically inspected and checked to ensure that these terminal devices are under proper control and working smoothly over their entire range of operation.

C. Adjustment procedure will include following steps:

1. Preliminary setup and calibration, as specified and as shown on shop drawings.
2. Physical checkout of all components for completeness and accuracy, simultaneously with system adjustment procedure outlined in SECTION 15990, BASIC MATERIALS - ADJUSTING AND BALANCING, together with any required modifications.
3. Review of system with Engineer.
4. Functional tests for Owner's benefit, instruction and acceptance.
5. Review of problems with Owner, rechecking adjustments and calibration as required. Review, rechecking and calibration will occur NOT less than 30 days nor more than 60 days after systems have been in full operation.

D. Control and Management systems will NOT be considered complete nor acceptable until:

1. All conditions of Sequence of Operation have been attained.
2. All temperatures are maintained within specified limits under all operating conditions.
3. All system damper leakage is controlled within specified limits.

E. Where pneumatic-actuated damper operators are required, provide current-to-pneumatic (I/P) transducers mounted within airflow control centers or DDC panels.

F. As part of work of this Section, provide calibration and adjustment of airflow control components and be responsible for setting control setpoints, operating sequences, and alarming systems contained within airflow control centers, to produce following overall system performance. Coordinate with SECTION 230593, BASIC MATERIALS - ADJUSTING AND BALANCING.

1. Constant static pressure control within 5% of duct static setpoint without any hunting or cycling.

4.3 CONTROL SYSTEM MOTOR TESTS

A. After systems are balanced and ready to be turned over to Owner, test and report motor performance data for motors.

B. Include following information in test report:

1. Size, number and ampere rating of overload heaters. Manufacturer's motor starter heater table.
2. Breaker and disconnect switch data, including size and manufacturer of switches and fuses and branch circuit wiring.

END OF SECTION 230913

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SECTION 230915 - LABORATORY AIRFLOW CONTROL SYSTEM

PART 1 - GENERAL

1.1 COMMISSIONING OF CONTROL SYSTEMS

A. Owner's Commissioning Agent

1. The Commissioning Agent (CxA) has been contracted directly by Dartmouth for this project. The CxA has overall responsibility for planning and coordinating the commissioning process and the commissioning team. The commissioning team is made up of all parties in the design and construction process, including the controls (Division 17) contractor, and all sub-contractors within Division 17, plus major equipment suppliers as required.

B. Contractor Responsibility

1. The controls (Division 17) contractor's responsibilities are defined in specification section 01650. These responsibilities apply to all contractors and sub-contractors, plus major equipment suppliers providing equipment for Division 17. Each contractor and supplier shall review Section 01650 as it applies to each Section within the Division 17 specifications, individually and collectively.

1.2 INTENT

A. It is the intent of this section to establish the scope of the control work. Specifications governing the CONTROL work are included under the BASIC MATERIALS sections and under other sections detailing general requirements. Refer also to:

1. GENERAL CONDITIONS and SUPPLEMENTARY CONDITIONS
2. Section 15050, Basic Mechanical Materials & Methods
3. Section 15071, Mechanical Seismic Restraint & Vibration Isolation
4. Section 15815, Metal Ducts
5. Section 15820, Air Duct Accessories
6. Section 15845, Air Terminals
7. Section 17000, Temperature Controls and Building Management Systems
8. Section 17200, Facility Monitoring & Control System
9. Section 15951, Variable Frequency Drives
10. Section 15990, Testing, Adjusting, & Balancing

B. Acceptable manufacturers of lab air controls are Tek-Air and Phoenix Controls Corporation. Design is based upon Tek-Air /AccuValve. Base bid shall be Tek-Air. Alternate system allowed to bid is by Phoenix Controls Corporation.

C. THIS PROJECT WILL BE COMMISSIONED. REFER TO COMMISSIONING SPECIFICATIONS SECTION 01810 and 01815 FOR INFORMATION AND RESPONSIBILITIES. THE COMMISSIONING PROCESS WILL REQUIRE ADDITIONAL LABOR, MATERIAL AND/OR OTHER COSTS WHICH MUST BE PROVIDED BY THE MECHANICAL CONTRACTOR AS PART OF THIS PROJECT.

1.3 SCOPE

A. Provide labor, materials, services, equipment and transportation necessary for complete and operational system of laboratory airflow control system, as indicated on Contract Drawings and specified herein for the new Dartmouth College Life Sciences Building.

B. This section covers the specification of control systems for heating, ventilating and air conditioning systems based on using DDC controls and electric actuators for all valve and damper operators, central fans and for temperature control of terminal equipment in *laboratory spaces*. All room temperature and volume control for laboratories will use Tek-Air/AccuValve electric digital controls with electric actuators (alternate Phoenix). See Section 17000 for Temperature Controls and Building Management Systems.

C. Provide labor, materials, services, equipment and transportation necessary for complete and operational system of automatic temperature control and building management, as indicated on the Contract Drawings and specified herein, including but NOT limited to the following:

1. Complete laboratory airflow control system including airflow control valves and associated control devices.
2. Controls for all devices within the lab area as indicated in the drawings, including reheat coils, chilled beams, etc.
3. Interface with building management system so that all lab air flow data, temperatures and room equipment alarms are readable on the BMS workstation and system graphics.
4. Controls for space heating systems including active beams, convectors and unit heaters in lab area.
5. Controls for space cooling systems including chilled beams in lab areas.
6. ALL CONTROL AND POWER wiring of LAC system controls including room controllers, actuators, room sensors, duct sensors, fume hood controllers and communication interface devices under SECTION 17000, Temperature Controls and Building Management Systems.
7. Mounting of LAC system control devices including room controllers, control valves and dampers, actuators, room sensors, duct sensors, fume hood controllers, fume hood monitors and communication interface devices under SECTION 17000, Temperature Controls and Building Management Systems.
8. Furnishing of automatic control valves and dampers, pressure sensors, and sensor wells under SECTION 17000, Temperature Controls and Building Management Systems.
9. Motorized combination fire/smoke dampers.
10. Sleeves, escutcheons, seals, waterproofing, and similar devices.
11. Hangers, anchors, guides, bases, and other supports.
12. Access panels and access doors at duct mounted devices.
13. System identification, including valve tags.
14. Noise and vibration control.
15. Seismic restraints, including equipment bolts and welding.
16. Cleaning, lubrication, testing and adjusting, satisfy this specification and to support balancing contract.
17. Coordination drawings.
18. Record drawings.
19. Operating and maintenance manuals.

D. Provide a laboratory airflow control system (LACS) to control the *temperature and airflow* into and out of laboratory rooms. The exhaust volume of a laboratory fume hood shall be controlled to maintain a constant average face velocity into the fume hood. The laboratory control system shall vary the amount of air into the room to operate the laboratories at the lowest possible airflow rates necessary to maintain temperature control, room DP, achieve minimum ventilation rates, and maintain laboratory pressurization in relation to adjacent spaces (negative). The laboratory airflow control system shall be capable of operating as a stand-alone system or as a system integrated with the Building Management System (BMS) via an open protocol interface (BACnet on Ethernet). All lab and lab corridors are to be controlled by the LACS without the use of any BMS controllers. Room occupancy sensor dry contacts provided under Division 16.

E. Where controls are required for non-laboratory airflow devices in building refer to Section 17000 for requirements. Such controls shall be provided under this section.

F. Provide the services of Laboratory Airflow Controls manufacturer's representative to be on-site during the entire testing and balancing procedures detailed in this specification. The representative shall be part of manufacturer's service organization and shall be skilled in the adjustment and calibration of all control devices as well as being capable of modifying and checking system and communications software. The representative shall perform calibration, system validation, startup, and acceptance testing in the presence of owner's representative or Engineer and commissioning authority. The commissioning process requires System Readiness Checklists on all commissioned equipment prior to system testing and verification. The service also includes startup of communications interface, and testing of systems integrity with the BMS system. Fifteen (15) days notice shall be provided before acceptance test. Notice shall certify that system is complete and operates as required by Contract Documents. When system performance is deemed satisfactory, the system shall be accepted by the owner's project manager, Office of Environmental Health and Safety and warranty shall begin.

G. Laboratory Airflow Control System shall perform all sequences of operation listed on control drawings or in this specification. Laboratory Airflow Control supplier shall provide all devices necessary to completely perform sequences whether such devices are explicitly shown on the drawings, specified, or not shown or specified.

H. The BMS Contractor and the Laboratory Airflow Controls manufacturer shall provide the owner with an installed and tested system. They shall demonstrate control sequences, control loop response times, set and reset controls variables, local monitoring and alarming, interface to the BMS, and display of points, alarms, color graphics, trends, reports, etc., on the BMS system.

1.4 ACCEPTABLE MANUFACTURERS

A. The plans and specifications for the laboratory airflow control system have been based on systems and equipment as manufactured by Tek-Air. No base bid substitutions allowed. An alternate price for LACS based on Phoenix Controls Corporation may be submitted refer to spec 01230, Alternates.

1.5 WARRANTY

A. Warranty shall commence upon the date of substantial completion and extend for a period of *twelve months* whereupon any defects in materials or system performance shall be repaired by the manufacturer at no cost to the owner.

1.6 SUBMITTALS

A. Within 90 days of the award the LAC Contractor shall submit installation drawings and control sequences for review.

B. Each submittal shall have a cover sheet with the following information provided: submittal ID number; date; project name, address, and title; Laboratory Airflow Controls supplier name, address and phone number, field engineer, quality control manager, and project engineer names and phone numbers.

C. Each submittal shall include the following information:

1. Riser diagram, showing all laboratory routers, network components, and communication wiring.
2. Lab room diagrams, showing all Fume Hood Controllers, space flow controllers, monitoring equipment, all miscellaneous components, and wiring.
3. Room Pressurization showing a detailed airflow analysis for each pressurization zone. The One-line schematics and system air flow diagrams showing the location of all control devices.
4. Coordination Drawings verified by the Laboratory Airflow Control System vendor for accessibility of system components, minimum upstream/downstream diameters, coordination with other trades, and physical installation of system components.
5. Laboratory Airflow Control Suppliers own written description for each sequence of operation, to include the following:

   a. Detailed airflow analysis for each pressurization zone showing all supply airflow, exhaust airflow, and offset airflow.
   b. The sequences of operation provided in the submittal by the Laboratory Controls Supplier shall represent the detailed and actual controls required for operation created from the design documentation.
   c. The sequence of operation shall cover normal operation and operation under the various alarm conditions applicable to that system.

6. Air valve & component schedules. This spreadsheet type schedule shall include a detailed line-by-line Bill of Material list for each component, identifying: quantity, part number, description, and associated room number.
7. Catalog cut sheets of all equipment used. This includes, but is not limited to, the following: Routers, Fume Hood Controllers, Air Valves and Actuators, Fume Hood Face Velocity Monitors, fume hood sash sensor, lab control panel, occupancy sensor system components, and so forth.

D. Submit circuit coordination information for review by Engineer and Contractor, indicating circuit requirements by electrical panel; i.e., panel identification and maximum load of each circuit required for control system. Submittal will be returned indicating Engineer's final determination of panels and circuits to be used.

1. Furnish copy of final circuit determinations to DIVISION 16 contractor, for use in preparing panel directories. Information on circuits shall include control component and area served.

E. Furnish point schedule for each controller. Schedule shall include point designation, point description, system location, location of device being controlled, device manufacturer and model number.

F. Furnish instruction manual for review. Manual shall describe function and operation of all control and management system components and shall include trouble-shooting and operating procedures. Manual shall be easily understood for use by Owner's personnel, shall show the total integrated control system, and shall include:

1. System description.
2. Control devices, including number, system, service, location, and normal position of each.
3. Information on sequencing of related devices.
4. Calibration charts and instructions.

G. Submit software manual to Owner for review. Software manual shall describe programming and testing, including:

1. System overview, and detailed description of each software feature.
2. Instructions for user operation, including verifying status and errors, changing passwords, and initiating or disabling control programs.
3. Description of programming language including commands, editing and writing control programs, algorithms, printouts and logs, mathematical calculations and passwords.
4. Copies of application program software and documentation necessary for Owner to interpret program and make any changes desired.
5. Instructions for user programming or reprogramming any portion of DDC system including control programs, algorithms, mathematical equations, variables, setpoints, time periods, messages, and other information necessary to load, alter, test and execute DDC system.
6. Reference summary sheets which compare control programs with pertinent information about hardware and field wiring information.
7. Point identification including terminal number, symbol, engineering units and control program reference number.
8. Field information including DDC system control hardware and locations, device type and function, electrical parameters, and record drawing reference numbers.

H. Submit data summary forms to Owner for review. Forms shall define the following information, for inclusion into DDC system, for each point in DDC system.

1. Description of each piece of equipment and the functions to be controlled.
2. For each DDC function, a listing of digital and/or analog hardware required to interface DDC system to equipment.
3. Listing of digital and analog alarms.
4. Listing of DDC system application programs associated with each piece of equipment. This listing shall include control algorithms and mathematical equations and shall be in easy-to-understand English format.

I. Upon completion of project, submit for review electric control shop drawings corrected for "as-built" conditions. Shop drawings shall include final pressure settings, temperature ranges, throttling ranges and temperature control settings. Three copies of accepted "record" shop drawings shall be furnished to Architect.

J. Submit a DVD-format videotape of instruction training. Videotape shall include training instructions given to Owner's personnel.

1.7 COORDINATION DRAWINGS

A. Before materials are purchased or work is begun, prepare Coordination Drawings showing size and location of mechanical pipes, ducts, equipment and appurtenances, relative to work of other trades.

B. Submit for review coordination drawings signed by following trades: sheet metal, plumbing, fire protection, electrical, and other HVAC trades. Drawings shall be composite construction floor plans, on mylar sepia transparencies. All drawings shall be done in Autocad format.

C. Preliminary coordination drawings shall be prepared as follows:

1. First: Sheet metal trade shall prepare coordination drawings, minimum 1/4 inch=1 foot scale, to be used as composite construction floor plans for coordination of trades. Plans shall show floor and ductwork layouts in detail, including ceiling heights, duct heights and sizes (including insulation), registers and diffusers, and light fixtures.
2. Second: As part of work of SECTION 15300, fire protection trade shall draw fire protection piping, etc., on coordination drawings prepared by sheet metal trade.
3. Third: As part of DIVISION 16, ELECTRICAL WORK, electrical trade shall draw electrical distribution conduits, wires, panels, and other electrical work which must be coordinated with other trades; on coordination drawings which have been prepared by fire protection trade.
4. Fourth: As part of work of SECTION 15400, plumbing trade shall draw waste piping, vent piping, water piping, risers and other plumbing work which must be coordinated with other trades; on coordination drawings which have been prepared by electrical trade.
5. Fifth: As part of work of SECTION 15050, HVAC trades shall draw HVAC piping work which must be coordinated with other trades; on coordination drawings which have been prepared by plumbing trade.
6. Each trade shall use a different color code.

D. Coordination Meeting and Drawing Revisions

1. Sixth: Contractor shall hold a coordination meeting with sheet metal, HVAC, fire protection, electrical and plumbing trades and shall resolve conflicts between trades. Coordination drawings are to assist in identifying trade conflicts.
2. Seventh: Sheet metal trade shall revise coordination drawings to reflect revisions to the various trade work (including sheet metal, HVAC, fire protection, electrical and plumbing trades), as determined by coordination meeting.
3. Eighth: Sheet metal, HVAC, fire protection, electrical and plumbing trades shall sign the revised coordination drawings as indication of their acceptance of the construction layout shown thereon.

E. Sheet metal trade shall submit the revised coordination drawings to Architect for review.

F. Coordination Drawings are for Contractor's and Engineer's use during construction and shall not be construed as replacing shop, "as-built" or record drawings required elsewhere in the Contract Documents.

1.8 SERVICE

A. Provide necessary service, adjusting and checking of control and management systems, at no additional cost to Owner, during 12-month period of warrantee.

1. This shall include service required to correct space airflow temperature alarms and equipment control problems which are the result of control component malfunctions.
2. This shall NOT include service required to correct failure of mechanical equipment provided by others.
3. This shall include full system checkout and calibration during the 12 months of warrantee period.

1.9 INSTRUCTION TRAINING

A. Competent technicians shall provide 16 hours of instruction to Owner's personnel in four 4-hour sessions. Instructions shall include, but are NOT limited to, following:

1. Familiarization with Laboratory Airflow Control system, hardware and operation procedures.
2. Familiarization with Management System Hardware.
3. Use of LACS software to operate and monitor systems.
4. Modifications of software packages.
5. Trouble-shooting and service procedures.
6. LACS maintenance procedures.

B. Instruction shall be made at times and places as convenient and designated by Owner, at least two weeks after acceptance of manuals.

C. All training sessions shall be videotaped for Owner's review.

1.10 ALTERNATE PRICES

A. Refer to the appropriate section in the Architectural Specifications for a complete list of alternate prices to be provided.

B. Based bid shall include a laboratory control system by Tek-Air. An alternate price and associated proposal shall be provided for a Laboratory Airflow Control system by Phoenix Controls. The Phoenix Controls system will not be fully compliant with all requirements of this section, so the following supporting information shall be provided along with the alternate price (may be submitted up to 14 days after bid submission):

1. General overview of proposed system.
2. Specific list of specification sections with which the proposed system is not compliant and details of the deviations from specifications.
3. Outline of any required modifications to other systems, ductwork systems in particular, required for the installation of the alternate system.
4. Outline of major components (with supporting data sheets) to be utilized as part of the proposed system.

C. Alternate systems and equipment other than by Tek-Air shall only be considered for acceptance provided that the substituted equipment be equal to the operational characteristics, capacities, and intent of control sequences specified in Section 17000. Acceptance does not relieve the laboratory controls manufacturer from complying with the minimum requirements or intent of the specification.

D. The Engineer and Owner shall be the sole judges of quality and equivalence of equipment, materials, and methods.

E. Any changes required in ductwork, air handling equipment, controls systems, interfaces or any other changes from the design which would be required for the application of any proposed fume hood control equipment other than the base bid, shall be included in the alternate pricing.

PART 2 - SYSTEM PERFORMANCE REQUIREMENTS/PRODUCTS

2.1 LABORATORY CONTROL SYSTEM - GENERAL REQUIREMENTS

A. This project will be an interoperable combination of a Lab Air Control (LAC) system and a Building Management System (BMS) for non-lab areas. The BMS system is covered in Section 17000.

B. The LAC system will provide lab air control in response to fume hood use and temperature control via chilled beams, reheat coils or increased exhaust flow to force more supply flow and match cooling loads. In addition, the LAC will provide two (2) future control points in each lab for universal inputs for alarm monitoring. For rooms with environmental chambers (CTR), LAC will connect digitally, or with discrete outputs and will report alarms.

C. The successful BMS bidder must provide a router or gateway to the successful LAC bidder, whether by means of a national standard interface such as BACnet or a custom gateway. This interface will occur in the building.

D. The points in the LAC to be *visible* in the BMS are: room setpoint and actual temperatures, room volume flows, offsets, and setpoints as well as supply, hood and general exhaust valve actuator signal (& open); room alarm inputs, air flow alarms and hood status (emergency hi-flow, standard flow, standby reduced flow, below design flow, energy waste flow -sash up with lights off). Room temperature and equipment alarm setpoints are to be adjustable, as well as the night override time and range of the room temperature adjuster through BMS interface.

E. Contract Drawings do NOT show every control device and every location. It shall be understood that Specifications are the primary guide to control requirements and that, unless specifically excluded, every piece of heating and cooling equipment shown on Contract Drawings requires controlling.

F. Control system shall be complete in all respects including:

1. Room, insert and immersion thermostats and sensors
2. Transmitters
3. Relays
4. Valves

5. Dampers
6. Control panels
7. Electronic analog sensors: temperature, pressure, flow and/or others as required
8. Digital controllers
9. Transmission power supply
10. Control wiring
11. Auxiliary devices and accessories
12. Interface with fire alarm system
13. Campus network interface

G. Electronic monitoring system shall be UL listed or ETL approved.

H. Provide power and control wiring (BMS Contractor), conduit, junctions boxes, fittings and other electrical appurtenances that are required for complete and operational control and monitoring systems; conform to electrical standards, codes and requirements specified under DIVISION 16, ELECTRICAL WORK. Power for control system will be obtained from "standby" power panels only.

1. Wiring of control and monitoring devices and circuits carrying voltages up to and including 120 V, unless otherwise indicated.
2. Wiring of 120 VAC power feeds to temperature controls panels, CPU, digital controllers, printer, and other control system equipment.
3. Wiring required for interfacing with building fire alarm, security and emergency generator systems; including wiring between DDC panels and fire alarm system panels.
4. Wiring of control system including wiring from sensors to panels, wiring from panels to CPU, and wiring from CPU to operator's terminal.
5. Wiring of LAC system control and monitoring devices including room controllers, actuators, room sensors, duct sensors, fume hood controllers and communication interface devices
6. Wiring to "Auto" side of hand-off-auto switches on units being controlled as part of work of this Division.
7. Wiring of devices controlled as part of the work of this Division, whether furnished under this Division or another Division. Examples of devices include: alarm device, relay, solenoid valve, actuator, and electro-mechanical device at control cabinet.
8. Wiring of devices providing control inputs, whether furnished under this Division or another Division. Examples of devices include: smoke detector contact; fire alarm relay contact; pressure, temperature, limit level, and motion switches; PE switch; and analog sensor.
9. Wring from temperature control panel to terminal strips.
10. Wiring between panel terminal strips and field-mounted devices.

I. For bidding purposes, unless otherwise indicated, closest appropriate electrical panel shall be assumed to have circuit(s) available for control system use. Coordinate selection of circuits for control system use, by special submittal; refer to paragraph.

J. All control and monitoring devices in this project shall be provided with standby power. Coordinate with work of Division 16 to ensure that all power feeds to control system components come from standby power panels.

K. Power wiring installed and terminated as part of the work of DIVISION 16, ELECTRICAL WORK, shall include:

1. Wiring of devices and circuits carrying voltages GREATER than 120 V, unless otherwise indicated.
2. Wiring of power feeds to disconnects, starters and electric motors.
3. Installation of, and wiring of line power to, fused disconnects for each air compressor.
4. Wiring from disconnects to equipment motor starters.
5. Wiring from equipment motor starters to equipment motors.
6. ALL WIRING (power and control) provided under this section shall be installed in conduit; refer to Division16 requirements.

2.2 TRANSMISSION NETWORK

A. Automatic system shall have multi-drop digital transmission network that provides communication link between operator's terminal and all DDC panels.

B. System shall have error checking feature to ensure signal reliability and shall identify signal transmission network failures. System shall ensure signal quality and strength. System shall support multiple multi-drop trunks.

C. All multi-drop trunks shall be interfaced to the system via standard EIA interface.

D. Transmission network shall be run in conduit. Wiring shall NOT be run in same conduit with fire alarm, security, lighting, building power or other dedicated systems. Where exposed and for ceiling to wall sensor drops within walls, cable will be in conduit.

E. High-level transmission network speed shall be minimum 10 megabit/sec. rate.

2.3 LAB AIR VOLUME CONTROLS

A. The LACS shall be fully stand-alone for each individual laboratory. The system shall not use or rely on information from controllers in other laboratory areas or from outside the laboratory space to control the functions within its laboratory.

B. The LACS shall employ individual Face Velocity controllers and proportionally control the hood's exhaust airflow in a variable volume mode to maintain a constant face velocity over a minimum range of 20% to 100% of full sash opening. Safety and energy savings shall be insured through a corresponding minimum change in hood exhaust flow of 5 to 1.

2.4 LAB OCCUPANCY SENSOR

A. The LAC will monitor the room occupancy sensor contacts provided under Division 16 and use this data to switch the space from occupied to unoccupied mode and back.

B. Response time shall be less than one second with no more than a 5% overshoot or undershoot.

C. The system shall achieve 90% of its commanded volume within one second of the sash reaching 90% of its final value, with a full height sash movement of one second.

2.5 PERFORMANCE

A. The LACS shall respond and maintain specific airflow (± 5%) and stability (< 5% over/undershoot) within one second of a change in room conditions.

B. The LACS shall also maintain inter-system stability within one second of a change in flow to eliminate hunting, system oscillations, and crosstalk between airflow controllers.

C. The LACS shall use volumetric offset control to maintain room pressurization. The system shall respond, recover to, and maintain proper room pressurization polarity (negative or positive) within one second of a change in any room/system conditions such as the raising and lowering of fume hood sash.

D. The LACS shall employ accurate airflow controllers (± 5%) with a minimum 10 to 1 turndown to insure accurate pressurization at low airflows and guarantee the maximum system diversity and energy efficiency.

E. The acceptable method of providing pressure relationships is by *flow tracking* with a fixed offset between the supply and exhaust air flows.

2.6 MATERIALS

A. Fume Hood Components

1. Exhaust airflow volume shall be controlled based on sash position at each laboratory fume hood by a dedicated fume hood controller. The fume hood controller shall be a fully functioning, independent control unit, capable of operating as a stand-alone element in a distributed laboratory airflow control system. Control hardware distribution shall be such that the failure of one controller shall not affect any other fume hoods on the network.
2. The fume hood controller shall consist of a controller, display module, sash position sensors, sash position transmitter and vortek-shedding type duct airflow probe. The sash position sensors shall mount physically on the fume hood sash and frame assemblies and cable-connect to the transmitter. The transmitter shall cable-connect to the controller.
3. The fume hood controller shall also have integral Airflow Measurement Circuitry to receive a signal directly proportional to duct air velocity, from a vortex-shedding type airflow measuring device, for the purpose of monitoring and controlling fume hood airflow volume. The signal shall be digitally processed by the controller, with no analog-to-digital circuitry required, eliminating A/D conversion error. The airflow measurement shall be incorporated in the control sequence as performed by the airflow controller, and communicated to other airflow controllers, via the network, as required. Measurement system accuracy shall be plus or minus 2% of volumetric airflow rate. Turndown capability shall be at least 10:1.
4. The fume hood sash shall be fitted with sash position measuring sensor(s) and associated sash position transmitter. Vertical position measuring devices shall be of the retracting drawstring potentiometer type. The sensors shall be permanently affixed to the fume hood structure and the drawstring affixed to the moving sash frame as best fits the particular hood design. The sash sensor transmitter shall convert potentiometer resistance values to a linear 4-20 mA output signal. The monitor shall have input ports for up to four (4) sash position measuring arrays for application on multiple-sash hoods. The monitor shall be cable-connected to and powered by the controller.

5. Horizontal position sensors shall be magnetic reed switch type, and utilize true proximity location sensing technology as opposed to resistance measurement. The sensor strip shall mount on the hood structure and a magnet shall be affixed to each sash frame. The horizontal sensing system shall be capable of measuring any number of sashes for hood widths up to 16'.
6. The transmitter/controller module shall be microprocessor based. The transmitter module shall be powered by 24VAC. It shall be provided with two 4-20mA analog outputs, two contact inputs, a SPDT alarm relay output, and an RS-485 communications port.
7. The RS-485 communications port shall provide communications with all other lab airflow and fume hood face velocity controllers in the facility via a single network operating at 625 kilobits speed. This shall be a peer-to-peer, token pass type of communications network. The individual controllers shall not be dependent upon this communications port for operation, and communication interrupts shall not slow the control response of the system. In the event that the network continuity is broken, the controllers shall automatically re-configure so that the labs will continue to control.
8. In the controller, the actual fume hood exhaust duct airflow (CFM) shall be compared to the desired fume hood exhaust airflow setpoint. The setpoint shall be continuously reset proportional sash open area, based on sash position.
9. Control equations shall be of the P+I type. Microprocessor based controllers shall read the airflow, perform control calculations, and update the output to the damper a minimum of ten times per second. Floating "Gap" control will not be acceptable.
10. The fume hood controller shall be capable of communicating digitally with the supply and general exhaust airflow controllers and a communications adapter via an RS485 digital peer-to-peer, token-pass network operating at 625 kilobits speed. The adapter shall permit connection to the BAS. All appropriate parameters, including sash position, face velocity, airflow, setpoint, alarm limits, output, and override condition, shall be available for communication to the BAS.
11. The fume hood controller shall be fully configurable via a hand-held setup tool or a PC. The tool shall have a keypad and digital display. Configuration shall be accomplished through simple operator-selectable menus.
12. The Controller shall have unoccupied mode capability. A digital input shall be assignable, through menu selection, to effect the transfer from occupied to unoccupied mode. The "Low Face Velocity Alarm" setpoint shall be replaced by a lower, adjustable, "Low-Low Alarm" setpoint during the unoccupied mode.
13. The unoccupied mode shall have the menu-selectable option for a countdown period with audible and visual warnings of the pending transfer to unoccupied mode. The duration of the countdown period shall be adjustable from 10 to 60 minutes in 10 minute intervals. The adjustable parameters shall be adjusted using the hand-held programming tool or a PC.
14. The fume hood controller shall provide a 4-digit display to indicate the calculated face velocity and actual exhaust airflow in CFM, plus setpoint parameters. Energy use meters shall not be acceptable alternatives to the digital display of the above parameters.
15. A green LED shall indicate a safe condition at the fume hood. A red LED indicator shall display either a high or low face velocity alarm condition. When an alarm condition occurs, the alarm LED shall flash and the alarm beeper shall sound. The operator shall be able to silence the beeper through a mute button located on the face of the controller.
16. The display shall provide the option to read in "Alpha" mode instead of numeric. The "Parameters" button on the face of the display shall allow the operator to scroll through all operating parameters and alarm setpoints, which shall be displayed on the LCD, including but not limited to:

a. Controller Software Revision Number
b. Controller Output Level, %
c. Sash Position, %
d. Calculated Face Velocity, FPM
e. Exhaust Airflow Measurement, CFM
f. High Airflow Alarm Setpoint, CFM
g. Low Airflow Alarm Setpoint, CFM
h. Low-Low Airflow Alarm Setpoint, CFM

2.7 AIRFLOW CONTROL VALVE - GENERAL

A. The airflow control valve components:

1. The Airflow Control Valve shall be a multi-chamber Phoenix Controls Corporation medium-pressure Traccell Venturi Valve.
2. The Airflow Control Valve shall consist of a compression section, two airflow control surfaces, factory-mounted digital airflow measuring device and factory-mounted high speed actuator.
3. The compression section shall divide the airstream into at least two separate airstreams. Each airstream shall be approximately equal in size and the total open area shall be approximately 50% of the duct open area. The divided sections shall cause compression therefore creating a more laminar flow for better airflow measurement and turndown. The compression section shall be of an aerodynamic shape with a static regain section to insure minimal pressure drop. The valve shall not require any duct straight runs either upstream or downstream of the airflow valve to achieve required performance.
4. Airflow control valves shall be a linear type and shall operate with a minimum turndown ratio of 8 to 1. Accuracy of the airflow valve shall be 5% of reading in the 8 to 1 range of the damper.
5. The airflow control valve shall respond within one second of a change in duct static pressure when provided with factory controls.
6. Valve shall be capable of being mounted in horizontal, vertical or 45 degree ductwork without the need for recalibration. It shall not be required to specify mounting plane when ordering valve to simplify installation of valves in the field.
7. Valves for fume hood or other corrosive service shall incorporate stainless steel materials of all components in contact with the airstream. Valves made of aluminum or steel that are coated will not be acceptable. Valves for non-corrosive service shall be made of galvanized steel. Because a coated valve cannot be welded or screwed, venturi valves must be provided with drawband clamps for connection to ductwork. This will also allow removal of the venturi valve for required recalibration. These clamps shall be provided at no additional cost to the customer.
8. Airflow control valves shall operate without linkages, springs, levers, or bearings in the airstream due to the effect of fume hood exhaust on those materials, and shall exhibit no deadband or hysteresis. Airflow control valves shall be field selectable fail-safe to either the open or closed position depending on the application. For airflow valves with linkage, springs, levers or bearings in the airstream, access doors must be provided upstream and downstream of each and every damper for inspection of those devices for maintenance purposes.

9. All critical components of the airflow control valve shall be easily accessible from one side of the valve. All linkages shall be out of the airstream to avoid possible corrosion and loss of accuracy.
10. Valve shall be capable of being used in a demand based static pressure reset control scheme. This scheme requires each valve to communicate the valve position as 0-100% open/closed via communications to the BMS where the reset control scheme is set up. Venturi valves shall not be acceptable for static pressure reset control because their valve position is not indicative of the static pressure in the duct.
11. The airflow valve shall be complete with a digital vortex type airflow-sensing device providing true airflow feedback for the system. Airflow valves using mechanical means for creating pressure independence will not be acceptable. If an airflow valve such as a venturi valve is submitted that uses mechanical means for creating pressure independence such as springs and plungers, the valve manufacturer shall provide a 5-year service contract to the owner at no additional charge. The contract shall provide recalibration of the mechanical device using NIST traceable air stations and instrumentation having a combined accuracy of at least ±1% of signal over the entire range of measurement. These mechanical devices shall be further calibrated and their accuracy verified to ±5% of signal at a minimum of eight different airflows across the full operation flow and static pressure range of the device. This service shall be provided twice annually for 5 years with complete service reports provided to the owner.
12. Airflow measuring devices shall be of the Vortex Shedding type, capable of continuously monitoring the airflow volume of the duct served and electronically transmitting a signal linear to the airflow volume. A Vortek airflow sensor shall be provided in each chamber of the airflow control valve. Airflow measuring devices shall be capable of measuring velocity over the full range of 400 to 5000 FPM. Pitot or Thermal Airflow sensors shall not be acceptable.
13. Individual airflow sensors shall be of rugged construction, and shall not require special handling during installation. Sensors shall be mounted on support bars. Standard materials shall be manufactured of corrosion resistant CPVC and ABS.
14. Individual velocity sensors shall not be affected by dust, temperature, pressure, or humidity. The sensors shall be passive in nature, with no active parts within the air stream. The output from individual sensors shall be linear with respect to airflow velocity and shall be capable of sensing airflow in one direction only. The velocity sensors shall not require calibration.
15. Velocity measurements from individual sensors shall be summed in the associated Airflow Controller via integral Airflow Measurement circuitry or an integral Airflow Transmitter. The measurement shall be input and conditioned digitally to eliminate Analog-to-Digital conversion error. The airflow measurement shall be incorporated in the control sequence as performed by the Airflow Controller, and communicated to other Airflow Controllers, via the network, as required. Measurement system accuracy shall be plus or minus 2% of volumetric airflow rate. Turndown capability shall be at least 8:1.
16. Velocity sensing methods other than those specified shall not be acceptable. For another velocity sensing method to be considered it must provide the basic requirements for linear electronic output, turndown, accuracy, materials of construction, and output signal. If differential pressure devices are to be considered, dual differential pressure transmitters, the span of the lower transmitter being one tenth the span of the higher, with an accuracy not less than +/- 0.5%, shall be utilized to provide the required turndown. Orifice type devices shall have a Beta ratio of 0.7 or less, and shall be installed in accordance with ASME MFC-3M guidelines for up and downstream conditions.

17. The airflow sensors shall be easily accessible in the valve for inspection without removing valve from the duct.
18. Use of valve or damper position for calculation of airflow volume is not acceptable. Direct airflow measurements must be taken.
19. Sensing methods employing thermal devices in the airstream shall not be acceptable due to their susceptibility to dust and dirt buildup in and exhaust airstream which could cause serious errors in readings and resultant safety issues in the laboratory.
20. Airflow Control Valve shall have factory installed electric actuator which shall operate on 24VAC. Actuator shall accept either a 4-20maDC or 2-10VDC signal and shall modulate the valve over the range of CFM. The actuator shall modulate the valve between 0 to full scale CFM in less than 2 seconds.

2.8 AIRFLOW CONTROL VALVE SOUND ATTENUATORS

A. Sound cancellation devices shall be provided for all supply and general exhaust with no future use in corrosive environments and used in conjunction with general exhaust or supply airflow control devices. Sound attenuating neutralizers shall be constructed using 24-gauge galvanized steel or other suitable material used in standard duct construction.

B. Sound cancellation devices shall be for the high frequency bands of 1000, 2000 and 4000 Hz. Device shall consist of resonator chambers that are tuned to the output frequencies of the valve.

C. The device shall have no porous surfaces.

D. The device shall be constructed with a continuous sealed seam.

E. Device to be constructed of 24 ga. Galvanized steel.

F. Pressure drop across device shall be less than 0.6"wc for the 8 in valve and 0.3"wc (75 Pa) for all others.

G. Unit shall be available for all valve configurations including single 8 in, single 10 in, single 12 in, dual 10 in, dual 12 in, triple 12 in and quad 12 in.

2.9 SHUT-OFF AIR VALVES (SERVING SNORKEL EXHAUST)

A. Air valves serving the snorkel exhaust and controlled by the PCMs shall be include the low-speed electric actuator and shall be used to modulate the airflow over the range of the specific valve size. The maximum time to modulate from minimum to maximum flow shall be less than 90 seconds. A UL listed electronic actuator shall be factory mounted to the valve. The actuator shall have sufficient torque to modulate the airflow against the maximum duct static pressure (within product specifications). Loss of main power shall cause the valve to maintain its last airflow position. This position shall be maintained until power is restored.

B. Air valves shall in all ways comply with the Specification Section 2.6 Airflow Control Device – General and 3.3 Exhaust and Supply Airflow Device Controller. Additionally, the Shut-off valve shall be able to provide low leakage isolation of the HVAC system from the controlled room.

C. Leakage must be less than 5 CFM at 4 inches WC.

D. Close-off must be mechanically driven by electric actuator.

E. Actuation Speed of response:

1. Low-speed electric response time of less than one minute shall be available.
2. High-speed electric response time of less than one second shall be available.

F. Failsafe:

1. Low-speed actuator: Fail to last position.
2. High-speed actuator: Fail open, Fail closed or Fail to last position.
3. Fail open is unacceptable in the Shut-off mode of operation.

G. Shut-off mode initiation shall be provided when all snorkel dampers are closed.

2.10 SNORKEL PANELS

A. The Laboratory Airflow Control System supplier shall provide one (1) control panel for each laboratory area that includes more than three snorkel type fume extractors.

B. The control panel shall, at a minimum, include the following:

1. One manual control switch for each snorkel fume extractor.

   a. Switch shall have separate contacts to operate the snorkel fume extractor motorized shutoff damper and to provide a signal to the Phoenix Programmable Control Module (PCM).
   b. Switch may optionally utilize toggle or rotary actuation.

2. One pilot lamp per switch to indicate that the fume extractor has been commanded to the "OPEN" position.

   a. The pilot lamp shall utilize an LED. Incandescent lamps are not acceptable.

3. Labeling as appropriate to indicate the snorkel fume extractor controlled by the switch and direction of operation.

2.11 PROGRAMMABLE CONTROLLER MODULES (TO BE USED FOR SNORKEL CONTROL)

A. The control system shall have an optional Programmable Control Module (PCM) that allows control and system functions, and integrates completely with the network at the room level.

B. PCMs shall be available in the following configurations and selected to provide the functionality as described in the sequence of operations.

1. Six, eight, or 12 universal inputs.
2. Seven, eight, or 12 analog/digital outputs.
3. Programmable control functions, including:

a. 10 PID control loops
b. 15 internal timers
c. 50 internal variables and 50 internal constants
d. 18 configurable network variable inputs and outputs (36 total inputs and outputs)
e. Multiple logic and arithmetic functions
f. Data logging capability up to 12,000 events
g. Status indicators for outputs

C. The following input/output configurations shall be included:

1. Voltage

a. Linear voltage signal
b. Scaled 0 to 10 Vdc
c. Accuracy ±0.5%

2. Current

a. Linear current signal
b. Scaled from 4 to 20 mA (external resistor)
c. Accuracy ±0.5%

3. Resistance (various linear and non-linear resistive inputs)

a. Thermistor, 10 K ohms, range -40°F to 302°F (-40°C to 150°C), accuracy ±0.9°F
b. Platinum RTD, 1 K ohms, range -40°F to 167°F, accuracy ±1.8°F (1°C), resolution 0.54°F (0.3°C)
c. Potentiometer 0 to 10 K ohms or 0 to 100 k, accuracy ±0.5%

4. Digital dry contact.
5. On/off or pulsed input.
6. The relay output option shall be rated at five amps at 14 to 24 Vdc and jumper selectable (either NO or NC).
7. The tri-mode output may be configured as a linear voltage output, a two state switched digital output, or a pulse width modulating (PWM) output.

a. Maximum current of 60 mA @ 12 Vdc
b. Current output option shall be available on specific controllers and scaled to modulate from four to 20 mA (linear) to a maximum load of 500 Ohms

D. Control functions

1. The PCM can be programmed in a BASIC-like language that incorporates, at a minimum, the following functions:

a. Conditional IF/THEN, AND/OR, ELSE logic
b. Comparative GREATER THAN, LESS THAN, EQUAL TO
c. Calculations, such as AVERAGE, +, -, *, /
d. Up to 10 configurable PID control loops

e. Up to 15 internal timers
f. Up to 50 defined variables
g. Up to 50 defined constants
h. HI-SELECT, LO-SELECT, and FAN-IN functions

E. Application capabilities

1. As a stand-alone controller, sensors and switches may be connected and perform required control sequences using the built-in functions.
2. Where required, PCM units shall be provided as input/output expansion modules where temperature, humidity, binary inputs, or other devices can be used to pass information to the Celeris network and may be included in control sequences. These data points may also be passed over the network to the building management system (BMS) for monitoring.
3. As described in the sequences of operation, PCM shall be provided as an integrated controller that may pass information to the Celeris valve controllers to supplement control routines. This technique shall be used in rooms with special temperature control requirements to allow overall room control with multiple heating and cooling control loops.

F. Power

1. The device shall be powered by 24 Vac or 24 Vdc. Power consumption shall range from 5 to 15 VA, depending on the type of controller.
2. The PCM shall be UL listed and CE certified.

2.12 CONTROL FUNCTIONS

A. Refer to Section 17000 for specific laboratory space control sequence.

B. The airflow control devices shall utilize a peer-to-peer, distributed control architecture to perform room level control functions. Master/Slave control schemes shall not be acceptable. Control functions shall, at a minimum, include, pressurization, temperature control and respond to occupancy and emergency control commands.

C. Pressurization Control:

1. The LACS shall control supply and auxiliary exhaust airflow devices in order to maintain a volumetric offset (either positive or negative). Offset shall be maintained regardless of any change in flow or static pressure. This offset shall be field adjustable and represents the volume of air, which will enter (or exit) the room from the corridor or adjacent spaces.
2. The pressurization control algorithm shall sum the flow values of all supply and exhaust airflow devices and command appropriate controlled devices to new setpoints to maintain the desired offset. The offset shall be adjustable. It will handle:

a. Up to three (3) non-networked devices providing a linear analog flow signal.
b. Any number of constant volume devices where the total of supply devices and the total of exhaust devices may be factored into the pressurization control algorithm.

3. Volumetric offset shall be the only acceptable means of controlling room pressurization. Systems that rely on differential pressure as a means for control shall provide documentation to demonstrate that space pressurization can be maintained if fume hood sashes are changed at the same time a door to the space is opened.
4. The pressurization control algorithm shall support the ability to regulate the distribution of total supply flow across multiple supply airflow control devices in order to optimize air distribution in the space.

D. Temperature Control:

1. The LACS shall regulate the space temperature through a combination of volumetric thermal override and control of reheat coils and/or auxiliary temperature control devices. Separate cooling and heating setpoints shall be writable from the BMS, without the option of a local offset adjustment.

E. Occupancy Control

1. The LACS shall have the ability to change the minimum ventilation and/or temperature control setpoints, based on the occupied state, in order to reduce energy consumption when the space is not occupied. The occupancy state will be set through the use of space occupancy sensors (provided under Division 16).

F. Emergency Mode Control

1. The LACS shall provide a means of overriding temperature and pressurization control in response to a command indicating an emergency condition exists and airflow control devices are to be driven to a specific flow setpoint. The emergency control modes may be initiated either by a local contact input, or BMS command (from Aircuity readings).
2. Once an emergency mode is invoked, pressurization and temperature control are overridden for the period that the mode is active. Emergency modes shall have a priority scheme allowing a more critical mode to override a previously set condition.

G. Local Alarm Control

1. The LACS shall provide the means of summing selective alarm activity at the room level network and generating a local alarm signal. The local alarm signal may be directed to any available output, as well as to the BMS. The alarm mask may be configured differently for each room level system.
2. The LACS will have the capacity to monitor with two universal inputs analog or binary process alarm data in each room.

H. All points shall be available through the Modbuss/Olink interface to the building management system (BMS) for trending, archiving, graphics, alarm notification and status reports. LACS performance (speed, stability and accuracy) shall be unaffected by the quantity of points being monitored, processed or controlled.

I. Refer to the BMS specification for the required input/output summary for the necessary points to be monitored and/or controlled.

2.13 INTERFACE TO BUILDING MANAGEMENT SYSTEM

A. The LACS network shall have the capability of digitally interfacing with the BMS. The required software interface drivers shall be developed and housed in a Gateway, a dedicated interface device furnished by BMS Contractor and installed in the building.

B. Any, or all, room level points shall be available to the BMS for monitoring or trending. The Gateway shall maintain a cache of all points to be monitored by the BMS. The room level airflow control devices shall update this cache continually.

C. The LACS area building level network shall be a high speed (min 1.0 mbps) communications protocol. The building level network shall support up to one hundred (50) sub nets, or pressurization zones, or six thousand (3,000) data points.

D. A commercially available interface card shall be provided with the LACS network in order to connect the communications gateway to the LACS building level network.

E. A commercially available network interface card shall be provided with the communication Gateway to interface with the BMS (BACnet).

PART 3 - EXECUTION

3.1 INSTALLATION

A. The LACS Contractor shall install the sash sensors, interface boxes, and the monitor on the fume hood. Vertical sash sensors and their stainless steel cables shall be hidden from view. Horizontal sash sensor bars shall be affixed to the individual sash panels. Sash interface boxes with interface cards shall be mounted within an accessible location.

B. The ATC contractor (spec section 17000) shall install all routers, repeaters, programmable controller modules and snorkel panels in an accessible location in or around the designated laboratory room.

C. The ATC Contractor (spec section 17000) shall install an appropriately sized and fused 24 VAC transformer suitable for NEC Class II wiring.

D. The ATC Contractor (spec section 17000) shall terminate and connect all cables as required. All cable and connectors shall be furnished by the LACS contractor. All wiring serving the LACS shall be in conduits. It shall be secured to building structure in a neat manner in other locations.

E. Calibrated, factory-insulated airflow control valves shall be installed in the duct work by the mechanical contractor. All reheat coils, transitions, and insulation shall be furnished and installed by the mechanical contractor.

F. Exhaust valve linkages shall be connected by the LACS contractor.

G. The ATC Contractor (spec section 17000) shall wire a dedicated, single phase 120 vac power circuit to the laboratory control unit and/or wall-mounted power supply. Sources for 120-volt power are shown on the drawings.

H. The ATC contractor (spec section 17000) and the LACS contractor are responsible for all labor and material of the complete LACS installation.

3.2 SYSTEM START-UP

A. System start-up shall be provided by a factory-authorized representative of the LACS manufacturer. Said start-up shall include setting of the fume hood face velocity and electronic verification of supply, make-up, and general exhaust airflows. The balancing contractor shall be responsible for final verification and reporting of all airflows.

B. System start-up will include a demonstration that all the laboratory airflow performance requirements of the specification are met. The LACS manufacturer shall provide a visual demonstration that the laboratory airflow systems are maintaining specified hood containment performance requirements.

C. The LACS manufacturer shall demonstrate that with the specified room offset the systems are maintaining the proper room pressurization polarity under static conditions and can recover to the proper polarity within one second of a change in room/system conditions, such as the raising and lowering of any or all hood sashes. Verification shall be provided by a permanent or temporary visual indication; i.e., smoke wand, or streamers taped to the undercut of the door.

D. If the airflow performance requirements cannot be demonstrated, then the LACS manufacturer shall be responsible for any costs and labor necessary to meet the minimum performance requirements.

END OF SECTION 17100

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SECTION 232113 – HYDRONIC PIPING

SECTION 232113 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes piping, special-duty valves, and hydronic specialties for hot-water heating, chilled-water cooling, and condenser water systems; makeup water for these systems; blowdown drain lines; and condensate drain piping.

B. Related Sections include the following:

1. Division 23 Section "Basic Mechanical Materials and Methods" for general piping materials and installation requirements.
2. Division 23 Section "Hangers and Supports" for pipe supports, product descriptions, and installation requirements. Hanger and support spacing is specified in this Section.
3. Division 23 Section "Valves" for general-duty gate, globe, ball, butterfly, and check valves.
4. Division 23 Section "Meters and Gages" for thermometers, flow meters, and pressure gages.
5. Division 23 Section "Mechanical Identification" for labeling and identifying hydronic piping.
6. Division 23 Section "Hydronic Pumps" for pumps, motors, and accessories for hydronic piping.
7. Division 23 Section "HVAC Instrumentation and Controls" for temperature-control valves and sensors.
8. Division 23 Section "Mechanical Seismic Restraint & Vibration Isolation" for flexible pipe connectors.

1.3 SUBMITTALS

A. Product Data: For each type of special-duty valve indicated. Include flow and pressure drop curves based on manufacturer's testing for diverting fittings, calibrated balancing valves, and automatic flow-control valves.

B. Shop Drawings: Detail fabrication of pipe anchors, hangers, special pipe support assemblies, alignment guides, expansion joints and loops, and their attachment to the building structure. Detail location of anchors, alignment guides, and expansion joints and loops.

C. Welding Certificates: Copies of certificates for welding procedures and personnel.

D. Field Test Reports: Written reports of tests specified in Part 3 of this Section. Include the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Failed test results and corrective action taken to achieve requirements.

E. Maintenance Data: For hydronic specialties and special-duty valves to include in maintenance manuals specified in Division 1.

1.4 QUALITY ASSURANCE

A. DEFINITIONS:

1. Welding Procedure Specification, WPS. It must have a specific procedure number, date written and identification of the person who wrote it.
2. Procedure Qualification Record, PQR. This is the record that indicates the procedure to be followed is a valid procedure.
3. Welding Operator Qualifications test, WPQ. This is a record, including bend test results or radiographic test results, for each welder. The WPQ is based on that company's procedure. It shall be certified and dated by the test agency within 12 months of the start of the work for the welder.

B. Welding and brazing procedure qualifications:

1. Contractor shall submit for review the Contractor's standard welding and brazing procedures (forms WPS or BPS). Procedure shall be submitted on PQR form as described in the ASME Boiler and Pressure Vessel Code.
2. The PQR shall be supported by the appropriate WPS and BPS.

C. All welders shall be certified to the WPS and BPS as listed on the Contractor's PQR. Certifications are to be performed by an independent testing laboratory within twelve months prior to the commencement of work.

1. Each welder is to stamp the pipe adjacent to each weld performed by him/her. The Contractor is required to, via the submittal process, provide a list of each welder's name and the mark used by each welder.

D. Tack welding may be performed by non-certified welders. All tack welds, whether performed by certified or non-certified welders, must be ground out and removed.

E. Contractor option: In lieu of submitting the contractor's welding procedures, the contractor may adopt Dartmouth College's procedure #1.1.1.2 Rev. 0 and ASME/ANSI B3 1.1, latest edition. The welding procedure is available from DC Facilities Operation and Management.

F. No welding may take place until a satisfactory reviewed submittal is complete. It is the contractor's responsibility to provide a submittal in a timely fashion so as not to delay the project.

G. Soldering and brazing procedures for refrigeration piping shall conform to ANSI B9. 1 "Standard Safety Code for Mechanical Refrigeration."

H. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

1.5 COORDINATION

A. Coordinate layout and installation of hydronic piping and suspension system components with other construction, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

B. Coordinate pipe sleeve installations for foundation wall penetrations.

C. Coordinate piping installation with roof curbs, equipment supports, and roof penetrations. Roof specialties are specified in Division 7 Sections.

D. Coordinate pipe fitting pressure classes with products specified in related Sections.

E. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into base. Concrete, reinforcement, and formwork requirements are specified in Division 3 Sections.

F. Coordinate installation of pipe sleeves for penetrations through exterior walls and floor assemblies. Coordinate with requirements for firestopping specified in Division 7 Section "Through-Penetration Firestop Systems" for fire and smoke wall and floor assemblies.

PART 2 - PRODUCTS

2.1 GENERAL

A. All pipe and fittings shall be fabricated in the USA or Canada.

B. Elbows for all pipe sizes over 2" diameter shall be long radius type (1.5 pipe diameter to centerline of pipe).

C. Use reducers, increasers, or reducing tees for change of pipe size. Bushings are not allowed.

D. Forged steel (3,000#) branch connectors (ie "Weld-O-Lets", "Thread-O-Lets"), per the limits set forth in Part 3 of this section, may be used to create branch connections in steel piping systems. All branch connectors shall be 3,000# fittings.

2.2 COPPER TUBE AND FITTINGS

A. Annealed Temper Copper Tubing:

ITEM	SIZE	ASTM SPEC NO.	MATERIAL WEIGHT & TYPE
Pipe	≤3"	B88 copper	Type L, drawn
Fittings	≤3"	Wrought copper or cast bronze	ANSI B16.22 & B16.18
Bolts	Per flange standard	A193, grade B7 carbon steel	Hex head (ANSI B18.2.1), B1.1, Class 2A course thread
Nuts	Per flange standard	A194, Grade 2H, Carbon steel	Heavy hex (ANSI B18.2.2), B1.1, Class 2B course thread
Gaskets	Per flange standard	1/16" Compound fiber	

2.3 STEEL PIPE AND FITTINGS

A. Steel Pipe, NPS 2 and Smaller: ASTM A 53, Type S (seamless) or Type F (furnace-butt welded), Grade A, Schedule 40, black steel, threaded ends.

B. Steel Pipe, NPS 2-1/2 through NPS 12: ASTM A 53, Type E (electric-resistance welded), Grade A, Schedule 40, black steel, plain ends.

C. Steel Pipe: Threaded and welded ends.

ITEM	*SIZE*	*ASTM SPEC NO.*	*MATERIAL WEIGHT & TYPE*
Pipe	all sizes	A53, grade B, type S	Schedule 40, ANSI B36.10
Fittings	≤2"	A197, Malleable Iron	Standard, threaded, ANSI B16.3
	>2"	A234, WPB, wrought carbon steel	Schedule 40, butt weld, ANSI B16.9
Flanges	≤2"	A105, forged carbon steel	Class 150, RF, threaded, ANSI B 16.5
	>2"	A105, forged carbon steel	Class 150, RF, weld neck or slip on, ANSI B 16.5
Bolts		A193, grade B7 carbon steel	Hex head (ANSI B18.2.1), B1.1, Class 2A course thread
Nuts		A194, Grade 2H, Carbon steel	Heavy hex (ANSI B18.2.2), B1.1, Class 2B course thread
Gaskets	Per flange standard	A304, stainless steel, Grafoil filled, spiral wound	Class 150, RF, ring style, ANSI B16.20

D. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300.

E. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300.

F. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced.

G. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

H. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

1. Material Group: 1.1.
2. End Connections: Butt welding.
3. Facings: Raised face.

I. Flexible Connectors: Refer to Section 15071.

J. Welding Materials: Comply with Section II, Part C, of the ASME Boiler and Pressure Vessel Code for welding materials appropriate for wall thickness and for chemical analysis of pipe being welded.

K. Gasket Material: Thickness, material, and type suitable for fluid to be handled; and design temperatures and pressures.

2.4 PLASTIC PIPE AND FITTINGS

A. CPVC Plastic Pipe: ASTM F 441, Schedules 40 and 80, plain ends.

B. PVC Plastic Pipe: ASTM D 1784, 1785, Schedule 80, plain ends.

C. CPVC Plastic Pipe Fittings: Socket-type pipe fittings, ASTM F 438 for Schedule 40 pipe; ASTM F 439 for Schedule 80 pipe.

1. CPVC Solvent Cement: ASTM F 493.

D. PVC Plastic Pipe Fittings: Socket-type pipe fittings ASTM D 2467, ASTM D2464 for Schedule 80 pipe.

1. PVC Solvent Cement: ASTM D 2564.

E. PVC piping and fittings for buried chilled water service; manufactured from Type I, Grade I Polyvinyl Chloride per ASTM D1784.

F. PEX pipe and fittings for medium temperature chilled water branch piping 1" and smaller.

2.5 VALVES

A. Globe, check, ball, and butterfly valves are specified in Division 15 Section "Valves."

B. Refer to Part 3 "Valve Applications" Article for applications of each valve.

C. Pressure-Reducing Valves: Diaphragm-operated, bronze or brass body with low inlet pressure check valve, inlet strainer removable without system shutdown, and noncorrosive valve seat and stem. Select valve size, capacity, and operating pressure to suit system. Valve shall be factory set at operating pressure and have capability for field adjustment.

D. Safety Valves: Diaphragm-operated, bronze or brass body with brass and rubber, wetted, internal working parts; shall suit system pressure and heat capacity and shall comply with the ASME Boiler and Pressure Vessel Code, Section IV.

2.6 HYDRONIC SPECIALTIES

A. Manual air vents shall be bronze body and nonferrous internal parts; 150 psig working pressure, 225°F operating temperature; manually operated with screwdriver or thumbscrew; and having 1/8" discharge connection and 1/2" inlet connection.

1. Bell and Gossett - No 4V
2. Taco, Inc. – 417
3. Armstrong Pumps, Inc. - #72

B. Automatic air vents shall be cast iron body with stainless steel, brass, EPDM, and silicone rubber internal components, two-stage air relief, 150 psig maximum pressure, and 250°F maximum temperature.

1. Bell and Gossett - #107 High Capacity Air Vent
2. Taco – Hy-Vent
3. Spirax Sarco – 1 3WS

C. Diaphragm-type expansion tanks shall be constructed of welded carbon steel. Separate air charge from system water to maintain design expansion capacity, by means of a flexible diaphragm securely sealed into tank. Provide taps for pressure gage and air charging fitting, and drain fitting. Support vertical tanks with steel legs or base; support horizontal tanks with steel saddles. Tank, with taps and supports, shall be constructed, tested, and labeled in accordance with ASME Pressure Vessel Code, Section VIII, Division 1. Expansion tanks must be gravity drainable.

1. Bell and Gossett
2. Taco, Inc.

D. Air separator ~2" shall be welded black steel; ASME constructed and labeled for minimum 125 psig water working pressure and three (3) 50°F operating temperature; perforated stainless steel air collector tube designed to direct released air into compression tank; tangential inlet and outlet connections; threaded blowdown connection; sized as required for full system flow capacity. Provide strainers where scheduled.

1. Bell and Gossett – Rolairtrol
2. Spirotherm - Spirovent
3. Taco, Inc. - Air Separator

E. Y-Pattern Strainers: 125-psig working pressure; cast-iron body (ASTM A 126, Class B), flanged ends for NPS 2-1/2 and larger, threaded connections for NPS 2 and smaller, bolted cover, perforated 304 stainless-steel basket, (20 mesh perforations) and bottom drain connection.

F. Basket Strainers: 125-psig working pressure; high-tensile cast-iron body (ASTM A 126, Class B), flanged-end connections, bolted cover, perforated stainless-steel basket, and bottom drain connection.

G. T-Pattern Strainers: 750-psig working pressure; ductile-iron or malleable-iron body, stainless-steel basket with 57 percent free area; removable access coupling and end cap for strainer maintenance.

H. Flexible Connectors: Refer to Section 15071.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Hot and Chilled Water, NPS 2 and Smaller: Aboveground, use Type L drawn-temper copper tubing with soldered joints or Schedule 40 steel pipe with threaded joints. Belowground or within slabs, use Type K annealed-temper copper tubing with soldered joints. Use the fewest possible joints belowground and within floor slabs.

B. Hot and Chilled Water, NPS 2-1/2 and Larger: Schedule 40 steel pipe with welded and flanged joints or grooved mechanical-joint couplings.

3.2 VALVE APPLICATIONS

A. General-Duty Valve Applications: Unless otherwise indicated, use the following valve types:

1. Shutoff Duty: Ball and butterfly valves.
2. Throttling Duty: Globe, ball, and butterfly valves.

B. Install shutoff duty valves at each branch connection to supply mains, at supply connection to each piece of equipment, unless only one piece of equipment is connected in the branch line. Install throttling duty valves at each branch connection to return mains, at return connections to each piece of equipment, and elsewhere as indicated.

C. Install safety valves on hot-water generators and elsewhere as required by the ASME Boiler and Pressure Vessel Code. Install safety-valve discharge piping, without valves, to floor. Comply with the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, for installation requirements.

D. Install pressure-reducing valves on hot-water generators and elsewhere as required to regulate system pressure.

3.3 PIPING INSTALLATIONS-INDOOR PIPING

A. Refer to Division 23 Section "Basic Mechanical Materials and Methods" for basic piping installation requirements.

B. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

C. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

D. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

E. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

F. Unless otherwise indicated, install branch connections to mains using tee fittings in main pipe, with the takeoff coming out the bottom of the main pipe. For up-feed risers, install the takeoff coming out the top of the main pipe.

G. Install strainers on supply side of each control valve, pressure-reducing valve, solenoid valve, in-line pump, and elsewhere as indicated. Install NPS 3/4 nipple and ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.

H. Anchor piping for proper direction of expansion and contraction.

I. Use minimum three elbows to form a swing connection for supply and return runouts to risers and/or heating equipment.

3.4 PIPING INSTALLATIONS-BURIED PIPING

A. All pipe and fittings shall be carefully handled from the truck onto the ground and into the trench or excavation so as to prevent damage to the pipe. Pipes shall be kept free of dirt and foreign material especially on the inside. Joint ends of pipe shall especially be kept clean.

   1. Pipe stored on site shall be protected from direct sunlight and suitably ventilated.

B. Pipe shall be installed at a minimum depth of 60" to top of pipe.

C. Alignment and placement of pipe

   1. Stakeout of work and setting of line and grade is the responsibility of the Contractor.
   2. Jointing of pipe and fittings shall be done in accordance with the printed recommendations of the manufacturer and as specified. The bell end of the pipe shall be thoroughly cleaned. The joint surfaces and the gasket shall be lubricated prior to making up the joint. The position of the gasket shall be checked to insure the joint has been properly made and is watertight. Care shall be taken not to exceed the manufacturer's recommended maximum deflection allowed for each joint.
   3. Keep pipe clear of all debris and dirt before installing and prevent trench material from entering pipe during installation. When pipe laying is not in progress, close open ends of pipe with temporary watertight plugs. If water exists in trench, do not remove plug until danger of water entering pipe has been prevented.
   4. Fitting and valves shall be restrained for the minimum lengths listed on the following table:

MINIMUM RESTRAINED LENGTHS

FITTING	*RESTRAINT LENGTH*
12" - 45° Bend	16-feet in each Direction
12" - 22-1/2° Bend	8-feet in each Direction
12" - 11-1/4° Bend	4-feet in each Direction
12"Vertical	
Upper 45° Bend	30-feet in each Direction
Lower 45° Bend	10-feet in each Direction
10" - 45° Bend	12-feet in each Direction
10" - 22-1/2° Bend	6-feet in each Direction
10" - 11-1/4° Bend	4-feet in each Direction
10" Vertical Offset	
Upper 45° Bend	24-feet in each Direction
Lower 45° Bend	8-feet in each Direction
6" - 90° Bend	12-feet in each Direction
6" - 45° Bend	6-feet in each Direction
6" - 22-1/2° Bend	4-feet in each Direction
6" Vertical Offset	
Upper 45° Bend	16-feet in each Direction
Lower 45° Bend	5-feet in each Direction
4" - 90° Bend	14-feet in each Direction
4" - 45° Bend	6-feet in each Direction
4" Vertical Offset	
Upper 45° Bend	12-feet in each Direction
Lower 45° Bend	4-feet in each Direction
12"x12"x12" Tee	6-foot in Branch
10"x10"x6" Tee	2-foot in Branch
12"x12"x4" Tee	2-foot in Branch
12" Valve or Dead-end	72-feet in each Direction

FITTING	*RESTRAINT LENGTH*
10" Valve or Dead-end	64-feet in each Direction
8" Valve or Dead-end	48-feet in each Direction
6" Valve or Dead-end	38-feet in each Direction
4" Valve or Dead-end	30-feet in each Direction
12"x10" Reducer	34-feet in Larger Diameter Direction
10"x8" Reducer	22-feet in Larger Diameter Direction
8"x6" Reducer	24-feet in Larger Diameter Direction

Length shown are based on 100 psi test pressure, 5-foot bury, soil type GP, trench Type 3, and 2:1 safety factor. Changes in conditions will require revision in lengths.

5. Restrained push on joints shall be installed with specified joint restraints. Restraints shall be installed in full accordance with the manufacturers instructions.
6. During backfilling operations, a brightly colored polyethylene tape manufactured specifically for warning and identification of buried utility lines shall be buried 2 feet below the ground surface along the entire length of the main. Tape shall be provided in rolls, 6-inches minimum width, color coded for intended service with warning and identification imprinted in bold black letters continuously and repeatedly over entire tape length. Warning and identification shall be "CAUTION BURIED CHILLED WATER MAIN BELOW" or similar wording. Code and letter coloring shall be permanent, unaffected by moisture and other substances contained the trench backfill material.

D. Flushing of the chilled water main

1. Prior to pressure testing, the entire line shall be water jetted to remove any rocks or debris which may have inadvertently entered the pipe during construction.
2. Sources of water for filling and flushing shall be located in coordination with the College Facilities Department and the Contractor constructing the interior building chilled water systems. The system shall be unidirectionally flushed where possible and flushing shall proceed from the chilled water plant where possible
3. Chilled water line blowoff taps shall be used to release air during filling and to provide additional flushing locations. Temporary taps of sufficient size and/or flushing hydrants shall be used to adequately flush the pipeline at end points as identified on the drawings. Building services shall only be used for flushing of the service lateral prior to connection within the building, and shall be coordinated with the College and the building Contractor to minimize disturbance within the building.
4. After successful testing, all corporations installed for flushing purposes shall be closed and plugged. All tubing shall be removed.

3.5 HANGERS AND SUPPORTS

A. Hanger, support, and anchor devices are specified in Division 15 Section "Hangers and Supports." Comply with requirements below for maximum spacing of supports.

B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.

C. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 3/4: Maximum span, 7 feet; minimum rod size, 1/4 inch.
2. NPS 1: Maximum span, 7 feet; minimum rod size, 1/4 inch.
3. NPS 1-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
4. NPS 2: Maximum span, 10 feet; minimum rod size, 3/8 inch.
5. NPS 2-1/2: Maximum span, 11 feet; minimum rod size, 3/8 inch.
6. NPS 3: Maximum span, 12 feet; minimum rod size, 3/8 inch.
7. NPS 4: Maximum span, 14 feet; minimum rod size, 1/2 inch.
8. NPS 6: Maximum span, 17 feet; minimum rod size, 1/2 inch.

D. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:

1. NPS 3/4: Maximum span, 5 feet; minimum rod size, 1/4 inch.
2. NPS 1: Maximum span, 6 feet; minimum rod size, 1/4 inch.
3. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
4. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
5. NPS 2-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
6. NPS 3: Maximum span, 10 feet; minimum rod size, 3/8 inch.

E. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

3.6 PIPE JOINT CONSTRUCTION

A. Refer to Division 23 Section "Basic Mechanical Materials and Methods" for joint construction requirements for soldered and brazed joints in copper tubing; threaded, welded, and flanged joints in steel piping; and solvent-welded joints for PVC and CPVC piping.

3.7 HYDRONIC SPECIALTIES INSTALLATION

A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.

B. Install automatic air vents in mechanical equipment rooms only at high points of system piping, at heat-transfer coils, and elsewhere as required for system air venting.

C. Install in-line air separators in pump suction lines. Install piping to compression tank with a 2 percent upward slope toward tank. Install drain valve on units NPS 2 and larger.

D. Install expansion tanks on floor. Vent and purge air from hydronic system, and ensure tank is properly charged with air to suit system design requirements.

3.8 TERMINAL EQUIPMENT CONNECTIONS

A. Size for supply and return piping connections shall be same as for equipment connections.

B. Install control valves in accessible locations close to connected equipment.

C. Install line size bypass piping with globe valve around control valve on systems over 5,000 CFM. If multiple, parallel control valves are installed, only one bypass is required.

D. Install ports for pressure and temperature gages at coil inlet connections.

3.9 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush system with clean water. Clean strainers.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release trapped air. Use drains installed at low points for complete draining of liquid.
3. Check expansion tanks to determine that they are not air bound and that system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the design pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed either 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A of ASME B31.9, "Building Services Piping."
5. After hydrostatic test pressure has been applied for two hours, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

3.10 ADJUSTING

A. Mark calibrated nameplates of pump discharge valves after hydronic system balancing has been completed, to permanently indicate final balanced position.

B. Perform these adjustments before operating the system:

1. Open valves to fully open position. Close coil bypass valves.
2. Check pump for proper direction of rotation.
3. Set automatic fill valves for required system pressure.
4. Check air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Check operation of automatic bypass valves.
7. Check and set operating temperatures of boilers, chillers, and cooling towers to design requirements.
8. Lubricate motors and bearings.

3.11 CLEANING

A. The mechanical contractor shall flush, clean, and final fill systems installed or modified with products purchased from the Campus water treatment contractor. Final fill shall not occur until the water treatment contractor has confirmed that the water is suitable for permanent chemical treatment.

B. Prior to installing the cleaning agent in the system, isolate the expansion tank from the system. Add the cleaning agent, and circulate the chemical per the manufacturer's written recommended procedure. Once the system is free of cleaning chemical, open the expansion tank to the system, and add the permanent chemicals.

END OF SECTION 232113

TABLE OF CONTENTS

SECTION 232123 – HYDRONIC PUMPS

SECTION 232123 - HYDRONIC PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following categories of hydronic pumps for hydronic systems:

1. In-line circulators.
2. Vertical in-line pumps.
3. Base-mounted end-suction pumps.
4. Automatic condensate pump units.

1.3 SUBMITTALS

A. Product Data: Include certified performance curves and rated capacities; shipping, installed, and operating weights; furnished specialties; final impeller dimensions; and accessories for each type of product indicated. Indicate pump's operating point on curves.

B. Shop Drawings: Show pump layout and connections. Include Setting Drawings with templates for installing foundation and anchor bolts and other anchorages.

1. Wiring Diagrams: Detail wiring for power, signal, and control systems and differentiate between manufacturer-installed and field-installed wiring.

C. Maintenance Data: For pumps to include in maintenance manuals specified in Division 1.

1.4 QUALITY ASSURANCE

A. UL Compliance: Fabricate and label pumps to comply with UL 778, "Motor-Operated Water Pumps," for construction requirements.

B. Product Options: Drawings indicate size, profiles, connections, and dimensional requirements of pumps and are based on the specific types and models indicated. Other manufacturers' pumps with equal performance characteristics may be considered. Refer to Division 1 Section "Substitutions."

C. Regulatory Requirements: Fabricate and test steam condensate pumps to comply with HI 1.1-1.5, "Centrifugal Pumps for Nomenclature, Definitions, Application and Operation," and HI 1.6, "Centrifugal Pump Tests."

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Manufacturer's Preparation for Shipping: Clean flanges and exposed machined metal surfaces and treat with anticorrosion compound after assembly and testing. Protect flanges, pipe openings, and nozzles with wooden flange covers or with screwed-in plugs.

B. Store pumps in dry location.

C. Retain protective covers for flanges and protective coatings during storage.

D. Protect bearings and couplings against damage from sand, grit, and other foreign matter.

E. Comply with pump manufacturer's written rigging instructions.

1.6 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3 Section "Cast-in-Place Concrete."

1.7 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Mechanical Seals: One mechanical seal for each pump.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. In-Line Circulators:

a. Armstrong Pumps, Inc. 1,000 Series
b. Bell & Gossett ITT; Div. of ITT Fluid Technology Corp. Series 60
c. Aurora Pump –326A Series
d. Taco; Fabricated Products Div. 1,600 Series

2. Vertical In-Line Pumps:

a. Armstrong Pumps, Inc. 4,300 Series
b. Bell & Gossett ITT; Div. of ITT Fluid Technology Corp. Series 80 & 90.
c. Aurora Pump – 326A Series.
d. Taco; Fabricated Products Div. KV Series

3. Base-mounted End Suction Pumps:

a. Aurora Pumps, Inc. 320 Series
b. Bell & Gossett ITT; Div. of ITT Fluid Technology Corp. 1,510 Series
c. Taco; Fabricated Products Div. FI Series
d. Ingersoll-Dresser, D-800 Series

4. Automatic Condensate Pump Units:

a. Beckett Corp.
b. Hartell Div.; Milton Roy Co.
c. Little Giant Pump Co.
d. Marsh Manufacturing, Inc.

2.2 GENERAL PUMP REQUIREMENTS

A. Pump Units: Factory assembled and tested.

B. Motors: Include built-in, thermal-overload protection and grease-lubricated ball bearings. Select each motor to be non-overloading over full range of pump performance curve.

C. Motors Indicated to Be Energy Efficient: Refer to Section 15055

2.3 INLINE CIRCULATORS

A. Circulators shall be horizontal inline, centrifugal, separately-coupled, single-stage, bronze-fitted, radially split case design, with mechanical seals, and rated for 125 psig working pressure and 225°F continuous water temperature.

B. Cast iron casings, with threaded companion flanges for piping connections smaller than 21/2", and threaded gage tappings at inlet and outlet connections.

C. Statically and dynamically balanced impeller, closed, overhung single-suction, fabricated from cast bronze or bronze conforming to ASTM B 584, and keyed to steel shaft. Provide slinger on motor shaft between motor and seals to prevent liquid that leaks past pump seals from entering the motor bearings.

D. Mechanical seals shall be carbon steel rotating ring, stainless steel spring, ceramic seat, and flexible bellows and gasket. Pump shaft bearings shall be oil-lubricated, bronze journal, and thrust bearings. Flexible pump couplings, capable of absorbing torsional vibration and shaft misalignment. Motors shall be resiliently mounted to the pump casing.

2.4 VERTICAL INLINE PUMPS

A. Pumps shall be centrifugal, close-coupled, single-stage, bronze-fitted, radially split case design, with mechanical seals, and rated for 175 psig working pressure and 225°F continuous water temperature.

B. Cast iron casings, with threaded companion flanges for piping connections smaller than 2-1/2", and threaded gage tappings at inlet and outlet connections.

C. Statically and dynamically balanced impeller, closed, overhung, single-suction, cast bronze, conforming to ASTM B 584, and keyed to shaft. Ground and polished steel shaft, with bronze sleeve and integral thrust bearing. Provide slinger on motor shaft between motor and seals to prevent liquid that leaks past pump seals from entering the motor bearings. Mechanical Seals consisting of carbon steel rotating ring, stainless steel spring, ceramic seat, and Buna-N bellows and gasket.

2.5 BASE-MOUNTED, SEPARATELY-COUPLED, END-SUCTION PUMPS

A. Pumps shall be base-mounted, centrifugal, separately-coupled, end-suction, single-stage, bronze-fitted, radially split case design, and rated for 175 psig working pressure and 225°F continuous water temperature. Pumps fabrication shall conform with the Hydraulics Institute (HI) Standards.

B. Cast iron casings, with flanged piping connections, and threaded gage tappings at inlet and outlet flange connections. Statically and dynamically balanced impeller, closed, overhung, single-suction, fabricated from cast bronze conforming to ASTM B 584, keyed (steel) to shaft and secured by a stainless steel locking cap screw. Provide replaceable bronze wear rings, steel pump shaft, with bronze sleeve.

C. Mechanical seals consisting of stainless steel metal parts, Ni-resist seat, and flexible Buna-N bellows and gasket. Pump bearing housing assembly shall have oil lubricated bearings replaceable without disturbing piping connections.

D. Provide flexible pump couplings, capable of absorbing torsional vibration and shaft misalignment; complete with metal coupling guard. Coupling shall be spacer type that allows the coupling to be removed without disturbing the piping or the motor. Spacers shall be Lovejoy flex shaft type couplings with EPDM rubber inserts or Woods equivalent.

E. Provide certified pump curves for all pumps with a capacity of 400 gpm or greater.

2.6 AUTOMATIC CONDENSATE PUMP UNITS

A. Description: Packaged units with corrosion-resistant pump, plastic tank with cover, and automatic controls. Include factory- or field-installed check valve and a 72-inch- minimum, electrical power cord with plug.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation.

1. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.

2. Examine foundations and inertia bases for suitable conditions where pumps are to be installed.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PUMP INSTALLATION

A. Install pumps according to manufacturer's written instructions.

1. Install pumps according to HI 1.1-1.5, "Centrifugal Pumps for Nomenclature, Definitions, Application and Operation."

B. Install pumps to provide access for periodic maintenance, including removing motors, impellers, couplings, and accessories.

C. Support pumps and piping separately so piping is not supported by pumps.

D. Suspend in-line pumps using continuous-thread hanger rod and vibration-isolation hangers. Install seismic bracing as required by authorities having jurisdiction.

E. Set base-mounted pumps on concrete foundation. Disconnect coupling halves before setting. Do not reconnect couplings until alignment operations have been completed.

1. Support pump baseplate on rectangular metal blocks and shims, or on metal wedges with small taper, at points near foundation bolts to provide a gap of 3/4 to 1-1/2 inches between pump base and foundation for grouting.
2. Adjust metal supports or wedges until pump and driver shafts are level. Check coupling faces and suction and discharge flanges of pump to verify that they are level and plumb.

F. Automatic Condensate Pump Units: Install units for collecting condensate and extend to open drain.

3.3 ALIGNMENT

A. Align pump and motor shafts and piping connections after setting them on foundations, after grout has been set and foundation bolts have been tightened, and after piping connections have been made.

B. Comply with pump and coupling manufacturers' written instructions.

C. Adjust pump and motor shafts for angular and offset alignment by methods specified in HI 1.1-1.5, "Centrifugal Pumps for Nomenclature, Definitions, Application and Operation."

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

3.4 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to machine to allow service and maintenance.

C. Connect piping to pumps. Install valves that are the same size as piping connected to pumps.

D. Install check valve and throttling valve on discharge side of in-line circulators.

E. Install nonslam check valve and ball or butterfly valve on discharge side of vertical in-line pumps.

F. Install shutoff valve on suction side of vertical in-line pumps and in-line circulators.

G. Install shutoff valve on suction side of base-mounted pumps.

H. Install a check, balancing and stop valve on discharge side of base-mounted pumps when pump is in constant speed service. When in variable speed (VFD driven) service only a check and stop valve shall be installed on the pump discharge.

I. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.

J. Install one pressure gage with valved connections on pump suction, discharge and strainer inlet. Install at integral pressure-gage tappings where provided.

K. Install check valve on each condensate pump unit discharge.

L. Install electrical connections for power, controls, and devices.

M. Ground equipment.

1. 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 UL 486B.

3.5 ALIGNMENT

A. Arrange for factory authorized agent to align pump and motor shafts and piping connections after setting on foundations, after grout has been set and foundations bolts have been tightened, and after piping connections have been made. Adjust alignment of pump and motor shafts for angular and parallel alignment by one of the two methods specified in the Hydraulic Institute "Centrifugal Pumps - Instructions for Installation, Operation and Maintenance" and per the manufacturer's written instructions.

B. After alignment is correct, tighten the foundation bolts evenly, but not too firmly. Fill the base plate completely with non-shrink, nonmetallic grout, with metal blocks and shims or wedges in place. After grout has cured, fully tighten foundation bolts.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain hydronic pumps as specified below:

1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining pumps.
2. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
3. Schedule training with Owner, through Architect, with at least seven days' advance notice.

END OF SECTION 232123

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SECTION 232213 – STEAM AND CONDENSATE PIPING

SECTION 232213 - STEAM AND CONDENSATE PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes steam and condensate piping and specialties for systems up to 125 psig, inside the building.

1.3 DEFINITIONS

A. HP Systems: High-pressure systems operating at more than 30 psig.

B. LP Systems: Low-pressure systems operating at 30 psig or less.

1.4 SUBMITTALS

A. Product Data: For each type of special-duty valve and steam trap indicated, including rated capacities and accessories.

B. Shop Drawings: Detail flash tank assemblies and fabrication of pipe anchors, hangers, special pipe support assemblies, alignment guides, and expansion joints and loops and their attachment to the building structure. Include dimensions, weights, loadings, required clearances, method of field assembly, components, and location and size of each field connection.

C. Welding Certificates: Copies of certificates for welding procedures and personnel.

D. Field Test Reports: Written reports of tests specified in Part 3 of this Section. Include the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Failed test results and corrective action taken to achieve requirements.

E. Maintenance Data: For steam traps, vacuum breakers, and meters to include in maintenance manuals specified in Division 1.

1.5 QUALITY ASSURANCE

A. DEFINITIONS:

1. Welding Procedure Specification, WPS. It must have a specific procedure number, date written and identification of the person who wrote it.
2. Procedure Qualification Record, PQR. This is the record that indicates the procedure to be followed is a valid procedure.
3. Welding Operator Qualifications test, WPQ. This is a record, including bend test results or radiographic test results, for each welder. The WPQ is based on that company's procedure. It shall be certified and dated by the test agency within 12 months of the start of the work for the welder.

B. Welding and brazing procedure qualifications:

1. Contractor shall submit for review the Contractor's standard welding and brazing procedures (forms WPS or BPS). Procedure shall be submitted on PQR form as described in the ASME Boiler and Pressure Vessel Code.
2. The PQR shall be supported by the appropriate WPS and BPS.

C. All welders shall be certified to the WPS and BPS as listed on the Contractor's PQR. Certifications are to be performed by an independent testing laboratory within twelve months prior to the commencement of work.

1. Each welder is to stamp the pipe adjacent to each weld performed by him/her. The Contractor is required to, via the submittal process, provide a list of each welder's name and the mark used by each welder.

D. Tack welding may be performed by non-certified welders. All tack welds, whether performed by certified or non-certified welders, must be ground out and removed.

E. Contractor option: In lieu of submitting the contractor's welding procedures, the contractor may adopt Dartmouth College's procedure #1.1.1.2 Rev. 0 and ASME/ANSI B3 1.1, latest edition. The welding procedure is available from DC Facilities Operation and Management.

F. No welding may take place until a satisfactory reviewed submittal is complete. It is the contractor's responsibility to provide a submittal in a timely fashion so as not to delay the project.

G. Soldering and brazing procedures for refrigeration piping shall conform to ANSI B9. 1 "Standard Safety Code for Mechanical Refrigeration."

H. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp flash tanks to comply with the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

1.6 COORDINATION

A. Coordinate layout and installation of steam and condensate piping and suspension system components with other construction, including light fixtures, hydronic piping, fire-suppression-system components, and partition assemblies.

B. Coordinate pipe sleeve installation for foundation wall penetrations.

C. Coordinate piping installation with roof curbs, equipment supports, and roof penetrations. Roof specialties are specified in Division 7 Sections.

D. Coordinate pipe fitting pressure classes with products specified in related Sections.

E. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3 Sections.

F. Coordinate installation of pipe sleeves for penetrations through exterior walls and floor assemblies. Coordinate with requirements for firestopping specified in Division 7 Section "Through-Penetration Firestop Systems" for fire and smoke wall and floor assemblies.

PART 2 - PRODUCTS

2.1 GENERAL

A. All pipe and fittings shall be fabricated in the USA or Canada.

B. Elbows for all pipe sizes over 2" diameter shall be long radius type (1.5 pipe diameter to centerline of pipe).

C. Use reducers, increasers, or reducing tees for change of pipe size. Bushings are not allowed.

D. Forged steel (3,000#) branch connectors (ie "Weld-O-Lets", "Thread-O-Lets"), per the limits set forth in Part 3 of this section, may be used to create branch connections in steel piping systems. All branch connectors shall be 3,000# fittings.

2.2 PIPING MATERIALS

A. General: Refer to Part 3 piping application articles for applications of pipe and fitting materials.

2.3 STEEL PIPE AND FITTINGS

A. Steam Supply Pipe: Threaded and welded ends.

ITEM	SIZE	ASTM SPEC NO.	MATERIAL WEIGHT & TYPE
Pipe	all sizes	A53 or A106, grade B, type S	Schedule 40, ANSI B36.10
Fittings	≤2"	A197, Malleable Iron	Standard, threaded, ANSI B16.3
	>2"	A234, WPB, wrought carbon steel	Schedule 40, butt weld, ANSI B16.9
Flanges	≤2"	A105, forged carbon steel	Class 150, RF, threaded, ANSI B 16.5
	>2"	A105, forged carbon steel	Class 150, RF, weld neck or slip on, ANSI B 16.5
Bolts	All	A193, grade B7 carbon steel	Hex head (ANSI B 18.2.1), B1.1, class 2A course thread
Nuts	All	A194, Grade 2H, Carbon steel	Heavy hex (ANSI B18.2.2), B1.1, class 2B course thread
Gaskets	Per flange standard	A304, stainless steel, Grafoil filled, spiral wound	Class 150, RF, ring style, ANSI B16.20

B. Gravity & Pumped Condensate: Threaded and welded ends.

ITEM	SIZE	ASTM SPEC NO.	MATERIAL WEIGHT & TYPE
Pipe	≤2"	A53 or A106, grade B, type S	Schedule 80, ANSI B36.10
	>2"	A53, grade B, type S	Schedule 80, ANSI B36.10
Fittings	≤2"	A197, Malleable Iron	Extra Heavy, threaded, ANSI B16.3
	>2"	A234, WPB, wrought carbon steel	Extra Heavy, butt weld, ANSI B16.9
Flanges	≤2"	A105, forged carbon steel	Class 300, RF, threaded, ANSI B 16.5
	>2"	A105, forged carbon steel	Class 300, RF, weld neck or slip on, ANSI B 16.5

ITEM	SIZE	ASTM SPEC NO.	MATERIAL WEIGHT & TYPE
Bolts	All	A193, grade B7 carbon steel	Hex head (ANSI B 18.2.1), B1.1, class 2A course thread
Nuts	All	A194, Grade 2H, Carbon steel	Heavy hex (ANSI B18.2.2), B1.1, class 2B course thread
Gaskets	Per flange standard	A304, stainless steel, Grafoil filled, spiral wound	Class 150, RF, ring style, ANSI B16.20

C. Unions: ANSI B16.39, malleable-iron, class 300 for schedule 80 piping system, hexagonal stock, with ball and socket joints, metal to metal bronze seating surfaces; female threaded ends. Threads shall conform to ANSI B1.20.1.

D. Flexible Connectors: Stainless steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket; 150-psig minimum working pressure and 250 deg F maximum operating temperature. Connectors shall have flanged or threaded-end connections to match equipment connected and shall be capable of 3/4-inch misalignment. Manufacturers: Keflex, Mason, Metraflex.

E. Welding Materials: Comply with Section II, Part C, of the ASME Boiler and Pressure Vessel Code for welding materials appropriate for wall thickness and for chemical analysis of pipe being welded.

2.4 VALVES

A. Globe, check, ball, and butterfly valves are specified in Division 15 Section "Valves."

B. Refer to Part 3 "Valve Applications" Article for applications of each valve.

C. Steam mains shall have isolation valves space no further than 200' apart. Steam isolation valves larger than 6" shall be equipped with 2" ball warm-up valves.

2.5 SAFETY VALVES

A. Size and Capacity: As required for equipment according to the ASME Boiler and Pressure Vessel Code.

B. Cast iron body and bronze seat, Class 250; forged copper alloy disc and nozzle; fully enclosed stainless steel spring having an adjustable pressure range and positive shut off; threaded end connections for valves 2" and smaller, raised face flanged inlet and threaded outlet connections for valves 2–1/2" and larger. Factory set valves to relieve at 10 psi above operating pressure.

C. Manufacturers:

Manufacturer	*Bronze*	*Cast Iron*	*Drip Pan Elbow*
O.C. Keckley Co.	#40	#300	Drip Pan Elbow
Spence Engineering Co., Inc.	#41	#41	DPE
Spirax/Sarco	#6010	SVI	DPE

D. Stop-Check Valves: Class 250, malleable-iron body and bonnet, cylindrical disc, removable liner and machined seat, brass-alloy stem, outside screw and yoke, polytetrafluoroethylene-impregnated packing with 2-piece packing gland assembly, flanged end connections, and cast-iron handwheel.

2.6 STEAM TRAPS

A. Balanced Pressure Thermostatic Traps: Cast brass, angle pattern body, with integral union tailpiece and screw-in cap; maximum operating pressure of 25 psig; balanced pressure stainless steel or monel diaphragm or bellows element, with renewable hardened stainless steel valve head and seat.

1. Spirax/Sarco TA-125, TH-125, TV-125
2. Tunstall series 'TA'.

B. Float and Thermostatic Traps: ASTM A 278, Class 30 cast iron body and bolted cap; renewable, stainless steel float mechanism, with renewable, hardened stainless steel head and seat; balanced pressure thermostatic air vent made of stainless steel or monel bellows with stainless steel head and seat.

1. Spirax/Sarco FT-30, FTI-30 (no substitutions).

C. Inverted Bucket Traps: ASTM A 278, Class 30 cast iron body and cap, pressure rated for 250 psi; stainless steel head and seat; stainless steel valve retainer, lever, guide pin assembly, brass or stainless steel bucket.

1. Spirax/Sarco B series.

2.7 THERMOSTATIC AIR VENTS

A. Cast iron or brass body, with balanced pressure stainless steel or monel thermostatic bellows, and stainless steel heads and seats.,

1. Spirax/Sarco – VS206 (steam)
2. Spirax/Sarco - 1 3WS (condensate).

2.8 VACUUM BREAKERS

A. Stainless steel or brass construction, factory set to open at 2" H_2O of vacuum, and shall be of a hardened ball check valve or spring restrained style. All spring style components shall be encapsulated with a protective cover.

1. Spirax/Sarco #VB14.

2.9 STRAINERS

A. Y-Pattern Strainers: 250-psig working steam pressure; ASTM A 126, Class B cast-steel body; stainless-steel screen, No. 20 mesh for NPS 2 and smaller and manufacturer's recommended perforations for NPS 2-1/2 and larger; tapped blowoff plug. Threaded connections for strainers NPS 2 and smaller and flanged connections for strainers NPS 2-1/2 and larger. Condensate systems and strainers prior to steam traps shall be cast-iron.

B. Basket Strainers: 250-psig working steam pressure; ASTM A 126, Class B cast-iron body; stainless-steel screen; bolted cover; threaded connections for strainers NPS 2 and smaller and flanged connections for strainers NPS 2-1/2 and larger.

2.10 FLASH TANKS

A. Shop or factory fabricated of welded steel according to the ASME Boiler and Pressure Vessel Code, for 150-psig rating; and bearing ASME label. Fabricate with tappings for vents, low-pressure steam and condensate outlets, high-pressure condensate inlet, air vent, safety valve, and legs.

2.11 PRESSURE REDUCING VALVE

2.12 PRESSURE REGULATING VALVES

A. Pilot actuated, diaphragm type, Class 250, with adjustable pressure range and positive shut off; cast iron body with flanged or threaded end connections, hardened stainless steel trim, and replaceable valve head and seat. Provide main head stem guide fitted with flushing and pressure arresting device. Provide cover over pilot diaphragm for protection against dirt accumulation.

1. Spirax/Sarco
2. Spence Engineering Co., Inc.

PART 3 - EXECUTION

3.1 LP STEAM PIPING APPLICATIONS

A. Steam Piping, NPS 2 and Smaller: Schedule 40 steel pipe, with threaded joints using Class 125 malleable-iron fittings.

B. Steam Piping, NPS 2-1/2 through NPS 12: Schedule 40 steel pipe, with welded joints using Schedule 40 wrought-steel welding fittings and Class 150 wrought-steel flanges.

C. Condensate Piping, NPS 2 and Smaller: Schedule 80 steel pipe, with threaded joints using extra heavy malleable-iron fittings.

D. Condensate Piping, NPS 2-1/2 through NPS 12: Schedule 80 steel pipe, with welded joints using Schedule 80 wrought-steel welding fittings and Class 300 wrought-steel flanges.

3.2 VALVE APPLICATIONS

A. General-Duty Valve Applications: Unless otherwise indicated, use the following valve types:

1. Shutoff Duty: Ball and high-performance butterfly valves.
2. Throttling Duty: Globe and ball valves.

B. Install shutoff-duty valves at each branch connection to supply mains, at inlet connection to each steam trap, and elsewhere as indicated.

3.3 LP STEAM-TRAP APPLICATIONS

A. Thermostatic Traps: Convectors and finned-tube radiation.

B. Float and Thermostatic Traps: Steam main and riser drip legs, laundry equipment, kitchen equipment, heat exchangers, and heating coils.

3.4 PIPING INSTALLATIONS

A. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for basic piping installation requirements.

B. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

C. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

D. Install steam supply piping at a uniform grade of 0.2 percent downward in direction of steam flow.

E. Install condensate return piping at a uniform grade of 1 percent downward in direction of condensate flow.

F. Reduce pipe sizes using eccentric reducer fitting installed with level side down.

G. Unless otherwise indicated, install branch connections to steam mains using 45-degree fittings in main pipe, with the takeoff coming out the top of the main pipe. Use of 90-degree tee fittings is permissible if 45-degree fittings are impractical. If length of branch takeoff is less than 10 feet, pitch branch line down toward mains at a 0.4 percent grade.

H. Install unions in piping NPS 2 and smaller adjacent to each valve, at final connections of each piece of equipment, and elsewhere as indicated.

I. Install flanges in piping NPS 2-1/2 and larger at final connections of each piece of equipment and elsewhere as indicated.

J. Install strainers on supply side of each control valve, pressure-reducing valve, solenoid valve, traps, and elsewhere as indicated. Install NPS 3/4 nipple and ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.

K. Anchor piping for proper direction of expansion and contraction.

L. Install drip legs at low points and natural drainage points in the system, such as at the ends on mains, bottoms of risers, and ahead of pressure regulators, control valves, isolation valves, pipe bends, expansion joints, at intervals not exceeding 150' where pipe is pitched down in the direction of the steam flow, a maximum of 100' where the pipe is pitched up in the direction of steam flow.

1. Drip legs, dirt pockets, and strainer blowdowns shall be equipped with drain valves (& caps) to allow removal of dirt and scale.
2. Install steam traps close (<3') to drip legs and at least 8" below the header. Drain valves serving drip legs shall be lower than the trap connection and never attached to the trap connection.
3. Drip legs shall be sized per the followin^{g} schedule:

Header Size	*Drip Leg Size*
≤4"	Same size as header
>4" & d8"	4"
>10" & d14"	6"
>14"	8"

M. Pitch condensate piping down toward flash tank. If more than one condensate pipe discharges into flash tank, install a swing check valve in each line. Install thermostatic air vent at top of tank. Install inverted bucket or float and thermostatic trap at low-pressure condensate outlet, sized for three times the condensate load. Install safety valve at tank top. Install pressure gage, gate valve, and swing check valve on low-pressure (flash) steam outlet.

3.5 STEAM-TRAP INSTALLATION

A. Install steam traps in accessible locations as close as possible to connected equipment, but not more than 48 inches from connected equipment.

1. Unless otherwise indicated, install isolation valve, strainer (leg vertical), and union upstream from the trap; install union, test tee with test valve, check valve, and isolation valve downstream from trap.

3.6 SAFETY VALVE INSTALLATIONS

A. Install safety valves according to ASME B31.1. Pipe safety valve discharge without valves to atmosphere outside building. Install drip-pan elbow fitting adjacent to safety valve and pipe drain connection to nearest floor drain.

3.7 STEAM TRAP INSTALLATIONS

A. Install steam traps in accessible locations as close as possible to connected equipment.

B. Install isolation valve, strainer (leg vertical), and union upstream from the trap; install union, test tee with test valve, check valve, and isolation valve downstream from trap.

3.8 HANGERS AND SUPPORTS

A. Hanger, support, and anchor devices are specified in Division 15 Section "Hangers and Supports."

B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.

C. Install hangers with the following maximum spacing and minimum rod sizes:

1. NPS 3/4: Maximum span, 9 feet; minimum rod size, 1/4 inch.
2. NPS 1: Maximum span, 9 feet; minimum rod size, 1/4 inch.
3. NPS 1-1/2: Maximum span, 12 feet; minimum rod size, 3/8 inch.
4. NPS 2: Maximum span, 13 feet; minimum rod size, 3/8 inch.
5. NPS 2-1/2: Maximum span, 14 feet; minimum rod size, 3/8 inch.
6. NPS 3: Maximum span, 15 feet; minimum rod size, 3/8 inch.
7. NPS 4: Maximum span, 17 feet; minimum rod size, 1/2 inch.
8. NPS 6: Maximum span, 21 feet; minimum rod size, 1/2 inch.
9. NPS 8: Maximum span, 24 feet; minimum rod size, 5/8 inch.
10. NPS 10: Maximum span, 26 feet; minimum rod size, 3/4 inch.
11. NPS 12: Maximum span, 30 feet; minimum rod size, 7/8 inch.
12. NPS 14: Maximum span, 32 feet; minimum rod size, 1 inch
13. NPS 16: Maximum span, 35 feet; minimum rod size, 1 inch.
14. NPS 18: Maximum span, 37 feet; minimum rod size, 1-1/4 inches.
15. NPS 20: Maximum span, 39 feet; minimum rod size, 1-1/4 inches.

D. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

3.9 PIPE JOINT CONSTRUCTION

A. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for joint construction requirements for threaded, welded, and flanged joints.

3.10 TERMINAL EQUIPMENT CONNECTIONS

A. Size for supply and return piping connections shall be same as for equipment connections.

B. Install traps and control valves in accessible locations close to connected equipment.

C. Install bypass piping with globe valve around control valve. If multiple, parallel control valves are installed, only one bypass is required.

D. Install vacuum breaker downstream from control valve and bypass and close to coil inlet connection.

E. Install ports for pressure and temperature gages at coil inlet connections.

F. Install a drip leg at coil outlet.

3.11 FIELD QUALITY CONTROL

A. Prepare steam and condensate piping according to ASME B31.9 and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Flush system with clean water. Clean strainers.
3. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
4. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on steam and condensate piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release trapped air. Use drip legs installed at low points for complete draining of liquid.
3. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the design pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed either 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A of ASME B31.9, "Building Services Piping."
4. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
5. Prepare written report of testing.

3.12 ADJUSTING

A. Mark calibrated nameplates of pump discharge valves after steam and condensate system balancing has been completed, to permanently indicate final balanced position.

B. Perform these adjustments before operating the system:

1. Open valves to fully open position. Close coil bypass valves.
2. Set temperature controls so all coils are calling for full flow.
3. Check operation of automatic bypass valves.

3.13 CLEANING

A. Flush steam and condensate piping with clean water. Remove and clean or replace strainer screens.

B. Provide cleaning of steam and condensate piping systems as follows:

1. Flush with water.
2. Disconnect steam traps, and bypass steam through condensate piping.
3. Flush piping system, under full steam pressure, wasting condensate until dirt, grease and oil are removed. Flushing period shall be minimum two days.
4. Take samples (approximately one pint, each) twice each day and allow samples to cool to room temperature in clean, covered glass containers for Architect's inspection.
5. Reinstall traps and operate system at normal pressure for period of five days. Waste condensate to drain during this period. Clean strainers as often as necessary to ensure clean systems.
6. Upon completion, clean traps, valves, strainers, dirt pockets and other apparatus where dirt may accumulate.

END OF SECTION 232213

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SECTION 233113 – METAL DUCTS

SECTION 233113 - METAL DUCTS

PART 1 - GENERAL

1.1 CODES AND QUALIFICATIONS

A. Firms regularly engaged in manufacture of metal ductwork, products and accessories of types, materials, and sizes required, whose products have been in satisfactory use in similar service for not less than 3 years.

B. Comply with SMACNA "HVAC Duct Construction Standards, Metal and Flexible, Second Edition (1995)" for fabrication and installation of metal ductwork. Comply with SMACNA "HVAC Air Duct Leakage Test Manual" for sealing requirements of metal ductwork.

C. Comply with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems", NFPA 90B "Standard for the Installation of Warm Air Heating and Air Conditioning Systems", and NFPA 96 "Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations".

D. Construct, test, and label fire dampers in accordance with UL Standard 555 and 555S, "Fire Dampers and Ceiling Dampers", latest edition.

E. Comply with 2006 IMC for fabrication of metal ductwork.

F. Test and rate louvers in accordance with AMCA 500, "Test Method for Louvers, Dampers and Shutters".

G. Comply with the North American Insulation Manufacturer's Association, "Fibrous Glass Duct Liner Standard", First Edition.

1.2 RELATED DOCUMENTS

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

1.3 SUMMARY

A. This Section includes metal ducts for supply, return, outside, and exhaust air-distribution systems in pressure classes from minus 2- to plus 10-inch wg. Metal ducts include the following:

1. Rectangular ducts and fittings.
2. Single-wall, round, and flat-oval spiral-seam ducts and formed fittings.
3. Double-wall, round, and flat-oval spiral-seam ducts and formed fittings.
4. Duct liner.

1.4 DEFINITIONS

A. FRP: Fiberglass-reinforced plastic.

B. NUSIG: National Uniform Seismic Installation Guidelines.

1.5 SUBMITTALS

A. Shop Drawings: CAD-generated and drawn to 1/4 inch equals 1 foot] scale. Show fabrication and installation details for metal ducts.

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Duct layout indicating sizes and pressure classes.
3. Elevations of top and bottom of ducts.
4. Dimensions of main duct runs from building grid lines.
5. Fittings.
6. Reinforcement and spacing.
7. Seam and joint construction.
8. Penetrations through fire-rated and other partitions.
9. Equipment installation based on equipment being used on Project.
10. Duct accessories, including access doors and panels.
11. Hangers and supports, including methods for duct and building attachment, vibration isolation, and seismic restraints.

B. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Ceiling suspension assembly members.
2. Other systems installed in same space as ducts.
3. Ceiling- and wall-mounting access doors and panels required to provide access to dampers and other operating devices.
4. Ceiling-mounting items, including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

C. Welding certificates.

D. Field quality-control test reports.

1.6 QUALITY ASSURANCE

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

B. NFPA Compliance:

1. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."
2. NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

C. Comply with NFPA 96, "Ventilation Control and Fire Protection of Commercial Cooking Operations," Ch. 3, "Duct System," for range hood ducts, unless otherwise indicated.

1.7 DELIVERY, STORAGE AND HANDLING

A. Deliver sealant and fire-stopping materials to site in original unopened containers or bundles with labels indicating manufacturer, product name and designation, color, expiration period for use, pot life, curing time and mixing instructions for multi-component materials.

B. Store and handle sealant and fire-stopping materials according to manufacturer's written recommendations.

C. Deliver and store stainless-steel sheets with mill-applied adhesive protective paper maintained through fabrication and installation.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 SHEET METAL MATERIALS

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

B. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653/A 653M and having G90 coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.

C. Carbon-Steel Sheets: ASTM A 366/A 366M, cold-rolled sheets; commercial quality; with oiled, matte finish for exposed ducts.

D. Stainless Steel: ASTM A 480/A 480M, Type 316, and having a No. 2D finish for concealed ducts and for exposed ducts.

E. Aluminum Sheets: ASTM B 209, alloy 3003, temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

F. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts.

G. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.3 DUCT LINER

A. Fibrous-Glass Liner: Comply with NFPA 90A or NFPA 90B and with NAIMA AH124.

1. Manufacturers:

   a. Johns Manville International, Inc.
   b. Knauf Fiber Glass GmbH.
   c. Owens Corning.

2. Materials: ASTM C 1071; surfaces exposed to airstream shall be coated to prevent erosion of glass fibers.

   a. Thickness: 1 inch.
   b. Thermal Conductivity (k-Value): 0.26 at 75 deg F mean temperature.
   c. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
   d. Mechanical Fasteners: Galvanized steel suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in duct.

      1) Tensile Strength: Indefinitely sustain a 50-lb- tensile, dead-load test perpendicular to duct wall.
      2) Fastener Pin Length: As required for thickness of insulation and without projecting more than 1/8 inch into airstream.

B. Minimum sound absorption ratings per the following schedule as tested using the ASTM C423 method:

Sound Absorption Coefficient @ Frequency (Cycles Per Second)							
Thickness	125	250	500	1000	2000	4000	NRC
1"	.09	.29	.67	.89	1.03	.99	.7
2	.16	.51	.9	1.05	1.06	1.01	.9

C. Flexible Elastomeric Duct Liner: Comply with NFPA 90A or NFPA 90B.

1. Manufacturers:

   a. Buckley – Flushmaster Type 2
   b. Acco

2. Materials: Unicellular polyethylene thermal plastic, preformed sheet insulation complying with ASTM C 534, Type II, except for density.

   a. Thickness: 1 inch.
   b. Thermal Conductivity (k-Value): 0.24 at 75 deg F mean temperature.
   c. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM C 411.
   d. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
   e. Operating pressure shall be 12" w.g positive, 10" w.g. negative on sizes ~12"Ø, 12" w.g positive, 5" w.g. negative on sizes 14" & 16".

2.4 SEALANT MATERIALS

A. Joint and Seam Sealants, General: The term "sealant" is not limited to materials of adhesive or mastic nature but includes tapes and combinations of open-weave fabric strips and mastics.

B. Water-Based Joint and Seam Sealant: Flexible, adhesive sealant, resistant to UV light when cured, UL 723 listed, and complying with NFPA requirements for Class 1 ducts.

C. Flanged Joint Mastic: One-part, acid-curing, silicone, elastomeric joint sealant complying with ASTM C 920, Type S, Grade NS, Class 25, Use O.

D. Flange Gaskets: Butyl rubber or EPDM polymer with polyisobutylene plasticizer.

2.5 HANGERS AND SUPPORTS

A. Hanger Materials: Galvanized sheet steel or threaded steel rod.

   1. Hangers Installed in Corrosive Atmospheres: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
   2. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for steel sheet width and thickness and for steel rod diameters.
   3. Galvanized-steel straps attached to aluminum ducts shall have contact surfaces painted with zinc-chromate primer.

B. Duct Attachments: Sheet metal screws, or self-tapping metal screws; compatible with duct materials.

C. Trapeze and Riser Supports: Steel shapes complying with ASTM A 36/A 36M.

   1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
   2. Supports for Stainless-Steel Ducts: Stainless-steel support materials.
   3. Supports for Aluminum Ducts: Aluminum support materials unless materials are electrolytically separated from ducts.

2.6 RECTANGULAR DUCT FABRICATION

A. Fabricate ducts, elbows, transitions, offsets, branch connections, and other construction according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" and complying with requirements for metal thickness, reinforcing types and intervals, tie-rod applications, and joint types and intervals.

1. Lengths: Fabricate rectangular ducts in lengths appropriate to reinforcement and rigidity class required for pressure class.
2. Deflection: Duct systems shall not exceed deflection limits according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."

B. Transverse Joints: Prefabricated slide-on joints and components constructed using manufacturer's guidelines for material thickness, reinforcement size and spacing, and joint reinforcement.

1. Manufacturers:

a. Ductmate Industries, Inc.
b. Nexus Inc.
c. Ward Industries, Inc.

C. Formed-On Flanges: Construct according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," Figure 1-4, using corner, bolt, cleat, and gasket details.

1. Manufacturers:

a. Ductmate Industries, Inc.
b. Lockformer.

2. Duct Size: Maximum 30 inches wide and up to 2-inch wg pressure class.
3. Longitudinal Seams: Pittsburgh lock sealed with noncuring polymer sealant.

D. Cross Breaking or Cross Beading: Cross break or cross bead duct sides 11 inches and larger and 0.0359 inch thick or less, with more than 4 sq. ft. of nonbraced panel area unless ducts are lined.

2.7 APPLICATION OF LINER IN RECTANGULAR DUCTS

A. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.

B. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.

C. Butt transverse joints without gaps and coat joint with adhesive.

D. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.

E. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and standard liner product dimensions make longitudinal joints necessary.

F. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm.

G. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.

H. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:

1. Fan discharges.
2. Intervals of lined duct preceding unlined duct.
3. Upstream edges of transverse joints in ducts where air velocities are greater than 2500 fpm (12.7 m/s) or where indicated.

I. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

2.8 ROUND AND FLAT-OVAL DUCT AND FITTING FABRICATION

A. Diameter as applied to flat-oval ducts in this Article is the diameter of a round duct with a circumference equal to the perimeter of a given size of flat-oval duct.

B. Round, Spiral Lock -Seam Ducts: Fabricate supply ducts of galvanized steel according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."

C. Flat-Oval, Spiral Lock -Seam Ducts: Fabricate supply ducts according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible." Fabricate ducts larger than 72 inches in diameter with butt-welded longitudinal seams.

1. Manufacturers:

    a. McGill AirFlow Corporation.
    b. SEMCO Incorporated.

D. Duct Joints:

1. Ducts up to 20 Inches in Diameter: Interior, center-beaded slip coupling, sealed before and after fastening, attached with sheet metal screws.
2. Ducts 21 to 72 Inches in Diameter: Three-piece, gasketed, flanged joint consisting of two internal flanges with sealant and one external closure band with gasket.
3. Ducts Larger Than 72 Inches in Diameter: Companion angle flanged joints per SMACNA "HVAC Duct Construction Standards--Metal and Flexible," Figure 3-2.
4. Round Ducts: Prefabricated connection system consisting of double-lipped, EPDM rubber gasket. Manufacture ducts according to connection system manufacturer's tolerances.

a. Manufacturers:

1) Ductmate Industries, Inc.
2) Lindab Inc.

5. Flat-Oval Ducts: Prefabricated connection system consisting of two flanges and one synthetic rubber gasket.

a. Manufacturers:

1) Ductmate Industries, Inc.
2) McGill AirFlow Corporation.
3) SEMCO Incorporated.

E. 90-Degree Tees and Laterals and Conical Tees: Fabricate to comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," with metal thicknesses specified for longitudinal-seam straight ducts.

F. Diverging-Flow Fittings: Fabricate with reduced entrance to branch taps and with no excess material projecting from fitting onto branch tap entrance.

G. Fabricate elbows using die-formed, gored, pleated, or mitered construction. Bend radius of die-formed, gored, and pleated elbows shall be 1-1/2 times duct diameter. Unless elbow construction type is indicated, fabricate elbows as follows:

1. Mitered-Elbow Radius and Number of Pieces: Welded construction complying with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," unless otherwise indicated.
2. Round Mitered Elbows: Welded construction with the following metal thickness for pressure classes from minus 2- to plus 2-inch wg:

a. Ducts 3 to 36 Inches in Diameter: 0.034 inch.
b. Ducts 37 to 50 Inches in Diameter: 0.040 inch.
c. Ducts 52 to 60 Inches in Diameter: 0.052 inch.
d. Ducts 62 to 84 Inches in Diameter: 0.064 inch.

3. Round Mitered Elbows: Welded construction with the following metal thickness for pressure classes from 2- to 10-inch wg:

a. Ducts 3 to 26 Inches in Diameter: 0.034 inch.
b. Ducts 27 to 50 Inches in Diameter: 0.040 inch.
c. Ducts 52 to 60 Inches in Diameter: 0.052 inch.
d. Ducts 62 to 84 Inches in Diameter: 0.064 inch.

4. Flat-Oval Mitered Elbows: Welded construction with same metal thickness as longitudinal-seam flat-oval duct.
5. 90-Degree, 2-Piece, Mitered Elbows: Use only for supply systems or for material-handling Class A or B exhaust systems and only where space restrictions do not permit using radius elbows. Fabricate with single-thickness turning vanes.

6. Round Elbows 8 Inches and Less in Diameter: Fabricate die-formed elbows for 45- and 90-degree elbows and pleated elbows for 30, 45, 60, and 90 degrees only. Fabricate nonstandard bend-angle configurations or nonstandard diameter elbows with gored construction.
7. Round Elbows 9 through 14 Inches in Diameter: Fabricate gored or pleated elbows for 30, 45, 60, and 90 degrees unless space restrictions require mitered elbows. Fabricate nonstandard bend-angle configurations or nonstandard diameter elbows with gored construction.
8. Round Elbows Larger Than 14 Inches in Diameter and All Flat-Oval Elbows: Fabricate gored elbows unless space restrictions require mitered elbows.
9. Die-Formed Elbows for Sizes through 8 Inches in Diameter and All Pressures 0.040 inch thick with 2-piece welded construction.
10. Round Gored-Elbow Metal Thickness: Same as non-elbow fittings specified above.
11. Flat-Oval Elbow Metal Thickness: Same as longitudinal-seam flat-oval duct specified above.
12. Pleated Elbows for Sizes through 14 Inches in Diameter and Pressures through 10-Inch wg: 0.022 inch.

PART 3 - EXECUTION

3.1 DUCT APPLICATIONS

A. Static-Pressure Classes: Unless otherwise indicated, construct ducts according to the following:

1. Supply Ducts (before Air Terminal Units): 2-inch wg.
2. Supply Ducts (after Air Terminal Units): 2-inch wg.
3. Supply Ducts (in Mechanical Equipment Rooms): 3-inch wg.
4. Return Ducts (Negative Pressure): 2-inch wg.
5. Exhaust Ducts (Negative Pressure): 2-inch wg .

B. All ducts shall be galvanized steel except as follows:

1. Acid-Resistant (Fume-Handling) Ducts: Type 316, stainless-steel sheet with No. 4 finish.

3.2 DUCT INSTALLATION

A. Construct and install ducts according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," unless otherwise indicated.

B. Install round and flat-oval ducts in lengths not less than 12 feet unless interrupted by fittings.

C. Install ducts with fewest possible joints.

D. Install fabricated fittings for changes in directions, size, and shape and for connections.

E. Install couplings tight to duct wall surface with a minimum of projections into duct. Secure couplings with sheet metal screws. Install screws at intervals of 12 inches, with a minimum of 3 screws in each coupling.

F. Install ducts, unless otherwise indicated, vertically and horizontally and parallel and perpendicular to building lines; avoid diagonal runs.

G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

I. Conceal ducts from view in finished spaces. Do not encase horizontal runs in solid partitions unless specifically indicated.

J. Coordinate layout with suspended ceiling, fire- and smoke-control dampers, lighting layouts, and similar finished work.

K. Seal all joints and seams. Apply sealant to male end connectors before insertion, and afterward to cover entire joint and sheet metal screws.

L. Electrical Equipment Spaces: Route ducts to avoid passing through transformer vaults and electrical equipment spaces and enclosures.

M. Non-Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls and are exposed to view, conceal spaces between construction openings and ducts or duct insulation with sheet metal flanges of same metal thickness as ducts. Overlap openings on 4 sides by at least 1-1/2 inches.

N. Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, install appropriately rated fire dampers, sleeves, and firestopping sealant. Fire and smoke dampers are specified in Division 15 Section "Duct Accessories." Firestopping materials and installation methods are specified in Division 7 Section "Through-Penetration Firestop Systems."

O. Install ducts with hangers and braces designed to withstand, without damage to equipment, seismic force required by applicable building codes. Refer to SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems."

P. Protect duct interiors from the elements and foreign materials until building is enclosed. Follow SMACNA's "Duct Cleanliness for New Construction."

3.3 INSTALLATION OF FLEXIBLE DUCTS

A. Install in accordance with Section III of SMACNA's, "HVAC Duct Construction Standards, Metal and Flexible, Second Edition (1995)", maximum 6'-0" extended length. Install insulated type flexible ducts in all supply air ductwork with temperature differences to the surrounding areas >10°F, non-insulated or insulated type flexible ducts with temperature differences <10°F and in return air systems. Attach flexible duct to metal duct and end terminals with drawbands on both the inner sleeve and the outer jacket.

B. Flexible ductwork shall be used to make corrections for minor misalignments of metal duct connections to diffusers. The angle of adjustment shall not exceed 30°. Flexible duct shall not be used to make sharp turns or any other configuration that compromises the net free area of the duct.

Where flexible duct runs are perpendicular to the outlet of the diffuser, use either a full radius elbow or a diffuser box at the diffuser connection.

3.4 INSTALLATION OF DUCTWORK ACCESSORIES

A. Install access doors to open against system air pressure. Install access doors at all fire dampers, smoke dampers, motor operated dampers, humidifiers, both sides of coils, and similar devices requiring access.

B. Install manual balancing dampers in all locations required to balance the system.

C. Provide flexible connection for each ductwork connection to equipment mounted on vibration isolators and/or equipment containing rotating machinery.

D. Fire dampers shall be installed in strict accordance with the manufacturer's written and tested installation instructions that are shipped with each fire damper. Dampers shall be installed square and shall not be malformed due to stretching or compressing to fit in misfabricated sleeves.

E. The 2000 International Mechanical Code requires smokes detectors be located in the air handler, NFPA 72 (2002) requires the smoke detector be located in the supply duct downstream of the air handler. As a point of clarification, the Town of Hanover wishes to comply with NFPA requirement rather than the IMC requirement.

3.5 SEAM AND JOINT SEALING

A. Seal all sheet metal ducts, regardless of pressure class to SMACNA Seal Class 'A'.

B. Seal ducts before external insulation is applied.

3.6 HANGING AND SUPPORTING

A. Support horizontal ducts within 24 inches of each elbow and within 48 inches of each branch intersection.

B. Support vertical ducts at maximum intervals of 16 feet and at each floor.

C. Install upper attachments to structures with an allowable load not exceeding one-fourth of failure (proof-test) load.

1. Install concrete inserts before placing concrete.

3.7 CONNECTIONS

A. Make connections to equipment with flexible connectors according to Division 15 Section "Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.8 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections according to SMACNA's "HVAC Air Duct Leakage Test Manual" and prepare test reports:

1. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
2. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If pressure classes are not indicated, test entire system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure. Give seven days' advance notice for testing.
3. Maximum Allowable Leakage: Comply with requirements for Leakage Class 3 for round and flat-oval ducts, Leakage Class 12 for rectangular ducts in pressure classes lower than and equal to 2-inch wg (both positive and negative pressures), and Leakage Class 6 for pressure classes from 2- to 10-inch wg.
4. Remake leaking joints and retest until leakage is equal to or less than maximum allowable.

B. Furnish leakage testing reports to the Architect/Engineer.

3.9 CLEANING NEW SYSTEMS

A. Mark position of dampers and air-directional mechanical devices before cleaning, and perform cleaning before air balancing.

B. Use service openings, as required, for physical and mechanical entry and for inspection.

1. Create other openings to comply with duct standards.
2. Disconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling sections to gain access during the cleaning process.

C. Vent vacuuming system to the outside. Include filtration to contain debris removed from HVAC systems, and locate exhaust down wind and away from air intakes and other points of entry into building.

D. Clean the following metal duct systems by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
4. Coils and related components.
5. Return-air ducts, dampers, and actuators except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.

E. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet.
5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.

F. Cleanliness Verification:

1. Visually inspect metal ducts for contaminants.
2. Where contaminants are discovered, re-clean and reinspect ducts.

END OF SECTION 233113

TABLE OF CONTENTS
SECTION 233315 – BREECHINGS, CHIMNEYS AND STACKS

SECTION 233315 - BREECHINGS, CHIMNEYS, AND STACKS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Listed double-wall breechings, vents and chimneys.
2. Field-fabricated metal breechings vents and chimneys.

B. Related Sections include the following:

1. Division 23 Section "Cast Iron Boilers" and "Vertical Tubeless Steam Boilers" and barometric dampers.

1.3 SUBMITTALS

A. Product Data: For the following:

1. Type L vents.
2. Field fabricated vents
3. Guy wires and connectors.

B. Shop Drawings: For vents, breechings, chimneys, and stacks. Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, methods of field assembly, components, hangers and seismic restraints, and location and size of each field connection.
2. For installed products indicated to comply with design loads, include calculations required for selecting seismic restraints and structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

C. Welding certificates.

D. Manufacturer Seismic Qualification Certification: Submit certification that factory-fabricated breeching, chimneys, and stacks; accessories; and components will withstand seismic forces defined in Division 23 Section "Mechanical Vibration and Seismic Controls." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
   b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Dimensioned Outline Drawings of Breeching, Chimneys, and Stacks: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of anchorage devices on which the certification is based and their installation requirements.

E. Warranty: Special warranty specified in this Section.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain listed system components through one source from a single manufacturer.

B. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code--Steel," for hangers and supports and AWS D9.1/D9.1M, "Sheet Metal Welding Code," for shop and field welding of joints and seams in vents, breechings, and stacks.

C. Certified Sizing Calculations: Manufacturer shall certify venting system sizing calculations.

1.5 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 7 Section "Roof Accessories."

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of venting system that fail in materials or workmanship within specified warranty period. Failures include, but are not limited to, structural failures caused by expansion and contraction.

1. Warranty Period: 20 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 LISTED TYPE L VENTS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

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

C. Acceptable manufacturers:

1. Heat-Fab, Inc.
2. Metal-Fab, Inc.
3. Selkirk Inc.; Selkirk Metalbestos and Air Mate.
4. Van-Packer Company, Inc.

D. Description: Double-wall metal vents tested according to UL 641 and rated for 570 deg F continuously, or 1700 deg F for 10 minutes; with neutral or negative flue pressure complying with NFPA 211.

E. Construction: Inner shell and outer jacket separated by at least a 1-inch airspace filled with high-temperature, mineral-wool insulation.

F. Inner Shell: ASTM A 666, Type 304 stainless steel.

G. Outer Jacket: Aluminized steel.

H. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.

1. Termination: Round chimney top designed to exclude 98 percent of rainfall.

2.2 FIELD-FABRICATED METAL BREECHINGS AND CHIMNEYS

A. Fabricate freestanding chimneys according to SMACNA's "Guide for Steel Stack Design and Construction."

B. Fabricate breechings and chimneys from ASTM A 1011/A 1011M hot-rolled steel with continuously welded joints, complying with NFPA 211 for minimum metal thickness.

1. Equal to or Less than 14 inches in diameter: 0.053 inch.
2. Up to 16 inches in diameter: 0.067 inch.
3. Up to18 inches in diameter: 0.093 inch.
4. Larger than above: 0.123 inch.

C. Fabricate chimneys and vent connectors from galvanized steel, complying with NFPA 211 for minimum metal thickness.

1. Equal to or less than 6 Inches in diameter: 0.019 inch.
2. Up to 10 Inches in diameter: 0.024 inch.
3. Up to 16 Inches in diameter: 0.029 inch.
4. Larger than above: 0.056 inch .

D. Fabricate cleanout doors from compatible material, same thickness as breeching, bolted and gasketed.

2.3 GUYING AND BRACING MATERIALS

A. Cable: Four galvanized, stranded wires of the following thickness:

1. For ID Sizes 4 to 15 Inches: 5/16 inch.
2. For ID Sizes 18 to 24 Inches: 3/8 inch.
3. For ID Sizes 27 to 30 Inches: 7/16 inch.

B. Pipe: galvanized steel, NPS 1-1/4.

C. Angle Iron: galvanized steel, 2 by 2 by 0.25 inch.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of work.

1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATION

A. Listed Type L Vent: Vents for low-heat appliances.

B. Field-Fabricated Metal Breechings and Chimneys: Alternate material to Listed Type L Vent.

3.3 INSTALLATION OF LISTED VENTS AND CHIMNEYS

A. Locate to comply with minimum clearances from combustibles and minimum termination heights according to product listing or NFPA 211, whichever is most stringent.

B. Seal between sections of positive-pressure vents according to manufacturer's written installation instructions, using sealants recommended by manufacturer.

C. Support vents at intervals recommended by manufacturer to support weight of vents and all accessories, without exceeding appliance loading.

D. Slope breechings down in direction of appliance, with condensate drain connection at lowest point piped to nearest drain.

E. Lap joints in direction of flow.

F. Connect base section to foundation using anchor lugs of size and number recommended by manufacturer.

G. Provide full sized weighted barometric dampers for boilers and humidifiers.

H. Join sections with acid-resistant joint cement to provide continuous joint and smooth interior finish.

I. Erect stacks plumb to finished tolerance of no more than 1 inch out of plumb from top to bottom.

J. Support chimney stacks above finished roof with guy wires and structural attachments per manufacturer's recommendations.

3.4 INSTALLATION OF UNLISTED, FIELD-FABRICATED BREECHINGS AND CHIMNEYS

A. Suspend breechings and chimneys independent of their appliance connections.

B. Install, support, and restrain according to seismic requirements.

C. Align breechings at connections, with smooth internal surface and a maximum 1/8-inch misalignment tolerance.

D. Slope breechings down in direction of appliance, with condensate drain connection at lowest point piped to nearest drain.

E. Insulate breechings, connectors and chimneys. Refer to Section 230713, DUCT INSULATION.

F. Lap joints in direction of flow.

G. Support breechings and chimneys from building structure with bolts, concrete inserts, steel expansion anchors, welded studs, C-clamps, or beam clamps according to manufacturer's written instructions.

H. Provide listed Type L chimney and termination located above roof exposed to sight. Support chimney stacks above finished roof with guy wires and structural attachments per manufacturer's recommendations.

3.5 CLEANING

A. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

B. Clean breechings internally, during and after installation, to remove dust and debris. Clean external surfaces to remove welding slag and mill film. Grind welds smooth and apply touchup finish to match factory or shop finish.

C. Provide temporary closures at ends of breechings, chimneys, and stacks that are not completed or connected to equipment.

END OF SECTION 233315

TABLE OF CONTENTS
SECTION 233300 – AIR DUCT ACCESSORIES

SECTION 233300 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Backdraft dampers.
2. Volume dampers.
3. Motorized control dampers.
4. Fire dampers.
5. Ceiling fire dampers.
6. Smoke dampers.
7. Combination fire and smoke dampers.
8. Duct silencers.
9. Turning vanes.
10. Duct-mounting access doors.
11. Flexible connectors.
12. Flexible ducts.
13. Duct accessory hardware.

1.3 SUBMITTALS

A. Product Data: For the following:

1. Backdraft dampers.
2. Volume dampers.
3. Motorized control dampers.
4. Fire dampers.
5. Ceiling fire dampers.
6. Smoke dampers.
7. Combination fire and smoke dampers.
8. Duct silencers.
9. Turning vanes.
10. Duct-mounting access doors.
11. Flexible connectors.
12. Flexible ducts.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Special fittings.
2. Manual-volume damper installations.
3. Motorized-control damper installations.
4. Fire-damper, smoke-damper, and combination fire- and smoke-damper installations, including sleeves and duct-mounting access doors.
5. Wiring Diagrams: Power, signal, and control wiring.

C. Coordination Drawings: Reflected ceiling plans, drawn to scale and coordinating penetrations and ceiling-mounting items. Show ceiling-mounting access panels and access doors required for access to duct accessories.

1.4 QUALITY ASSURANCE

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

1.5 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 SHEET METAL MATERIALS

A. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods, unless otherwise indicated.

B. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653/A 653M and having G90 coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.

C. Stainless Steel: ASTM A 480/A 480M.

D. Aluminum Sheets: ASTM B 209, alloy 3003, temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

E. Extruded Aluminum: ASTM B 221, alloy 6063, temper T6.

F. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

G. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.3 BACKDRAFT DAMPERS

A. Manufacturers:

1. Air Balance, Inc.
2. Greenheck.
3. Ruskin Company.

B. Description: Multiple-blade, parallel action gravity balanced, with blades of maximum 6-inch width, with sealed edges, assembled in rattle-free manner with 90-degree stop, steel ball bearings, and axles; adjustment device to permit setting for varying differential static pressure.

C. Frame: 0.052-inch thick, galvanized sheet steel, with welded corners and mounting flange.

D. Blades: 0.050-inch thick aluminum sheet.

E. Blade Seals: Vinyl.

F. Blade Axles: Galvanized steel.

G. Tie Bars and Brackets: Galvanized steel.

H. Return Spring: Adjustable tension.

2.4 VOLUME DAMPERS

A. Manufacturers:

1. METALAIRE, Inc.
2. Nailor Industries Inc.
3. Penn Ventilation Company, Inc.
4. Ruskin Company.

B. General Description: Factory fabricated, with required hardware and accessories. Stiffen damper blades for stability. Include locking device to hold single-blade dampers in a fixed position without vibration. Close duct penetrations for damper components to seal duct consistent with pressure class.

1. Pressure Classes of 3-Inch wg or Higher: End bearings or other seals for ducts with axles full length of damper blades and bearings at both ends of operating shaft.

C. Standard Volume Dampers: Multiple- or single-blade, parallel- or opposed-blade design as indicated, standard leakage rating, with linkage outside airstream, and suitable for horizontal or vertical applications.

1. Steel Frames: Hat-shaped, galvanized/stainless sheet steel channels, minimum of 0.064 inch thick, with mitered and welded corners; frames with flanges where indicated for attaching to walls and flangeless frames where indicated for installing in ducts.
2. Roll-Formed Steel Blades: 0.064-inch- thick, galvanized sheet steel for galvanized ductwork and stainless for stainless ductwork.
3. Aluminum Frames: Hat-shaped, 0.10-inch- thick, aluminum sheet channels; frames with flanges where indicated for attaching to walls; and flangeless frames where indicated for installing in ducts.
4. Roll-Formed Aluminum Blades: 0.10-inch- thick aluminum sheet.
5. Extruded-Aluminum Blades: 0.050-inch- thick extruded aluminum.
6. Blade Axles: Galvanized steel/Stainless steel.
7. Bearings: Oil-impregnated bronze/Stainless-steel sleeve.
8. Tie Bars and Brackets: Galvanized steel.

D. Low-Leakage Volume Dampers: Multiple- or single-blade, parallel- or opposed-blade design as indicated, low-leakage rating, with linkage outside airstream, and suitable for horizontal or vertical applications.

1. Steel Frames: Hat -shaped, galvanized/stainless sheet steel channels, minimum of 0.064 inch thick, with mitered and welded corners; frames with flanges where indicated for attaching to walls and flangeless frames where indicated for installing in ducts.
2. Roll-Formed Steel Blades: 0.064-inch- thick, galvanized stainless sheet steel.
3. Aluminum Frames: Hat -shaped, 0.10-inch- thick, aluminum sheet channels; frames with flanges where indicated for attaching to walls and flangeless frames where indicated for installing in ducts.
4. Roll-Formed Aluminum Blades: 0.10-inch- thick aluminum sheet.
5. Extruded-Aluminum Blades: 0.050-inch- thick extruded aluminum.
6. Blade Axles: Galvanized steel/Stainless steel.
7. Bearings: Oil-impregnated bronze/Stainless-steel sleeve thrust or ball.
8. Blade Seals: Vinyl.
9. Jamb Seals: Cambered stainless steel.
10. Tie Bars and Brackets: Galvanized steel.

E. Jackshaft: 1-inch- diameter, galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.

1. Length and Number of Mountings: Appropriate to connect linkage of each damper in multiple-damper assembly.

F. Damper Hardware: Zinc-plated, die-cast core with dial and handle made of 3/32-inch- thick zinc-plated steel, and a 3/4-inch hexagon locking nut. Include center hole to suit damper operating-rod size. Include elevated platform for insulated duct mounting.

2.5 MOTORIZED CONTROL DAMPERS

A. Manufacturers:

1. Greenheck.
2. METALAIRE, Inc.
3. Nailor Industries Inc.
4. Ruskin Company.

B. General Description: AMCA-rated, opposed-blade design; minimum of 0.1084-inch- thick, galvanized-steel frames with holes for duct mounting; minimum of 0.0635-inch- thick, galvanized-steel damper blades with maximum blade width of 8 inches. Parallel blades for open/close two position damper and opposed blades for modular type damper

1. Secure blades to 1/2-inch- diameter, zinc-plated axles using zinc-plated hardware, with nylon blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.
2. Operating Temperature Range: From minus 40 to plus 200 deg F.
3. Provide closed-cell neoprene edging.

C. Motorized control dampers or smoke evacuation system shall be ultra-low leakage and rated for the temperature exposure.

D. Motorized control dampers for outside air shall be insulated type.

2.6 FIRE DAMPERS

A. Manufacturers:

1. Air Balance, Inc.
2. Greenheck.
3. Ruskin Company.

B. Fire dampers shall be labeled according to UL 555.

C. Fire Rating: 1-1/2 to 3 hours. See Architectural Plans for rating of walls.

D. Frame: Curtain type with blades outside airstream; fabricated with roll-formed, 0.034-inch-thick galvanized steel; with mitered and interlocking corners.

E. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.

1. Minimum Thickness: 0.052 or 0.138 inch thick as indicated and of length to suit application.
2. Exceptions: Omit sleeve where damper frame width permits direct attachment of perimeter mounting angles on each side of wall or floor, and thickness of damper frame complies with sleeve requirements.

F. Mounting Orientation: Vertical or horizontal as indicated.

G. Blades: Roll-formed, interlocking, 0.034-inch- thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- thick, galvanized-steel blade connectors.

H. Horizontal Dampers: Include blade lock and stainless-steel closure spring.

I. Fusible Links: Replaceable, 165 deg F rated.

2.7 CEILING FIRE DAMPERS

A. Manufacturers:

1. Air Balance, Inc.
2. Greenheck.
3. Ruskin Company.

B. General Description: Labeled according to UL 555C; comply with construction details for tested floor- and roof-ceiling assemblies as indicated in UL's "Fire Resistance Directory."

C. Frame: Galvanized sheet steel, round or rectangular, style to suit ceiling construction.

D. Blades: Galvanized sheet steel with refractory insulation.

E. Fusible Links: Replaceable, 165 deg F rated.

2.8 SMOKE/COMBINATION FIRE AND SMOKE DAMPERS

A. Manufacturers:

1. Greenheck.
2. Nailor Industries Inc.
3. Ruskin Company.

B. General Description: Labeled according to UL 555S. Combination fire and smoke dampers shall be labeled according to UL 555 for 1-1/2-hour rating.

C. Fusible Links: Replaceable, 165 deg F rated.

D. Frame and Blades: 0.064-inch- thick, galvanized sheet steel.

E. Mounting Sleeve: Factory-installed, 0.052-inch- thick, galvanized sheet steel; length to suit wall or floor application.

F. Damper Motors: Modulating and two-position action.

1. Comply with requirements in Division 23 Section "Motors."
2. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.

3. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.
4. Outdoor Motors and Motors in Outside-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.
5. Nonspring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf.
6. Electrical Connection: 115 V, single phase, 60 Hz.

2.9 DUCT SILENCERS

A. Manufacturers:

1. Aero
2. IAC
3. Vibro-Acoustics.

B. General Description: Factory-fabricated and -tested, round or rectangular silencers with performance characteristics and physical requirements as indicated.

C. Fire Performance: Adhesives, sealants, packing materials, and accessory materials shall have fire ratings not exceeding 25 for flame-spread index and 50 for smoke-developed index when tested according to ASTM E 84.

D. Rectangular Units: Fabricate casings with a minimum of 0.034-inch- thick, solid galvanized sheet metal for outer casing and 0.022-inch- thick, ASTM A 653/A 653M, G90, perforated galvanized sheet metal for inner casing.

E. Round Units:

1. Outer Casings:

a. ASTM A 653/A 653M, G90, galvanized sheet steel.
b. Up to 24 Inches in Diameter: 0.034 inch thick.
c. 26 through 40 Inches in Diameter: 0.040 inch thick.
d. 42 through 52 Inches in Diameter: 0.052 inch thick.
e. 54 through 60 Inches in Diameter: 0.064 inch thick.
f. Casings fabricated of spiral lock-seam duct may be one size thinner than that indicated.

2. Interior Casing, Partitions, and Baffles:

a. ASTM A 653/A 653M, G90, galvanized sheet steel.
b. At least 0.034 inch thick and designed for minimum aerodynamic losses.

F. Sheet Metal Perforations: 1/8-inch diameter for inner casing and baffle sheet metal.

G. Fill Material: Moisture-proof nonfibrous material.

1. Erosion Barrier: Polymer bag enclosing fill and heat-sealed before assembly.

H. Fabricate silencers to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations.

1. Do not use nuts, bolts, or sheet metal screws for unit assemblies.
2. Lock form and seal or continuously weld joints.
3. Suspended Units: Factory-installed suspension hooks or lugs attached to frame in quantities and spaced to prevent deflection or distortion.
4. Reinforcement: Cross or trapeze angles for rigid suspension.

I. Source Quality Control:

1. Acoustic Performance: Test according to ASTM E 477.
2. Record acoustic ratings, including dynamic insertion loss and self-noise power levels with an airflow of at least 2000-fpm face velocity.
3. Leak Test: Test units for airtightness at 200 percent of associated fan static pressure or 6-inch wg static pressure, whichever is greater.

2.10 TURNING VANES

A. Fabricate to comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for vanes and vane runners. Vane runners shall automatically align vanes.

B. Manufactured Turning Vanes: Fabricate 1-1/2-inch- wide, single-vane, curved blades of galvanized sheet steel set 3/4 inch o.c.; support with bars perpendicular to blades set 2 inches o.c.; and set into vane runners suitable for duct mounting.

1. Manufacturers:

a. Ductmate Industries, Inc.
b. Duro Dyne Corp.
c. METALAIRE, Inc.
d. Ward Industries, Inc.

C. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

2.11 DUCT-MOUNTING ACCESS DOORS

A. General Description: Fabricate doors airtight and suitable for duct pressure class.

B. Door: Double wall, duct mounting, and rectangular; fabricated of galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class. Include vision panel where indicated. Include 1-by-1-inch butt or piano hinge and cam latches.

1. Manufacturers:

    a. Ductmate Industries, Inc.
    b. Greenheck.
    c. Nailor Industries Inc.

2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
3. Provide number of hinges and locks as follows:

    a. Less Than 12 Inches Square: Secure with two sash locks.
    b. Up to 18 Inches Square: Two hinges and two sash locks.
    c. Up to 24 by 48 Inches: Three hinges and two compression latches with outside and inside handles.
    d. Sizes 24 by 48 Inches and Larger: One additional hinge.

C. Door: Double wall, duct mounting, and round; fabricated of galvanized sheet metal with insulation fill and 1-inch thickness. Include cam latches.

1. Manufacturers:

    a. Ductmate Industries, Inc.
    b. Flexmaster U.S.A., Inc.

2. Frame: Galvanized sheet steel, with spin-in notched frame.

D. Pressure Relief Access Door: Double wall and duct mounting; fabricated of galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class. Include vision panel where indicated, latches, and retaining chain.

1. Manufacturers:

    a. Ductmate Industries, Inc.
    b. Greenheck.
    c. KEES, Inc.

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

E. Seal around frame attachment to duct and door to frame with neoprene or foam rubber.

F. Insulation: 1-inch- thick, fibrous-glass or polystyrene-foam board.

2.12 FLEXIBLE CONNECTORS

A. Manufacturers:

1. Ductmate Industries, Inc.
2. Duro Dyne Corp.
3. Ventfabrics, Inc.
4. Ward Industries, Inc.

B. General Description: Flame-retardant or noncombustible fabrics, coatings, and adhesives complying with UL 181, Class 1.

C. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches wide attached to two strips of 2-3/4-inch- wide, 0.028-inch- thick, galvanized sheet steel or 0.032-inch- thick aluminum sheets. Select metal compatible with ducts.

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

1. Minimum Weight: 26 oz./sq. yd..
2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
3. Service Temperature: Minus 40 to plus 200 deg F.

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

1. Minimum Weight: 24 oz./sq. yd..
2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
3. Service Temperature: Minus 50 to plus 250 deg F.

F. High-Temperature System, Flexible Connectors: Glass fabric coated with silicone rubber.

1. Minimum Weight: 16 oz./sq. yd..
2. Tensile Strength: 285 lbf/inch in the warp and 185 lbf/inch in the filling.
3. Service Temperature: Minus 67 to plus 500 deg F.

G. High-Corrosive-Environment System, Flexible Connectors: Glass fabric with chemical-resistant coating.

1. Minimum Weight: 14 oz./sq. yd..
2. Tensile Strength: 450 lbf/inch in the warp and 340 lbf/inch in the filling.
3. Service Temperature: Minus 67 to plus 500 deg F.

2.13 FLEXIBLE DUCTS

A. Manufacturers:

1. Flexmaster U.S.A., Inc.
2. Hart & Cooley, Inc.

B. Noninsulated-Duct Connectors: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire.

1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
2. Maximum Air Velocity: 4000 fpm.
3. Temperature Range: Minus 10 to plus 160 deg F.

C. Noninsulated-Duct Connectors: UL 181, Class 0, interlocking spiral of aluminum foil.

1. Pressure Rating: 8-inch wg positive or negative.
2. Maximum Air Velocity: 5000 fpm.
3. Temperature Range: Minus 100 to plus 435 deg F.

D. Insulated-Duct Connectors: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene vapor barrier film.

1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
2. Maximum Air Velocity: 4000 fpm.
3. Temperature Range: Minus 10 to plus 160 deg F.

E. Flexible Duct Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action, in sizes 3 through 18 inches to suit duct size.

2.14 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 APPLICATION AND INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for metal ducts.

B. Provide duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. Install backdraft dampers on exhaust fans or exhaust ducts nearest to outside and where indicated.

D. Install volume dampers in ducts with liner; avoid damage to and erosion of duct liner.

E. Provide balancing dampers at points on supply, return, and exhaust systems where branches lead from larger ducts as required for air balancing. Install at a minimum of two duct widths from branch takeoff.

F. Provide test holes at fan inlets and outlets and elsewhere as indicated.

G. Install fire and smoke dampers, with fusible links, according to manufacturer's UL-approved written instructions.

H. Install duct silencers rigidly to ducts.

I. Install duct access doors to allow for inspecting, adjusting, and maintaining accessories and terminal units as follows:

1. On both sides of duct coils.
2. Downstream from volume dampers and equipment.
3. Adjacent to fire or smoke dampers, providing access to reset or reinstall fusible links.
4. To interior of ducts for cleaning; before and after each change in direction, at maximum 50-foot spacing.
5. On sides of ducts where adequate clearance is available.

J. Install the following sizes for duct-mounting, rectangular access doors:

1. One-Hand or Inspection Access: 8 by 5 inches.
2. Two-Hand Access: 12 by 6 inches.
3. Head and Hand Access: 18 by 10 inches.
4. Head and Shoulders Access: 21 by 14 inches.
5. Body Access: 25 by 14 inches.
6. Body Plus Ladder Access: 25 by 17 inches.

K. Install the following sizes for duct-mounting, round access doors:

1. One-Hand or Inspection Access: 8 inches in diameter.
2. Two-Hand Access: 10 inches in diameter.
3. Head and Hand Access: 12 inches in diameter.
4. Head and Shoulders Access: 18 inches in diameter.
5. Body Access: 24 inches in diameter.

L. Install the following sizes for duct-mounting, pressure relief access doors:

1. One-Hand or Inspection Access: 7 inches in diameter.
2. Two-Hand Access: 10 inches in diameter.
3. Head and Hand Access: 13 inches in diameter.
4. Head and Shoulders Access: 19 inches in diameter.

M. Label access doors according to Division 23 Section "Mechanical Identification."

N. Install flexible connectors immediately adjacent to equipment in ducts associated with fans and motorized equipment supported by vibration isolators.

O. For fans developing static pressures of 5-inch wg and higher, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

P. Connect terminal units to supply ducts directly or with maximum 12-inch lengths of flexible duct. Do not use flexible ducts to change directions.

Q. Connect diffusers or light troffer boots to low pressure ducts directly or with maximum 60-inch lengths of flexible duct clamped or strapped in place.

R. Connect flexible ducts to metal ducts with draw bands.

S. Install duct test holes where indicated and required for testing and balancing purposes.

3.2 ADJUSTING

A. Adjust duct accessories for proper settings.

B. Adjust fire and smoke dampers for proper action.

C. Final positioning of manual-volume dampers is specified in Division 23 Section "Testing, Adjusting, and Balancing."

END OF SECTION 233300

TABLE OF CONTENTS
SECTION 233413 – AXIAL FANS

SECTION 233413 - AXIAL FANS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Tubeaxial fans.
2. Vaneaxial fans.
3. Mixed-flow fans.

1.3 PERFORMANCE REQUIREMENTS

A. Project Altitude: Base fan performance ratings on actual Project site elevations above sea level.

B. Operating Limits: Classify according to AMCA 99.

1.4 SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:

1. Certified fan performance curves with system operating conditions indicated.
2. Certified fan sound-power ratings.
3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
4. Material thickness and finishes, including color charts.
5. Dampers, including housings, linkages, and operators.
6. Fan speed controllers.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring.
2. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
3. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.

C. Coordination Drawings: Show fan room layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate and certify field measurements.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For axial fans to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

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

B. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.

C. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations, with protective crating and covering.

B. Disassemble and reassemble units, as required for moving to final locations, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

1.7 COORDINATION

A. Coordinate size and location of structural-steel support members.

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 7 Section "Roof Accessories."

1.8 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Belts: One set(s) for each belt-driven unit.

PART 2 - PRODUCTS

2.1 TUBEAXIAL FANS

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

B. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
    1. Aerovent; a Twin City Fan Company.
    2. Barry Blower Div.; Penn Ventilation Companies, Inc.
    3. Carnes Company HVAC.
    4. Chicago Blower Corporation.
    5. Greenheck.
    6. Hartzell Fan, Inc.
    7. Loren Cook Company.
    8. New York Blower Company (The).

C. Description: Fan wheel and housing, factory-mounted motor with belt drive or direct drive, an inlet cone section, and accessories.

D. Housings: Steel with flanged inlet and outlet connections.

E. Wheel Assemblies: Cast or extruded aluminum with airfoil-shaped blades mounted on cast-iron wheel plate keyed to shaft with solid-steel key.

F. Drives: Factory mounted, with final alignment and belt adjustment made after installation.
    1. Service Factor Based on Fan Motor Size: 1.4.
    2. Fan Shaft: Turned, ground, and polished steel designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
    3. Fan Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
    4. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
    5. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
    6. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.
    7. Motor Mount: Adjustable base.
    8. Shaft Bearings: Radial, self-aligning ball or roller bearings.
        a. Ball-Bearing Rating Life: ABMA 9, L10 of 100,000 hours.
        b. Roller-Bearing Rating Life: ABMA 11, L10 of 100,000 hours.
        c. Extend lubrication lines to outside of casing and terminate with grease fittings.

G. Accessories:
    1. Companion Flanges: Rolled flanges of same material as housing.
    2. Inspection Door: Bolted door allowing limited access to internal parts of fan, of same material as housing.
    3. Propeller Access Section Door: Short duct section bolted to fan inlet and outlet allowing access to internal parts of fan for inspection and cleaning, of same material as housing.
    4. Swingout Construction: Assembly allowing entire fan section to swing out from duct for cleaning and servicing, of same material as housing.
    5. Mounting Clips: Horizontal or Vertical mounting clips welded to fan housing, of same material as housing.
    6. Horizontal Support: Pair of supports bolted to fan housing, of same material as housing.

7. Vertical Support: Short duct section with welded brackets bolted to fan housing, of same material as housing.
8. Inlet and Outlet Screens: Wire-mesh screen on fans not connected to ductwork, of same material as housing.
9. Backdraft Dampers: Butterfly style, for bolting to the discharge of fan or outlet cone, of same material as housing.
10. Shaft Seal: Elastomeric seal and Teflon wear plate, suitable for up to 300 deg F.
11. Motor Cover: Cover with side vents to dissipate motor heat, of same material as housing.
12. Inlet Vanes: Adjustable; with peripheral control linkage operated from outside of airstream, bronze sleeve bearings on each end of vane support, and provision for manual or automatic operation of same material as housing.
13. Inlet Bell: Curved inlet for when fan is not attached to duct, of same material as housing.
14. Inlet Cones: Round-to-round transition of same material as housing.
15. Outlet Cones: Round-to-round transition of same material as housing.
16. Stack Cap: Vertical discharge assembly with backdraft dampers, of same material as housing.

H. Motors: Comply with requirements in Division 15 Section "Motors."

1. Direct-Driven Units: Encase motor in housing outside of airstream, factory wired to disconnect switch located on outside of fan housing.

I. Factory Finishes:

1. Sheet Metal Parts: Prime coat before final assembly.
2. Exterior Surfaces: Baked-enamel finish coat after assembly.
3. Coatings: Powder-baked enamel:

a. Apply to finished housings.
b. Apply to fan wheels.

2.2 VANEAXIAL FANS

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

B. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

1. Aerovent; a Twin City Fan Company.
2. Barry Blower Div.; Penn Ventilation Companies, Inc.
3. Carnes Company HVAC.
4. Chicago Blower Corporation.
5. Greenheck.
6. Hartzell Fan, Inc.
7. Howden Fan Co.
8. Loren Cook Company.

C. Description: Fan wheel and housing, straightening vane section, factory-mounted motor with belt drive or direct drive, an inlet cone section, and accessories.

1. Variable-Pitch Fans: Internally mounted electric actuator, externally mounted positive positioner, and mechanical-blade-pitch indicator.

D. Housings: Steel.

1. Inlet and Outlet Connections: Flanges.
2. Guide Vane Section: Integral guide vanes downstream from fan wheel designed to straighten airflow.

E. Wheel Assemblies: Cast aluminum with airfoil-shaped blades mounted on cast-iron wheel plate keyed to shaft with solid-steel key.

F. Drives: Factory mounted, with final alignment and belt adjustment made after installation.

1. Service Factor Based on Fan Motor Size: 1.4.
2. Fan Shaft: Turned, ground, and polished steel designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
3. Fan Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
4. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
5. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
6. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.
7. Motor Mount: Adjustable base.
8. Shaft Bearings: Radial, self-aligning ball or roller bearings.

   a. Ball-Bearing Rating Life: ABMA 9, L10 of 100,000 hours.
   b. Roller-Bearing Rating Life: ABMA 11, L10 of 100,000 hour.
   c. Extend lubrication lines to outside of casing and terminate with grease fittings.

G. Accessories:

1. Companion Flanges: Rolled flanges of same material as housing.
2. Inspection Door: Bolted door allowing limited access to internal parts of fan, of same material as housing.
3. Propeller Access Section Door: Short duct section bolted to fan inlet and outlet allowing access to internal parts of fan for inspection and cleaning, of same material as housing.
4. Swingout Construction: Assembly allowing entire fan section to swing out from duct for cleaning and servicing, of same material as housing.
5. Mounting Clips: Horizontal or Vertical mounting clips welded to fan housing, of same material as housing.
6. Horizontal Support: Pair of supports bolted to fan housing, of same material as housing.
7. Vertical Support: Short duct section with welded brackets bolted to fan housing, of same material as housing.
8. Inlet and Outlet Screens: Wire-mesh screen on fans not connected to ductwork of same material as housing.

9. Backdraft Dampers: Butterfly style, for mounting with flexible connection to the discharge of fan or direct mounted to the discharge diffuser section of same material as housing.
10. Stall Alarm Probe: Sensing probe capable of detecting fan operation in stall and signaling control devices. Control devices and sequence of operation are specified in Division 15 Sections "HVAC Instrumentation and Controls" and "Sequence of Operation."
11. Flow Measurement Port: Pressure measurement taps installed in the inlet of fan to detect and signal airflow readings to temperature-control systems. Control devices and sequence of operation are specified in Division 15 Sections "HVAC Instrumentation and Controls" and "Sequence of Operation."
12. Shaft Seal: Elastomeric seal and Teflon wear plate, suitable for up to 300 deg F.
13. Motor Cover: Cover with side vents to dissipate motor heat, of same material as housing.
14. Inlet Vanes: Adjustable; with peripheral control linkage operated from outside of airstream, bronze sleeve bearings on each end of vane support, and provision for manual or automatic operation of same material as housing.
15. Inlet Bell: Curved inlet for when fan is not attached to duct, of same material as housing.
16. Inlet Cones: Round-to-round transition of same material as housing.
17. Outlet Cones: Round-to-round transition of same material as housing.
18. Stack Cap: Vertical discharge assembly with backdraft dampers, of same material as housing.

H. Motors: Comply with requirements in Division 15 Section "Motors."

1. Direct-Driven Units: Encase motor in housing outside of airstream, factory wired to disconnect switch located on outside of fan housing.

I. Factory Finishes:

1. Sheet Metal Parts: Prime coat before final assembly.
2. Exterior Surfaces: Baked-enamel finish coat after assembly.
3. Coatings: Powder-baked enamel:

a. Apply to finished housings.
b. Apply to fan wheels.

2.3 MIXED-FLOW FANS

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

B. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

1. Loren Cook Company.
2. Greenheck.

C. Description: Fan wheel and housing, straightening vane section, factory-mounted motor with belt drive, and accessories.

D. Housings: Steel.

1. Inlet and Outlet Connections: Outer mounting frame and companion flanges.
2. Guide Vane Section: Integral guide vanes downstream from fan wheel designed to straighten airflow.
3. Mixed-Flow Outlet Connection: One flanged discharge(s) perpendicular to fan inlet.

E. Wheel Assemblies: Cast aluminum with airfoil-shaped blades mounted on cast-iron wheel plate keyed to shaft with solid-steel key.

F. Drives: Factory mounted, with final alignment and belt adjustment made after installation.

1. Service Factor Based on Fan Motor Size: 1.4.
2. Fan Shaft: Turned, ground, and polished steel designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
3. Fan Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
4. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
5. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
6. Motor Mount: Adjustable base.
7. Shaft Bearings: Radial, self-aligning ball or roller bearings.

   a. Ball-Bearing Rating Life: ABMA 9, L10 of 100,000 hours.
   b. Roller-Bearing Rating Life: ABMA 11, L10 of 100,000 hours.
   c. Extend lubrication lines to outside of casing and terminate with grease fittings.

G. Accessories:

1. Mounting Clips: Horizontal or Vertical mounting clips welded to fan housing, of same material as housing.
2. Inlet and Outlet Screens: Wire-mesh screen on fans not connected to ductwork of same material as housing.
3. Backdraft Dampers: Butterfly style, for mounting with flexible connection to the discharge of fan or direct mounted to the discharge diffuser section of same material as housing.
4. Motor Cover: Cover with side vents to dissipate motor heat, of same material as housing.
5. Inlet Bell: Curved inlet for when fan is not attached to duct, of same material as housing.
6. Inlet Cones: Round-to-round transition of same material as housing.
7. Outlet Cones: Round-to-round transition of same material as housing.
8. Stack Cap: Vertical discharge assembly with backdraft dampers, of same material as housing.

H. Motors: Comply with requirements in Division 15 Section "Motors."

1. Direct-Driven Units: Encase motor in housing outside of airstream, factory wired to disconnect switch located on outside of fan housing.

I. Factory Finishes:

1. Sheet Metal Parts: Prime coat before final assembly.
2. Exterior Surfaces: Baked-enamel finish coat after assembly.
3. Coatings: Powder-baked enamel:

a. Apply to finished housings.
b. Apply to fan wheels.

2.4 SOURCE QUALITY CONTROL

A. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install axial fans level and plumb.

B. Support floor-mounting units using vibration- and seismic-control devices specified in Division 23 Section "Mechanical Vibration and Seismic Controls."

1. Secure vibration and seismic controls to concrete bases using anchor bolts cast in concrete base.

C. Install floor-mounting units on concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 3 Section "Cast-in-Place Concrete."

D. Install floor-mounting units on concrete bases designed to withstand, without damage to equipment, the seismic force required by authorities having jurisdiction. Concrete, reinforcement, and formwork requirements are specified in Division 3 Section "Cast-in-Place Concrete."

E. Support suspended units from structure using vibration-control devices are specified in Division 23 Section "Mechanical Vibration and Seismic Controls."

F. Install units with clearances for service and maintenance.

G. Label fans according to requirements specified in Division 15 Section "Mechanical Identification."

3.2 CONNECTIONS

A. Duct installation and connection requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 23 Section "Duct Accessories."

B. Ground equipment according to Division 26 Section "Grounding and Bonding."

C. Connect wiring according to Division 26 Section "Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

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

B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.4 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Lubricate bearings.

END OF SECTION 233413

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SECTION 233416 – CENTRIFUGAL FANS

SECTION 233416 - CENTRIFUGAL FANS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes centrifugal fans and vent sets.

1.3 PERFORMANCE REQUIREMENTS

A. Project Altitude: Base air ratings on actual site elevations .

B. Operating Limits: Classify according to AMCA 99.

1.4 SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:

1. Certified fan performance curves with system operating conditions indicated.
2. Certified fan sound-power ratings.
3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
4. Material gages and finishes, including color charts.
5. Dampers, including housings, linkages, and operators.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.
2. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
3. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.

C. Coordination Drawings: Show fan room layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate and certify field measurements.

D. Maintenance Data: For centrifugal fans to include in maintenance manuals specified in Division 1.

1.5 QUALITY ASSURANCE

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

B. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.

C. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations, with protective crating and covering.

B. Disassemble and reassemble units, as required for moving to the final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

1.7 COORDINATION

A. Coordinate size and location of structural-steel support members.

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3 Section "Cast-in-Place Concrete."

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 7 Section "Roof Accessories."

1.8 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Belts: One set for each belt-driven unit.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Aerovent; a Twin City Fan Company.
2. Chicago Blower Corp.
3. New York Blower Company (The).

4. Greenheck
5. Loren Cook
6. Hartzell

2.2 MANUFACTURED UNITS

A. Description: Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and fused disconnect switch, drive assembly, and support structure.

2.3 HOUSINGS

A. Materials and Fabrication: Formed and reinforced steel panels to make curved scroll housings with shaped cutoff, spun-metal inlet bell, and doors or panels to allow access to internal parts and components. Use galvanized steel to fabricate fans downstream from humidifiers.

1. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
2. Fabrication Class: AMCA 99, Class I .
3. Horizontal Flanged Split Housing: Bolted construction.
4. Plug Fans: Fabricate without fan scroll and volute housing, with steel cabinet.
5. Tubular Centrifugal Fans: Fabricate tubular housing from formed and reinforced steel panels with welded seams and the following:

    a. Outlet guide vanes.
    b. Motor and fused disconnect switch.
    c. Spun inlet cone with flange.
    d. Outlet flange.
    e. Brackets suitable for horizontal or vertical mounting.

B. Coatings: Powder-baked enamel.

2.4 WHEELS

A. Backward-Inclined Fan Wheels: Steel construction with curved inlet flange, back plate, backward-inclined blades welded or riveted and fastened to shaft with set screws.

B. Forward-Curved Fan Wheels: Black-enameled or galvanized steel construction with inlet flange, back plate, shallow blades with inlet and tip curved forward in direction of airflow, mechanically secured to flange and back plate; cast-steel hub swaged to back plate and fastened to shaft with set screws.

C. Airfoil-Fan Wheels: Steel construction with smooth-curved inlet flange; heavy back plate; hollow die-formed, airfoil-shaped blades continuously welded at tip flange and back plate; cast-iron or cast-steel hub riveted to back plate and fastened to shaft with set screws.

D. Coatings: Powder-baked enamel.

2.5 SHAFTS

A. Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.

B. Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.

C. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

2.6 BEARINGS

A. Prelubricated and Sealed Shaft Bearings: Self-aligning, pillow-block-type ball bearings.

1. Ball-Bearing Rating Life: ABMA 9, L_{10} of 200,000 hours.
2. Roller-Bearing Rating Life: ABMA 11, L_{10} of 200,000 hours.

B. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.

1. Ball-Bearing Rating Life: ABMA 9, L_{10} of 200,000hours.
2. Roller-Bearing Rating Life: ABMA 11, L_{10} of 200,000hours.

C. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.

1. Ball-Bearing Rating Life: ABMA 9, L_{10} of 200,000hours.
2. Roller-Bearing Rating Life: ABMA 11, L_{10} of 200,000hours.

2.7 BELT DRIVES

A. Description: Factory mounted, with final alignment and belt adjustment made after installation.

1. Service Factor Based on Fan Motor: 1.5.

B. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.

C. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with motors larger than 5 hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.

D. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.

1. Belt Guards: Fabricate to comply with OSHA and SMACNA requirements; 0.1046-inch-thick, 3/4-inch diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.

E. Motor Mount: Adjustable for belt tensioning.

2.8 ACCESSORIES

A. Scroll Access Doors: Shaped to conform to scroll, with quick-opening latches and gaskets.

B. Companion Flanges: Galvanized steel, for duct connections.

C. Variable Inlet Vanes: Steel, with blades supported at both ends with two permanently lubricated bearings. Variable mechanism terminating in single control lever with control shaft for double-width fans.

D. Discharge Dampers: Heavy-duty steel assembly with opposed blades constructed of two plates formed around and welded to shaft, channel frame, sealed ball bearings, with blades linked outside of airstream to single control lever.

E. Inlet Screens: Galvanized steel welded grid screen.

F. Scroll Drain Connection: NPS 1 steel pipe coupling welded to low point of fan scroll.

G. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.

H. Spark-Resistant Construction: AMCA 99.

I. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.

J. Weather Cover: Enameled-steel sheet with ventilation slots, bolted to housing.

2.9 MOTORS

A. Comply with requirements in Division 15 Section "Motors."

B. Enclosure Type: Guarded drip proof.

2.10 SOURCE QUALITY CONTROL

A. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install centrifugal fans level and plumb.

B. Support floor-mounting units using vibration- and seismic-control devices are specified in Division 23 Section "Mechanical Vibration Controls and Seismic Restraints."

1. Secure vibration and seismic controls to concrete bases using anchor bolts cast in concrete base.

C. Install floor-mounting units on concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 3 Section "Cast-in-Place Concrete."

D. Install floor-mounting units on concrete bases designed to withstand, without damage to equipment, the seismic force required by authorities having jurisdiction. Concrete, reinforcement, and formwork requirements are specified in Division 3 Section "Cast-in-Place Concrete."

E. Support suspended units from structure using threaded steel rods and spring hangers. Vibration-control devices are specified in Division 23 Section "Mechanical Vibration Controls and Seismic Restraints."

1. In seismic zones, restrain support units.

F. Install units with clearances for service and maintenance.

G. Label fans according to requirements specified in Division 23 Section "Mechanical Identification."

3.2 CONNECTIONS

A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 15 Section "Duct Accessories."

B. Install ducts adjacent to fans to allow service and maintenance.

C. Ground equipment.

D. 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 UL 486B.

3.3 FIELD QUALITY CONTROL

A. Equipment Startup Checks:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and fused disconnect switches.
3. Verify that cleaning and adjusting are complete.
4. Fused disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
5. Verify lubrication for bearings and other moving parts.
6. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.

B. Starting Procedures:

1. Energize motor and adjust fan to indicated rpm.
2. Measure and record motor voltage and amperage.

C. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new units, and retest.

D. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Shut unit down and reconnect automatic temperature-control operators.

F. Refer to Division 23 Section "Testing, Adjusting, and Balancing" for testing, adjusting, and balancing procedures.

G. Replace fan and motor pulleys as required to achieve design airflow.

H. Repair or replace malfunctioning units. Retest as specified above after repairs or replacements are made.

3.4 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Lubricate bearings.

3.5 CLEANING

A. On completion of installation, internally clean fans according to manufacturer's written instructions. Remove foreign material and construction debris. Vacuum fan wheel and cabinet.

B. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

3.6 DEMONSTRATION

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

1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.
2. Review data in maintenance manuals. Refer to Division 1 Section "Closeout Procedures."
3. Schedule training with Owner, through Architect, with at least seven days' advance notice.

END OF SECTION 233416

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SECTION 233423 – POWER VENTILATORS

SECTION 233423 - POWER VENTILATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Utility set fans.
2. Centrifugal roof/wall ventilators.
3. In-line centrifugal fans.
4. Propeller fans.

1.3 PERFORMANCE REQUIREMENTS

A. Project Altitude: Base fan-performance ratings on actual Project site elevations.

B. Operating Limits: Classify according to AMCA 99.

1.4 SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:

1. Certified fan performance curves with system operating conditions indicated.
2. Certified fan sound-power ratings.
3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
4. Material thickness and finishes, including color charts.
5. Dampers, including housings, linkages, and operators.
6. Roof curbs.
7. Fan speed controllers.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring.
2. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
3. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.

C. Operation and Maintenance Data: For power ventilators to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

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

B. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.

C. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

D. UL Standard: Power ventilators shall comply with UL 705.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver fans as factory-assembled unit, to the extent allowable by shipping limitations, with protective crating and covering.

B. Disassemble and reassemble units, as required for moving to final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

1.7 COORDINATION

A. Coordinate size and location of structural-steel support members.

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 7 Section "Roof Accessories."

1.8 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Belts: One set(s) for each belt-driven unit.

PART 2 - PRODUCTS

2.1 UTILITY SET FANS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

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

C. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

1. Loren Cook Company Model CPS.
2. Penn Ventilation, Dynamo Series.
3. Greenheck, Series 21

D. Description: Belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and fused disconnect switch, drive assembly, and accessories.

E. Housing: Fabricated of galvanized steel with side sheets fastened with a deep lock seam or welded to scroll sheets.

1. Housing Discharge Arrangement: Adjustable to eight standard positions.

F. Fan Wheels: Single-width, single inlet; welded to cast-iron or cast-steel hub and spun-steel inlet cone, with hub keyed to shaft.

1. Blade Materials: Steel.
2. Blade Type: Backward inclined.

G. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.

H. Shaft Bearings: Prelubricated and sealed, self-aligning, pillow-block-type ball bearings with ABMA 9, L_{50} of 200,000 hours.

I. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.

1. Service Factor Based on Fan Motor Size: 1.5.
2. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
3. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
4. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.

J. Accessories:

1. Inlet and Outlet: Flanged.
2. Companion Flanges: Rolled flanges for duct connections of same material as housing.
3. Access Door: Gasketed door in scroll with latch-type handles.
4. Inlet Screens: Removable wire mesh.
5. Drain Connections: NPS 3/4 threaded coupling drain connection installed at lowest point of housing.
6. Vibration Isolators:

a. Type: Restrained spring isolators.
b. Static Deflection: 1" (25mm)

K. Coatings: Powder-baked enamel.

2.2 CENTRIFUGAL ROOF VENTILATORS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

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

C. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

1. Loren Cook, AC Series
2. Greenheck, Models A, AB & C Series.

D. Description: Direct- or belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and fused disconnect switch, drive assembly, curb base, and accessories.

E. Housing: Removable, spun-aluminum, dome top and outlet baffle; square, one-piece, aluminum base with venturi inlet cone.

1. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains.
2. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.

F. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.

G. Belt-Driven Drive Assembly: Resiliently mounted to housing, with the following features:

1. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
2. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
3. Pulleys: Cast-iron, adjustable-pitch motor pulley.
4. Fan and motor isolated from exhaust airstream.

H. Accessories:

1. Fused disconnect Switch: Nonfusible type, with thermal-overload protection mounted outside fan housing, factory wired through an internal aluminum conduit.
2. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.
3. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
4. Motorized Dampers: Provided under section 230913, HVAC Instrumentation and Controls.

I. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch- thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.

1. Configuration: Self-flashing without a cant strip, with mounting flange.
2. Overall Height: 12 inches.
3. Sound Curb: Curb with sound-absorbing insulation matrix.
4. Pitch Mounting: Manufacture curb for roof slope.
5. Metal Liner: Galvanized steel.

J. Shaft Bearings: Prefabricated and sealed, self-aligning pillow – block-type with ABMA9 L50 of 200,000 hours.

2.3 IN-LINE CENTRIFUGAL FANS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

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

C. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

1. Loren Cook Company, Model SQI or SQN.
2. Greenheck, Model SQ or BSQ.

D. Description: In-line, direct/belt-driven centrifugal fans consisting of housing, wheel, outlet guide vanes, fan shaft, bearings, motor and fused disconnect switch, drive assembly, mounting brackets, and accessories.

E. Housing: Galvanized steel or factory cold rolled steel. Fan housing shall be square with removable hinged panels for access.

F. Direct-Driven Units: Motor mounted in airstream, factory wired to fused disconnect switch located on outside of fan housing.

G. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.

H. Fan Wheels: Aluminum, backward inclined blades welded to aluminum hub.

I. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.

J. Accessories:

1. Disconnect switch accessible from the exterior of the fan.
2. Vibration Isolators:

   a. Type: Elastomeric hangers.
   b. Static Deflection: 1 inch.

2.4 PROPELLER FANS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

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

C. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

1. Loren Cook Company, S Series.
2. Penn Ventilation, Breezeway Series.
3. Greenheck, SB & S Series.

D. Description: Direct- or belt-driven propeller fans consisting of fan blades, hub, housing, orifice ring, motor, drive assembly, and accessories.

E. Housing: Galvanized-steel sheet with flanged edges and integral orifice ring with baked-enamel finish coat applied after assembly.

F. Steel Fan Wheels: Formed-steel blades riveted to heavy-gage steel spider bolted to cast-iron hub.

G. Belt-Driven Drive Assembly: Resiliently mounted to housing, statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.

1. Service Factor Based on Fan Motor Size: 1.4.
2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
3. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
    a. Ball-Bearing Rating Life: ABMA 9, L_{10} of 100,000 hours.
4. Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
5. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
6. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
7. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.

H. Accessories:

1. Motor-Side Back Guard: Galvanized steel, complying with OSHA specifications, removable for maintenance.
2. Fused disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.
3. Vibration Isolators:

a. Type: Elastomeric hangers.
b. Static Deflection: 1 inch.

2.5 MOTORS

A. Comply with requirements in Division 15 Section "Motors."

B. Enclosure Type: Totally enclosed, fan cooled.

2.6 SOURCE QUALITY CONTROL

A. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install power ventilators level and plumb.

B. Support units using elastomeric mounts/restrained elastomeric mounts/spring isolators having a static deflection of 1 inch. Vibration- and seismic-control devices are specified in Division 15 Section "Mechanical Vibration and Seismic Controls."

1. Secure vibration and seismic controls to concrete bases using anchor bolts cast in concrete base.

C. Install floor-mounting units on concrete bases designed to withstand, without damage to equipment, the seismic force required by code. Concrete, reinforcement, and formwork requirements are specified in Division 3 Section "Cast-in-Place Concrete."

D. Secure roof-mounting fans to roof curbs with cadmium-plated hardware. Refer to Division 7 Section "Roof Accessories" for installation of roof curbs.

E. Support suspended units from structure using threaded steel rods and elastomeric hangers having a static deflection of 1 inch. Vibration-control devices are specified in Division 23 Section "Mechanical Vibration and Seismic Controls."

F. Install units with clearances for service and maintenance.

G. Label units according to requirements specified in Division 15 Section "Mechanical Identification."

3.2 CONNECTIONS

A. Duct installation and connection requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 23 Section "Duct Accessories."

B. Install ducts adjacent to power ventilators to allow service and maintenance.

C. Ground equipment according to Division 26 Section "Grounding and Bonding."

D. Connect wiring according to Division 26 Section "Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

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

B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.4 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Refer to Division 15 Section "Testing, Adjusting, and Balancing" for testing, adjusting, and balancing procedures.

D. Replace fan and motor pulleys as required to achieve design airflow.

E. Lubricate bearings.

END OF SECTION 233423

TABLE OF CONTENTS
SECTION 233424 – HIGH PLUME DILUTION BLOWERS

SECTION 233424 - HIGH PLUME DILUTION BLOWERS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. High-Plume Dilution Laboratory Exhaust Fans.

1.2 RELATED WORK

A. All Sections, Drawing Plans, Specifications and Contract Documents.

1.3 QUALITY ASSURANCE

A. Performance Ratings: Conform to AMCA Standard 211 and 311. Fan sizes 18" and larger must be licensed and bear the AMCA Seal for Certified Sound and Air Performance. Acceptable manufacturers whose equipment is not licensed to bear the AMCA Seal for Certified Sound and Air Performance must submit air and sound performance tests conducted by an independent third party and stamped by a Registered Professional Engineer.

B. Classification for Spark Resistant Construction Conform to AMCA 99.

C. Each fan shall be tested before shipping. Motors to be tested for amperage draw.

D. D.A certificate shall be supplied for each fan, certifying quality control and compliance to specifications, prior to shipping.

E. Fans shall be tested as per AMCA-210, AMCA-300, AMCA-204.

1.4 SUBMITTALS

A. Provide dimensional drawings and product data on each high-plume dilution laboratory exhaust fan assembly.

B. Provide fan curves for each fan at the specified operation point, with the flow, static pressure and horsepower clearly plotted.

C. Provide nozzle velocity of exhaust fan, total exhaust flow and discharge plume height at specified wind velocity.

D. Strictly adhere to QUALITY ASSURANCE requirements of AMCA CERTIFICATION, as stated in Section 1.04.A of this specification and provide QC certificate as stated in Section 1.04.D of this specification.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Loren Cook, Greenheck or approved M.K. Plastics Corporation.

2.2 GENERAL

A. Base fan performance at standard conditions (density 0.075 lb/ft^3).

B. Fans selected shall be capable of accommodating static pressure and flow variations of +/-15% of scheduled values.

C. Each fan shall be belt driven in AMCA arrangement 10 according to drawings. Fans submitted that are not in arrangement 10 with the motor accessible at roof level, shall have a job crane (complete with removable hoist), provided by the fan manufacturer, to perform motor maintenance and replacement.

D. Fans to be equipped with lifting lugs.

E. Fan stand to be coated steel with a minimum of 4 mils of Plastifer Epoxy #ES90-AS81 epoxy.

F. Fasteners to be 316 stainless steel.

2.3 FAN HOUSING AND OUTLET

A. Fan housing to be aerodynamically designed with high-efficiency inlet, engineered to reduce incoming air turbulence.

B. Fan housing on 1225 and 1500 sizes shall be manufactured in specifically formulated resins, for maximum corrosion resistance, UV inhibited and reinforced with fiberglass for structural strength. Fastening bolts holding the casing to the support plate are to be encapsulated in FRP. No uncoated metal fan parts in the corrosive air stream will be tolerated. Fans shall be supplied with an internal graphite liner and grounding strap to remove static electricity, as well as flame retardancy of 25 or less, if scheduled.

C. Fan housing on 1825 and larger sizes shall be manufactured of coated steel with a minimum of 4-6 mils of Plastifer Epoxy #ES90-AS81 no uncoated metal fan parts will be allowed.

D. A bifurcated fiberglass reinforced plastic (FRP) discharge nozzle shall be supplied by the fan manufacturer and be designed to efficiently handle an outlet velocity of up to 7200 FPM. The discharge shall include a venturi and wind band to induce ambient air up to 270% of fan capacity.

E. Sound attenuators to meet sound power level and sound pressure level variations as indicated on the fan schedule.

F. Provide housing drain attached at the lowest point for condensation removal.

G. An access door shall be supplied for impeller inspection and service.

H. Custom finish and color to be selected by Architect.

2.4 FAN IMPELLER

A. Fan impeller shall be centrifugal, backward inclined, of airfoil design with non-stall characteristics. The impeller shall be electronically balanced both statically and dynamically Grade G6.3 per AMCA Standard.

B. For 1225 and 1500 sizes, the impellers to be molded FRP, backward inclined. A metal backplate integral to the FRP impeller and encapsulated in resin shall have the hub extending to the outside of the fan housing. The shaft end in the housing to be covered by a tight fitting FRP cap.

C. Fan impeller on 1825 and larger shall be manufactured of steel and coated with a minimum of 4-6 mils of Plastifer Epoxy #ES90-AS81.

2.5 FAN INLET ELBOW/PLENUM

A. For constant volume systems, the fan shall be connected directly to duct without the need of bypass damper.

B. For variable volume systems, an inlet elbow/plenum shall be equipped with a bypass air damper and drainable inlet air louver for introducing outside air at roof level upstream of the fan. The plenum shall be constructed of galvanized steel and coated with 4-6 mils of Plastifer Epoxy TC-B62Z-B60VZ70, and mounted on roof curb or rails as shown on the project drawings. Inlet elbow/plenum to be attached to the fan inlet by a flexible PVC connector, provided by the fan manufacturer.

C. Bypass air damper shall be opposed blade design and the damper and inlet louver for each inlet elbow/plenum shall be fabricated of aluminum.

D. A fan isolation damper fabricated of epoxy coated aluminum shall be provided as shown on the project documents.

2.6 FAN MOTORS AND DRIVE

A. Motors to be premium efficiency, standard NEMA frame, 1800 RPM, TEFC with a 1.15 service factor. A factory-mounted NEMA 3R fused disconnect switch shall be provided for each fan. Motor maintenance shall be accomplished without fan impeller removal or requiring maintenance personnel to access the contaminated exhaust components. If removal of the fan nozzle and windband is required for motor replacement, the manufacturer of the fan shall pay for this removal for the period of five years after start-up of the fan.

B. Fans submitted that use 900 RPM, 1200 RPM or are C-Face motors, shall include one spare motor per fan system, in accordance with ANSI Z9.5, Section 4.14.7.4, CRITICAL SERVICE SPARES.

C. Drive belts and sheaves shall be sized for 200% of the fan operating brake horsepower and shall be readily and easily accessible for service, if required.

D. Shaft to be ANSI C-1045 steel and be protected with TECTYL 822B protective coating.

E. Fan shaft bearings to be selected according to bearing manufacturer's recommendations and be sized for an L-10 life of 200,000 hours. Bearings shall be ball or spherical pillow block type, sealed to retain lubricant and exclude dust and air.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install fans as indicted, with resilient mountings and flexible electrical leads.

B. Install flexible connections provided between fan inlet and plenum. Insure that the flexible connection is at least 2 inches wide.

C. Pipe housing drain to nearest drain.

D. Install fans in accordance with manufacturer's instructions.

END OF SECTION 233424

TABLE OF CONTENTS
SECTION 233600 – AIR TERMINALS

SECTION 233600 - AIR TERMINALS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. VAV box.
2. Active chilled beams.

1.3 SUBMITTALS

A. Product Data: Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories for each model indicated. Include a schedule showing drawing designation, room location, number furnished, model number, size, and accessories furnished.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loadings, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Detail wiring for power, signal, and control systems and differentiate between manufacturer-installed and field-installed wiring.

C. Coordination Drawings: Reflected ceiling plans drawn to scale and coordinating air outlets with other items installed in ceilings.

D. Maintenance Data: List of parts for each type of air terminal and troubleshooting maintenance guide to include in the maintenance manuals specified in Division 1.

1.4 QUALITY ASSURANCE

A. Product Options: Drawings and schedules indicate requirements of air terminals and are based on specific systems indicated. Other manufacturers' systems with equal performance characteristics may be considered. Refer to Division 1 Section "Substitutions."

B. Listing and Labeling: Provide electrically operated air terminals specified in this Section that are listed and labeled.

1. The Terms "Listed" and "Labeled": As defined in NFPA 70, Article 100.
2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" as defined in OSHA Regulation 1910.7.

C. NFPA Compliance: Install air terminals according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

D. Comply with NFPA 70 for electrical components and installation.

PART 2 - PRODUCTS

2.1 SINGLE-DUCT AIR TERMINALS

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

1. Anemostat Products Div.
2. Environmental Technologies.
3. Nailor

B. Configuration: Volume-damper assembly inside unit casing. Locate control components inside protective metal shroud.

C. Casings: Steel or aluminum sheet metal of the following minimum thicknesses:

1. Casing shall be constructed of not less than 22 gauge galvanized steel with round collars and rectangular slip and drive discharge openings. Interior of unit casing shall be lined with not less than 1/2", 1-1/2 pcf fiberglass insulation. All exposed insulation edges shall be coated with an NFPA 90A approved sealant to prevent the entrainment of fibers into the airstream. Minimum box size is 6".
2. Construct casings such that when subjected to 3" w.g. pressure, total leakage does not exceed four percent of specified air flow capacity or 10 cfm maximum with outlets sealed and inlets wide open. Construct air dampers such that when subjected to 5" w.g. inlet pressure with damper closed, total leakage does not exceed 2% of specified air flow capacity.

D. Casing Lining: Minimum of 1/2-inch- thick, neoprene- or vinyl-coated, fibrous-glass insulation; 1.5-lb/cu. ft. density, complying with NFPA 90A requirements and UL 181 erosion requirements. Secure lining to prevent delamination, sagging, or settling.

1. Coat liner surfaces and edges with erosion-resistant coating or cover with perforated metal.

E. Plenum Air Inlets: Round stub connections or S-slip and drive connections for duct attachment.

F. Plenum Air Outlets: S-slip and drive connections.

G. Access: Removable panels to permit access to dampers and other parts requiring service, adjustment, or maintenance; with airtight gasket and quarter-turn latches.

H. Volume Damper: Construct of galvanized steel with peripheral gasket and self-lubricating bearings.

1. Maximum Damper Leakage: 2 percent of nominal airflow at 3-inch wg inlet static pressure.
2. Damper Position: Normally open.

I. Attenuator Section: Line with 2-inch- thick, neoprene- or vinyl-coated, fibrous-glass insulation.

J. Hot-Water Heating Coil: 1/2-inch copper tube, mechanically expanded into aluminum-plate fins; leak tested underwater to 200 psig; and factory installed.

K. Controls: Damper operator, thermostat, and other devices compatible with temperature controls specified in other Division 15 Sections.

L. Electronic Controls: Bidirectional damper operator and microprocessor-based controller with integral airflow transducer and room sensor provide control with the following features:

1. Proportional plus integral control of room temperature.
2. Time-proportional reheat-coil control.
3. Occupied/unoccupied operating mode.
4. Remote reset of airflow or temperature set points.
5. Adjusting and monitoring with portable terminal.
6. Communication with temperature-control system specified in other Division 15 Sections.

M. Construct air dampers of materials that cannot corrode, do not require lubrication, nor periodic servicing. Linkage must be external to the box; internal linkage is not acceptable.

2.2 ACTIVE CHILLED BEAMS

A. Manufacturers: Subject to compliance with requirements provide active chilled beams by one of the following:

1. Trox
2. Krantz
3. Flaktwoods

B. Construction: Casing, heat exchanger with connection flanges, induction nozzles.

C. Casing: Dipcoated galvanized steel, color selected by Architect from Color Scale.

D. Induction Bar Grille: Powder-coated extruded aluminum.

E. Heat Exchanger: Two coils, copper tubes with formed aluminum fins.

F. Nozzles: Black plastics.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install air terminals level and plumb, according to manufacturer's written instructions, rough-in drawings, original design, and referenced standards; and maintain sufficient clearance for normal service and maintenance.

B. Connect ductwork to air terminals according to Division 15 ductwork Sections.

C. Where VAV boxes are to be located above ceilings, install them with their bottoms no higher than 36 inches above finished ceiling surface unless specified elsewhere to facilitate maintenance.

3.2 CONNECTIONS

A. Install piping adjacent to air terminals to allow service and maintenance.

B. Hot-Water Piping: In addition to requirements in Division 15 Section "Hydronic Piping," connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange.

C. Electrical: Comply with applicable requirements in Division 16 Sections.

D. Ground equipment.

1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.3 FIELD QUALITY CONTROL

A. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.4 CLEANING

A. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel as specified below:

1. Train Owner's maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventive maintenance.

2. Review data in the maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
3. Schedule training with Owner, through Architect, with at least 7 days' advance notice.

END OF SECTION 233600

VANZELM MEP DRAWING LIST

Project Name: University of New England-College of Pharmacy
Project number: 2007120.00
Updated: February 8, 2008

VANZELM MEP DRAWING	Drawing Title	Drawing Scale	File Location	File Name	Package SD	DD	DD Plus	CD 1/7/2008	1/24/2008	2/8/2008	2/29/2008	Comments
SITE UTILITY DRAWINGS												
SU1.1	MEP SITE UTILITY PLAN	1"=20'	U:\2007120.00\Dwgs\Site	MEP-SITE.DWG	X	X	0	0	0	0	0	
FIRE PROTECTION DRAWINGS												
FP0.1	FIRE PROTECTION LEGEND, SCHEDULES, AND NOTES	NONE	U:2007120.00.00\Dwgs\Fire-Protection	FP-SCHD.DWG	X				X	X		
FP1.1	FIRE PROTECTION FLOOR PLANS	1/16"=1'-0"	U:2007120.00.00\Dwgs\Fire-Protection	FP1.1.DWG	X			X	X	X		
PLUMBING DRAWINGS												
P0.1	PLUMBING LEGEND, SCHEDULES, AND NOTES	NONE	U:2007120.00.00\Dwgs\Plumbing	P-SCHD.DWG	X	X		X	X	X		
										X		
PS1.0	PLUMBING LOWER LEVEL PLAN - SUPPLY	1/8"=1'-0"	U:2007120.00.00\Dwgs\Plumbing	PS-FLBA.DWG	X	X		X	X	X		
PS1.1	PLUMBING LOWER LEVEL PLAN SUPPLY - ALTERNATE	1/8"=1'-0"	U:2007120.00.00\Dwgs\Plumbing	PS-FLBA-ALT.DWG	X	X		X	X	X		
PS1.2	PLUMBING FIRST FLOOR PLAN - SUPPLY	1/8"=1'-0"	U:2007120.00.00\Dwgs\Plumbing	PS-FL01.DWG	X	X		X	X	X		
PS1.3	PLUMBING SECOND FLOOR PLAN - SUPPLY	1/8"=1'-0"	U:2007120.00.00\Dwgs\Plumbing	PS-FL02.DWG	X	X	X	X	X	X		
PS1.4	PLUMBING THIRD FLOOR PLAN - SUPPLY	1/8"=1'-0"	U:2007120.00.00\Dwgs\Plumbing	PS-FL03.DWG	X	X		X	X	X		
PW1.0	PLUMBING LOWER LEVEL PLAN - WASTE	1/8"=1'-0"	U:2007120.00.00\Dwgs\Plumbing	PW-FLBA.DWG	X	X		X	X	X		
PW1.1	PLUMBING LOWER LEVEL PLAN - ALTERNATE	1/8"=1'-0"	U:2007120.00.00\Dwgs\Plumbing	PW-FLBA-ALT.DWG		X		X	X	X		
PW1.2	PLUMBING FIRST FLOOR PLAN - WASTE	1/8"=1'-0"	U:2007120.00.00\Dwgs\Plumbing	PW-FL01.DWG		X		X	X	X		
PW1.3	PLUMBING SECOND FLOOR PLAN - WASTE	1/8"=1'-0"	U:2007120.00.00\Dwgs\Plumbing	PW-FL02.DWG		X		X	X	X		
PW1.4	PLUMBING THIRD FLOOR PLAN - WASTE	1/8"=1'-0"	U:2007120.00.00\Dwgs\Plumbing	PW-FL03.DWG		X		X	X	X		
P1.5	PLUMBING ATTIC PLAN	1/8"=1'-0"	U:2007120.00.00\Dwgs\Plumbing	P-FLMZ.DWG	X	X		X	X	X		
P1.6	PLUMBING ROOF PLAN	1/8"=1'-0"	U:2007120.00.00\Dwgs\Plumbing	P-FLRF.DWG				X	X	X		
P2.0	PLUMBING THIRD FLOOR PLAN - ENLARGED A	1/4"=1'-0"	U:2007120.00.00\Dwgs\Plumbing	P-FL03-QUARTER					X	X		
P2.1	PLUMBING THIRD FLOOR PLAN - ENLARGED B	1/4"=1'-0"	U:2007120.00.00\Dwgs\Plumbing	P-FL03-QUARTER					X	X		
P3.0	PLUMBING PURE WATER (RODI) RISER	NONE	U:2007120.00.00\Dwgs\Plumbing	P-RISER				X	X	X		
P3.1	PLUMBING GAS, AIR, AND VACUUM RISER	NONE	U:2007120.00.00\Dwgs\Plumbing	P-RISER					X	X		
P4.0	PLUMBING DETAILS	NONE	U:2007120.00.00\Dwgs\Plumbing	P-DETL		X		X	X	X		
P4.1	PLUMBING DETAILS	NONE	U:2007120.00.00\Dwgs\Plumbing	P-DETL		X		X	X	X		
MECHANICAL DRAWINGS												
M0.1	MECHANICAL LEGENDS	NONE	U:2007120.00.00\Dwgs\Mechanical	M-LGND.DWG	X	X	X	X	X	X		
							X	X	X	X		
M1.0	MECHANICAL LOWER LEVEL PLAN	1/8"=1'-0"	U:2007120.00.00\Dwgs\Mechanical	M-FLBA.DWG	X	X	X	X	X	X		
M1.1	MECHANICAL LOWER LEVEL PLAN-ALTERNATE	1/8"=1'-0"	U:2007120.00.00\Dwgs\Mechanical	M-FLBS-ALT.DWG		X	X	X	X	X		
M1.2	MECHANICAL FIRST FLOOR PLAN	1/8"=1'-0"	U:2007120.00.00\Dwgs\Mechanical	M-FL01.DWG	X	X	X	X	X	X		
M1.3	MECHANICAL SECOND FLOOR PLAN	.1/8"=1'-0"	U:2007120.00.00\Dwgs\Mechanical	M-FL02.DWG	X	X	X	X	X	X		
M1.4	MECHANICAL THIRD FLOOR PLAN	1/8"=1'-0"	U:2007120.00.00\Dwgs\Mechanical	M-FL03.DWG	X	X	X	X	X	X		
M1.5	MECHANICAL ATTIC PLAN	1/8"=1'-0"	U:2007120.00.00\Dwgs\Mechanical	M-FLMZ.DWG	X	X	X	X	X	X		
M1.6	MECHANICAL ROOF PLAN	1/8"=1'-0"	U:2007120.00.00\Dwgs\Mechanical	M-FLRF.DWG	0	0	0	0	0	X		
MP1.0	MECHANICAL PIPING LOWER LEVEL BASE PLAN	1/8"=1'-0"	U:2007120.00.00\Dwgs\Mechanical	MP-FLBA.DWG	X	X	X	X	X	X		
MP1.1	MECHANICAL PIPING LOWER LEVEL PLAN-ALTERNATE	1/8"=1'-0"	U:2007120.00.00\Dwgs\Mechanical	MP-FLBA-ALT.DWG		X	X	X	X	X		
MP1.2	MECHANICAL PIPING FIRST FLOOR PLAN	1/8"=1'-0"	U:2007120.00.00\Dwgs\Mechanical	MP-FL01.DWG	X	X	X	X	X	X		
MP1.3	MECHANICAL PIPING SECOND FLOOR PLAN	1/8"=1'-0"	U:2007120.00.00\Dwgs\Mechanical	MP-FL02.DWG	X	X	X	X	X	X		
MP1.4	MECHANICAL PIPING THIRD FLOOR PLAN	1/8"=1'-0"	U:2007120.00.00\Dwgs\Mechanical	MP-FL03.DWG	X	X	X	X	X	X		
~~MP1.5~~	~~MECHANICAL PIPING ATTIC PLAN~~	~~1/8"=1'-0"~~	~~U:2007120.00.00\Dwgs\Mechanical~~	~~MP-FLMZ.DWG~~	X	X	0	0	0	X		Drawing deleted from set
M2.0	MECHANICAL LOWER LEVEL MER PART PLAN	1/4"=1'-0"	U:2007120.00.00\Dwgs\Mechanical	M-PART-FLBA.DWG	0	X	X	X	X	X		
M2.1	MECHANICAL LOWER LEVEL MER PART PLAN-ALTERNATE	1/4"=1'-0"	U:2007120.00.00\Dwgs\Mechanical	M-PART-FLBA.DWG	0	O	O	X	X	X		
M2.2	MECHANICAL ATTIC MER PART PLANS	1/4"=1'-0"	U:2007120.00.00\Dwgs\Mechanical	M-PART-FLMZ	0	X	X	X	X	X		
M2.3	MECHANICAL ATTIC MER SECTIONS	1/4"=1'-0"	U:2007120.00.00\Dwgs\Mechanical	M-SECT.DWG	0	X	X	X	X	X		
M2.4	MECHANICAL CHILLER PLANT PART PLANS	1/4"=1'-0"	U:2007120.00.00\Dwgs\Mechanical	M-DET-CHILL.DWG	X	X	X	X	X	X		

VANZELM MEP DRAWING LIST

Project Name: University of New England-College of Pharmacy
Project number: 2007120.00
Updated: February 8, 2008

VANZELM MEP DRAWING	Drawing Title	Drawing Scale	File Location	File Name	Package							Comments
					SD	DD	DD Plus	CD				
								1/7/2008	1/24/2008	2/8/2008	2/29/2008	
M3.1	MECHANICAL AIR RISER DIAGRAM	NTS	U:2007120.00.00\Dwgs\Mechanical	M-DIAG-RISE-AIRS.DWG	X	X	X	X	X	X		
M3.2	MECHANICAL STEAM RISER DIAGRAM	NTS	U:2007120.00.00\Dwgs\Mechanical	M-DIAG-FLOW-STM-.DWG	X	X	X	X	X	X		
M3.3	MECHANICAL HOT WATER RISER DIAGRAM	NTS	U:2007120.00.00\Dwgs\Mechanical	M-DIAG-FLOW-HW.DWG	X	X	X	X	X	X		
M3.4	MECHANICAL CHILLED WATER RISER DIAGRAM	NTS	U:2007120.00.00\Dwgs\Mechanical	M-DIAG-FLOW-CHW.DWG	X	X	X	X	X	X		
M3.5	MECHANICAL CHILLER PLANT FLOW DIAGRAM	NTS	U:2007120.00.00\Dwgs\Mechanical	M-DIAG-FLOW-PIPE.DWG	X	X	X	X	X	X		
M4.1	MECHANICAL DETAILS	NTS	U:2007120.00.00\Dwgs\Mechanical	M-DETL.DWG.DWG	X	X	X	X	X	X		
M4.2	MECHANICAL DETAILS	NTS	U:2007120.00.00\Dwgs\Mechanical	M-DETL.DWG.DWG	X	X	X	X	X	X		
M4.3	MECHANICAL DETAILS	NTS	U:2007120.00.00\Dwgs\Mechanical	M-DETL.DWG.DWG	X	X	X	X	X	X		
M4.4	MECHANICAL DETAILS	NTS	U:2007120.00.00\Dwgs\Mechanical	M-DETL.DWG.DWG	X	X	X	X	X	X		
M4.5	MECHANICAL DETAILS	NTS	U:2007120.00.00\Dwgs\Mechanical	M-DETL.DWG.DWG	X	X	X	X	X	X		
M4.6	MECHANICAL DETAILS	NTS	U:2007120.00.00\Dwgs\Mechanical	M-DETL.DWG.DWG	0	0	0	0	0	X		
M5.1	MECHANICAL TEMPERATURE CONTROLS	NTS	U:2007120.00.00\Dwgs\Mechanical	M-CTRL-DIAG.DWG	X	X	X	X	X	X		
M5.2	MECHANICAL TEMPERATURE CONTROLS	NTS	U:2007120.00.00\Dwgs\Mechanical	M-CTRL-DIAG.DWG	X	X	X	X	X	X		
M5.3	MECHANICAL TEMPERATURE CONTROLS	NTS	U:2007120.00.00\Dwgs\Mechanical	M-CTRL-DIAG.DWG	0	0	0	0	0	X		
M6.1	MECHANICAL EQUIPMENT SCHEDULES	NONE	U:2007120.00.00\Dwgs\Mechanical	M-SCHD.DWG	0	X	X	X	X	X		
M6.2	MECHANICAL EQUIPMENT SCHEDULES	NONE	U:2007120.00.00\Dwgs\Mechanical	M-SCHD.DWG	0	X	X	X	X	X		
M6.3	MECHANICAL EQUIPMENT SCHEDULES	NONE	U:2007120.00.00\Dwgs\Mechanical	M-SCHD.DWG	0	X	X	X	X	X		
M6.4	MECHANICAL EQUIPMENT SCHEDULES	NONE	U:2007120.00.00\Dwgs\Mechanical	M-SCHD.DWG	0	X	X	X	X	X		
M6.4	MECHANICAL EQUIPMENT SCHEDULES	NONE	U:2007120.00.00\Dwgs\Mechanical	M-SCHD.DWG	0	0	0	0	0	X		

VANZELM MEP DRAWING LIST

Project Name: *University of New England-College of Pharmacy*
Project number: *2007120.00*
Updated: *February 8, 2008*

VANZELM MEP DRAWING	Drawing Title	Drawing Scale	File Location	File Name	Package							Comments
					SD	DD	DD Plus	CD				
								1/7/2008	1/24/2008	2/8/2008	2/29/2008	
ELECTRICAL DRAWINGS												
E0.0	ELECTRICAL LEGEND	NONE	U:2007120.00.00\Dwgs\Electrical	E-LGND.DWG	X	X		X	X	X		
E0.1	ELECTRICAL GENERAL NOTES	NONE	U:2007120.00.00\Dwgs\Electrical	E-LGND.DWG	X	X		X	X	X		
EL1.0	ELECTRICAL LIGHTING PLAN - LOWER LEVEL	1/8"=1'-0"	U:2007120.00.00\Dwgs\Electrical	E-FL0B-LITE.DWG	X	X	X	X	X	X		
EL1.1	ELECTRICAL LIGHTING PLAN - LOWER LEVEL - ALTERNATE	1/8"=1'-0"	U:2007120.00.00\Dwgs\Electrical	E-FL0B-LITE.DWG		X	X	X	X	X		
EL1.2	ELECTRICAL LIGHTING PLAN - FIRST FLOOR	1/8"=1'-0"	U:2007120.00.00\Dwgs\Electrical	E-FL01-LITE.DWG	X	X	X	X	X	X		
EL1.3	ELECTRICAL LIGHTING PLAN - SECOND FLOOR	1/8"=1'-0"	U:2007120.00.00\Dwgs\Electrical	E-FL02-LITE.DWG	X	X	X	X	X	X		
EL1.4	ELECTRICAL LIGHTING PLAN - THIRD FLOOR	1/8"=1'-0"	U:2007120.00.00\Dwgs\Electrical	E-FL03-LITE.DWG	X	X	X	X	X	X		
EL1.5	ELECTRICAL LIGHTING PLAN - ATTIC	1/8"=1'-0"	U:2007120.00.00\Dwgs\Electrical	E-FLMZ-LITE.DWG	X	X	X	X	X	X		
								X	X	X		
EP1.0	ELECTRICAL POWER PLAN - LOWER LEVEL	1/8"=1'-0"	U:2007120.00.00\Dwgs\Electrical	E-FL0B-POWR.DWG	X	X	X	X	X	X		
EP1.1	ELECTRICAL POWER PLAN - LOWER LEVEL - ALTERNATE	1/8"=1'-0"	U:2007120.00.00\Dwgs\Electrical	E-FL0B-POWR.DWG		X	X	X	X	X		
EP1.2	ELECTRICAL POWER PLAN - FIRST FLOOR	1/8"=1'-0"	U:2007120.00.00\Dwgs\Electrical	E-FL01-POWR.DWG	X	X		X	X	X		
EP1.3	ELECTRICAL POWER PLAN - SECOND FLOOR	1/8"=1'-0"	U:2007120.00.00\Dwgs\Electrical	E-FL02-POWR.DWG	X	X		X	X	X		
EP1.4	ELECTRICAL POWER PLAN - THIRD FLOOR	1/8"=1'-0"	U:2007120.00.00\Dwgs\Electrical	E-FL03-POWR.DWG	X	X	X	X	X	X		
EP1.5	ELECTRICAL POWER PLAN - ATTIC	1/8"=1'-0"	U:2007120.00.00\Dwgs\Electrical	E-FLMZ-POWR.DWG		X	X	X	X	X		
EP1.6	ELECTRICAL POWER PLAN - ROOF	1/8"=1'-0"	U:2007120.00.00\Dwgs\Electrical	E-FLRF.DWG					X	X		
E2.0	LIGHTNING PROTECTION PLAN	1/8"=1'-0"	U:2007120.00.00\Dwgs\Electrical	E-LIGHTNING PROTECT.DWG		X		X	X	X		
E2.1	LIGHTNING PROTECTION DETAILS	NONE	U:2007120.00.00\Dwgs\Electrical	E-LIGHTNING PROTECT.DWG		X		X	X	X		
								X	X	X		
E3.0	ELECTRICAL POWER RISER DIAGRAM	NONE	U:2007120.00.00\Dwgs\Electrical	E-DIAG-RISER.DWG	X	X		X	X	X		
E3.1	LOW-VOLTAGE RISER DIAGRAMS AND SCHEDULES	NONE	U:2007120.00.00\Dwgs\Electrical	E-DIAG-RISER.DWG	X	X		X	X	X		
E4.0	ELECTRICAL SCHEDULES	NONE	U:2007120.00.00\Dwgs\Electrical	E-SCHEDULES.DWG		X	X	X	X	X		
E4.1	ELECTRICAL SCHEDULES	NONE	U:2007120.00.00\Dwgs\Electrical	E-SCHEDULES.DWG		X		X	X	X		
E4.2	ELECTRICAL SCHEDULES	NONE	U:2007120.00.00\Dwgs\Electrical	E-SCHEDULES.DWG						X		
E4.3	ELECTRICAL SCHEDULES	NONE	U:2007120.00.00\Dwgs\Electrical	E-SCHEDULES.DWG						X		
E4.4	ELECTRICAL SCHEDULES - ALTERNATE	NONE	U:2007120.00.00\Dwgs\Electrical	E-SCHEDULES.DWG						X		
E5.0	ELECTRICAL DETAILS	NONE	U:2007120.00.00\Dwgs\Electrical	E-DETAILS.DWG						X		
E5.1	ELECTRICAL DETAILS	NONE	U:2007120.00.00\Dwgs\Electrical	E-DETAILS.DWG						X		
E6.0	CHILLER PLANT ELECTRICAL POWER PLAN	1/4"=1'-0"	U:2007120.00.00\Dwgs\Electrical	E-CHILLER PLANT.DWG	X	X		X	X	X		

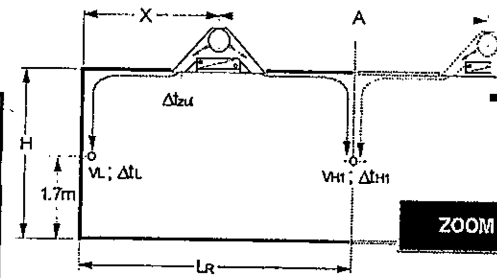
DID 600 calculation

Input DID	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Vwater DID	1.5000 GPM	0.2500 GPM	1.5000 GPM	1.5000 GPM
Unit length	5.5 ft			
Nozzle-type	b			
Vair-primary DID	65.0 CFM			
	30.7 l/s			
No-nozzles active	45			

Project	room-No.	comment
UNE CoP	106	

Input temperatures	cooling		heating	
Tair-primary	55.0 °F		55.0 °F	
Troom / rel. Humidity	75.0 °F	50.0 %	72.0 °F	50.0 %
Twater-flow	57.0 °F		140.0 °F	

Input room measures	
room height	10.0 ft
A	6.0 ft
X	3.0 ft



TROX® TECHNIK
The art of handling air

ZOOM

results	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Δtwater	-4.0 °F	34.1 °F	-3.4 °F	12.8 °F
Twater-return	61.0 °F	105.9 °F	60.4 °F	127.2 °F
ΔT room - water flow	-18.0 °F	68.0 °F	-18.0 °F	68.0 °F
ΔT Room water average	-16.0 °F	51.0 °F	-16.3 °F	61.6 °F
Q water DID	-2996 BTUH	4267 BTUH	-2548 BTUH	9626 BTUH
Q air DID	-1417 BTUH	-1208 BTUH	-1417 BTUH	-1208 BTUH
Q DID	-4412 BTUH	3059 BTUH	-3965 BTUH	8418 BTUH
ΔP water	10.872 ft WG	0.132 ft WG	7.409 ft WG	6.300 ft WG
ΔP air	0.53 inches WG			
NC (incl. 10 dB absorbtion)	25			

Stand : 11.10.2007

Language
english

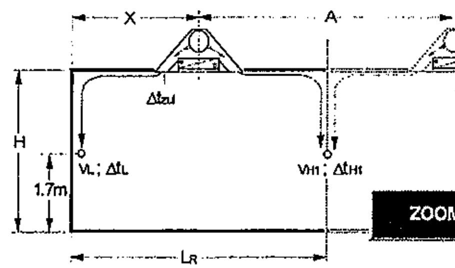
vL	108.40 FPM		108.40 FPM	
vH1	48.80 FPM		48.80 FPM	
ΔTL	-5.3 °F		-4.8 °F	
ΔTH1	-1.1 °F		-0.9 °F	
X-crit	12.1 ft		12.1 ft	
Archimedes-number	0.000095		0.000095	
ΔTsupply	-15.4 °F	10.7 °F	-13.8 °F	29.4 °F
Connection-diameter / primary air	4 inches			

support values	
N-active nozzles	45
N-nozzles total	52
Aeff	0.02435 sq ft
veff	2669.69 FPM
H1	4.4 ft
L	7.4 ft
room air dew point-cooling	55.1 °F

DID 600 calculation

Input DID	4 pipe coil		2 pipe coil		Project	room-No.	comment
	cooling	heating	cooling	heating	UNE CoP	107	
Vwater DID	1.5000 GPM	0.1500 GPM	1.5000 GPM	1.5000 GPM			
Unit length	5.5 ft						
Nozzle-type	b						
Vair-primary DID	65.0 CFM						
	30.7 l/s						
No-nozzles active	45						

Input temperatures	cooling		heating		Input room measures	
Tair-primary	55.0 °F		55.0 °F		room height	10.0 ft
Troom / rel. Humidity	75.0 °F	50.0 %	72.0 °F	50.0 %	A	6.0 ft
Twater-flow	57.0 °F		140.0 °F		X	3.0 ft



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ZOOM

results	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Δtwater	-4.0 °F	44.4 °F	-3.4 °F	12.8 °F
Twater-return	61.0 °F	95.6 °F	60.4 °F	127.2 °F
ΔT room - water flow	-18.0 °F	68.0 °F	-18.0 °F	68.0 °F
ΔT Room water average	-16.0 °F	45.8 °F	-16.3 °F	61.6 °F
Q water DID	-2996 BTUH	3335 BTUH	-2548 BTUH	9626 BTUH
Q air DID	-1417 BTUH	-1208 BTUH	-1417 BTUH	-1208 BTUH
Q DID	-4412 BTUH	2127 BTUH	-3965 BTUH	8418 BTUH
ΔP water	10.872 ft WG	0.053 ft WG	7.409 ft WG	6.300 ft WG
ΔP air	0.53 inches WG			
NC (incl. 10 dB absorbtion)	25			

Language
english

Stand : 11.10.2007

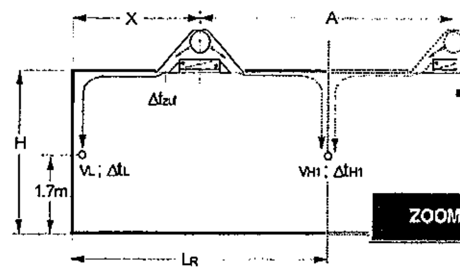
					support values	
vL	108.40 FPM		108.40 FPM			
vH1	48.80 FPM		48.80 FPM		N-active nozzles	45
ΔTL	-5.3 °F		-4.8 °F		N-nozzles total	52
ΔTH1	-1.1 °F		-0.9 °F		Aeff	0.02435 sq ft
X-crit	12.1 ft		12.1 ft		veff	2669.69 FPM
Archimedes-number	0.000095		0.000095		H1	4.4 ft
ΔTsupply	-15.4 °F	7.4 °F	-13.8 °F	29.4 °F	L	7.4 ft
Connection-diameter / primary air	4 inches				room air dew point-cooling	55.1 °F

107.xls 2/6/2008 FE/WO

DID 600 calculation

Input DID	4 pipe coil		2 pipe coil		Project	room-No.	comment
	cooling	heating	cooling	heating	UNE CoP	110	
Vwater DID	0.2600 GPM	0.6500 GPM	0.3000 GPM	1.5000 GPM			
Unit length	9.5 ft						
Nozzle-type	c						
Vair-primary DID	152.0 CFM						
	71.8 l/s						
No-nozzles active	73						

Input temperatures	cooling		heating		Input room measures	
Tair-primary	55.0 °F		55.0 °F		room height	10.0 ft
Troom / rel. Humidity	75.0 °F	50.0 %	72.0 °F	50.0 %	A	7.0 ft
Twater-flow	57.0 °F		140.0 °F		X	100.0 ft



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ZOOM

results	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Δtwater	-16.4 °F	26.6 °F	-14.5 °F	19.5 °F
Twater-return	73.4 °F	113.4 °F	71.5 °F	120.5 °F
ΔT room - water flow	-18.0 °F	68.0 °F	-18.0 °F	68.0 °F
ΔT Room water average	-9.8 °F	54.7 °F	-10.7 °F	58.3 °F
Q water DID	-2140 BTUH	8648 BTUH	-2182 BTUH	14617 BTUH
Q air DID	-3313 BTUH	-2824 BTUH	-3313 BTUH	-2824 BTUH
Q DID	-5453 BTUH	5824 BTUH	-5495 BTUH	11793 BTUH
ΔP water	0.729 ft WG	1.123 ft WG	0.636 ft WG	9.622 ft WG
ΔP air	0.48 inches WG			
NC (incl. 10 dB absorbtion)	31			

Language: english

Stand : 11.10.2007

					support values	
vL	36.99 FPM		36.99 FPM			
vH1	59.67 FPM		59.67 FPM		N-active nozzles	73
ΔTL	-1.0 °F		-1.0 °F		N-nozzles total	88
ΔTH1	-0.3 °F		-0.3 °F		Aeff	0.06171 sq ft
X-crit	14.5 ft		14.5 ft		veff	2462.98 FPM
Archimedes-number	0.000178		0.000178		H1	4.4 ft
ΔTsupply	-9.8 °F	10.5 °F	-9.9 °F	21.2 °F	L	104.4 ft
Connection-diameter / primary air	5 inches				room air dew point-cooling	55.1 °F

110.xls 2/6/2008 FE/WO

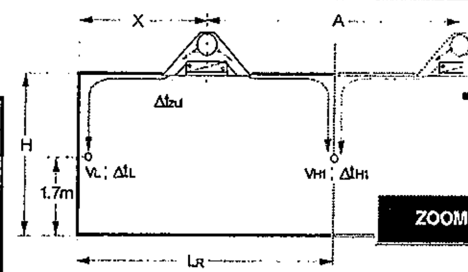
DID 600 calculation

Input DID	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
V_{water} DID	0.2700 GPM	1.5000 GPM	0.3000 GPM	1.5000 GPM
Unit length	7.5 ft			
Nozzle-type	c			
$V_{air-primary}$ DID	103.0 CFM			
	48.6 l/s			
$N_{o-nozzles}$ active	60			

Project	room-No.	comment
UNE CoP	111	

Input temperatures	cooling		heating	
$T_{air-primary}$	55.0 °F		55.0 °F	
T_{room} / rel. Humidity	75.0 °F	50.0 %	72.0 °F	50.0 %
$T_{water-flow}$	57.0 °F		120.0 °F	

Input room measures	
room height	10.0 ft
A	6.0 ft
X	100.0 ft



ZOOM

TROX® TECHNIK
The art of handling air

results	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Δt_{water}	-13.2 °F	7.1 °F	-11.8 °F	10.4 °F
$T_{water-return}$	70.2 °F	112.9 °F	68.8 °F	109.6 °F
ΔT room - water flow	-18.0 °F	48.0 °F	-18.0 °F	48.0 °F
ΔT Room water average	-11.4 °F	44.4 °F	-12.1 °F	42.8 °F
Q water DID	-1779 BTUH	5367 BTUH	-1777 BTUH	7774 BTUH
Q air DID	-2245 BTUH	-1914 BTUH	-2245 BTUH	-1914 BTUH
Q DID	-4024 BTUH	3453 BTUH	-4022 BTUH	5860 BTUH
ΔP water	0.635 ft WG	4.319 ft WG	0.519 ft WG	8.235 ft WG
ΔP air	0.32 inches WG			
NC (incl. 10 dB absorbtion)	26			

Language: english

Stand : 11.10.2007

vL	30.00 FPM		30.00 FPM	
vH1	51.01 FPM		51.01 FPM	
ΔTL	-1.1 °F		-1.1 °F	
ΔTH1	-0.3 °F		-0.3 °F	
X-crit	11.5 ft		11.5 ft	
Archimedes-number	0.000237		0.000237	
ΔTsupply	-10.7 °F	9.2 °F	-10.7 °F	15.6 °F
Connection-diameter / primary air	5 inches			

support values	
N-active nozzles	60
N-nozzles total	69
Aeff	0.05072 sq ft
veff	2030.61 FPM
H1	4.4 ft
L	104.4 ft
room air dew point-cooling	55.1 °F

111.xls 2/6/2008 FE/WO

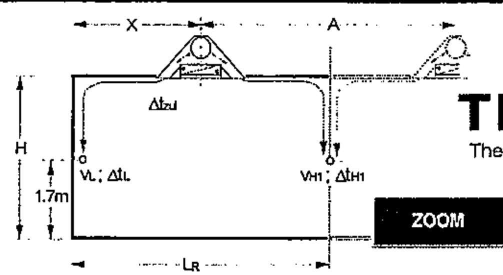
DID 600 calculation

Input DID	4 pipe coil cooling	4 pipe coil heating	2 pipe coil cooling	2 pipe coil heating
Vwater DID	1.4000 GPM	1.5000 GPM	1.5000 GPM	1.5000 GPM
Unit length	5.5 ft			
Nozzle-type	c			
Vair-primary DID	85.0 CFM			
	40.1 l/s			
No-nozzles active	45			

Project	room-No.	comment
UNE CoP	112	

Input temperatures	cooling		heating	
Tair-primary	55.0 °F		55.0 °F	
Troom / rel. Humidity	75.0 °F	50.0 %	72.0 °F	50.0 %
Twater-flow	57.0 °F		120.0 °F	

Input room measures	
room height	10.0 ft
A	6.0 ft
X	100.0 ft



TROX® TECHNIK
The art of handling air

results	4 pipe coil cooling	4 pipe coil heating	2 pipe coil cooling	2 pipe coil heating
Δtwater	-4.0 °F	6.3 °F	-3.4 °F	9.1 °F
Twater-return	61.0 °F	113.7 °F	60.4 °F	110.9 °F
ΔT room - water flow	-18.0 °F	48.0 °F	-18.0 °F	48.0 °F
ΔT Room water average	-16.0 °F	44.8 °F	-16.3 °F	43.4 °F
Q water DID	-2800 BTUH	4759 BTUH	-2576 BTUH	6870 BTUH
Q air DID	-1853 BTUH	-1579 BTUH	-1853 BTUH	-1579 BTUH
Q DID	-4653 BTUH	3180 BTUH	-4429 BTUH	5291 BTUH
ΔP water	9.594 ft WG	3.466 ft WG	7.408 ft WG	6.519 ft WG
ΔP air	0.38 inches WG			
NC (incl. 10 dB absorbtion)	26			

Language
english

Stand : 11.10.2007

vL	31.34 FPM		31.34 FPM	
vH1	53.72 FPM		53.72 FPM	
ΔTL	-1.4 °F		-1.3 °F	
ΔTH1	-0.3 °F		-0.3 °F	
X-crit	11.6 ft		11.6 ft	
Archimedes-number	0.000169		0.000169	
ΔTsupply	-15.0 °F	10.2 °F	-14.3 °F	17.0 °F
Connection-diameter / primary air	4 inches			

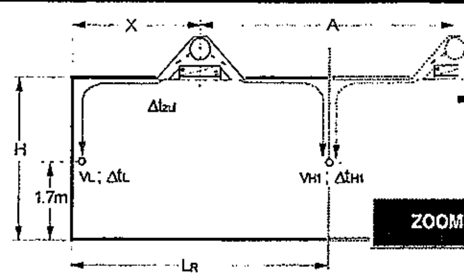
support values	
N-active nozzles	45
N-nozzles total	52
Aeff	0.03804 sq ft
veff	2234.33 FPM
H1	4.4 ft
L	104.4 ft
room air dew point-cooling	55.1 °F

112.xls 2/6/2008 FE/WO

DID 600 calculation

Input DID	4 pipe coil cooling	4 pipe coil heating	2 pipe coil cooling	2 pipe coil heating	Project	room-No.	comment
Vwater DID	0.7000 GPM	0.1500 GPM	1.5000 GPM	1.5000 GPM	UNE CoP	115	
Unit length	5.5 ft						
Nozzle-type	b						
Vair-primary DID	60.0 CFM						
	28.3 l/s						
No-nozzles active	45						

Input temperatures	cooling		heating		Input room measures	
Tair-primary	55.0 °F		55.0 °F		room height	10.0 ft
Troom / rel. Humidity	75.0 °F	50.0 %	72.0 °F	50.0 %	A	100.0 ft
Twater-flow	57.0 °F		140.0 °F		X	3.0 ft



TROX® TECHNIK
The art of handling air

ZOOM

results	4 pipe coil cooling	4 pipe coil heating	2 pipe coil cooling	2 pipe coil heating
Δtwater	-6.9 °F	42.9 °F	-3.3 °F	12.3 °F
Twater-return	63.9 °F	97.1 °F	60.3 °F	127.7 °F
ΔT room - water flow	-18.0 °F	68.0 °F	-18.0 °F	68.0 °F
ΔT Room water average	-14.5 °F	46.6 °F	-16.4 °F	61.9 °F
Q water DID	-2424 BTUH	3221 BTUH	-2445 BTUH	9235 BTUH
Q air DID	-1308 BTUH	-1115 BTUH	-1308 BTUH	-1115 BTUH
Q DID	-3732 BTUH	2106 BTUH	-3752 BTUH	8121 BTUH
ΔP water	2.726 ft WG	0.053 ft WG	7.410 ft WG	6.297 ft WG
ΔP air	0.45 inches WG			
NC (incl. 10 dB absorbtion)	23			

Language
english

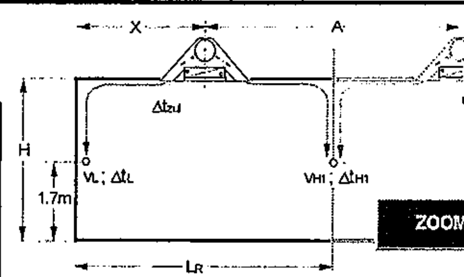
Stand : 11.10.2007

vL	100.06 FPM		100.06 FPM		support values	
vH1	8.39 FPM		8.39 FPM		N-active nozzles	45
ΔTL	-4.9 °F		-4.9 °F		N-nozzles total	52
ΔTH1	-1.0 °F		-1.0 °F		Aeff	0.02435 sq ft
X-crit	11.3 ft		11.3 ft		veff	2464.33 FPM
Archimedes-number	0.000111		0.000111		H1	4.4 ft
ΔTsupply	-14.1 °F	8.0 °F	-14.2 °F	30.7 °F	L	7.4 ft
Connection-diameter / primary air	4 inches				room air dew point-cooling	55.1 °F

DID 600 calculation

Input DID	4 pipe coil		2 pipe coil		Project	room-No.	comment
	cooling	heating	cooling	heating	UNE CoP	116	
Vwater DID	0.5000 GPM	0.1500 GPM	1.5000 GPM	1.5000 GPM			
Unit length	3.5 ft						
Nozzle-type	a						
Vair-primary DID	20.0 CFM						
	9.4 l/s						
No-nozzles active	31						

Input temperatures	cooling		heating		Input room measures	
Tair-primary	55.0 °F		55.0 °F		room height	10.0 ft
Troom / rel. Humidity	75.0 °F	50.0 %	72.0 °F	50.0 %	A	100.0 ft
Twater-flow	57.0 °F		140.0 °F		X	3.0 ft



TROX® TECHNIK
The art of handling air

ZOOM

results	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Δtwater	-4.7 °F	25.2 °F	-1.8 °F	6.9 °F
Twater-return	61.7 °F	114.8 °F	58.8 °F	133.1 °F
ΔT room - water flow	-18.0 °F	68.0 °F	-18.0 °F	68.0 °F
ΔT Room water average	-15.7 °F	55.4 °F	-17.1 °F	64.6 °F
Q water DID	-1173 BTUH	1895 BTUH	-1364 BTUH	5153 BTUH
Q air DID	-436 BTUH	-372 BTUH	-436 BTUH	-372 BTUH
Q DID	-1609 BTUH	1523 BTUH	-1800 BTUH	4781 BTUH
ΔP water	1.047 ft WG	0.037 ft WG	5.391 ft WG	4.651 ft WG
ΔP air	0.31 inches WG			
NC (incl. 10 dB absorbtion)	8			

Language
english

Stand : 11.10.2007

					support values	
vL	60.79 FPM		60.79 FPM			
vH1	4.65 FPM		4.65 FPM		N-active nozzles	31
ΔTL	-4.4 °F		-4.9 °F		N-nozzles total	36
ΔTH1	-0.9 °F		-1.0 °F		Aeff	0.00943 sq ft
X-crit	7.6 ft		7.6 ft		veff	2119.55 FPM
Archimedes-number	0.000094		0.000094		H1	4.4 ft
ΔTsupply	-14.1 °F	13.4 °F	-15.8 °F	42.0 °F	L	7.4 ft
Connection-diameter / primary air	4 inches				room air dew point-cooling	55.1 °F

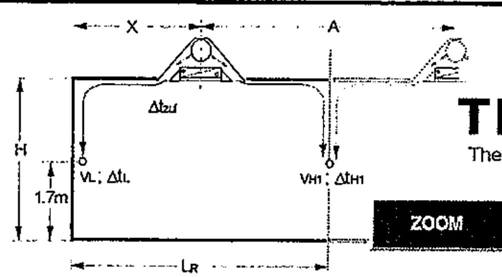
DID 600 calculation

Input DID	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Vwater DID	1.5000 GPM	0.2500 GPM	1.5000 GPM	1.5000 GPM
Unit length	7.5 ft			
Nozzle-type	a			
Vair-primary DID	55.0 CFM			
	26.0 l/s			
No-nozzles active	60			

Project	room-No.	comment
UNE CoP	118	

Input temperatures	cooling		heating	
Tair-primary	55.0 °F		55.0 °F	
Troom / rel. Humidity	75.0 °F	50.0 %	72.0 °F	50.0 %
Twater-flow	57.0 °F		140.0 °F	

Input room measures	
room height	10.0 ft
A	100.0 ft
X	3.0 ft



TROX® TECHNIK
The art of handling air

results	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Δtwater	-4.1 °F	35.7 °F	-3.8 °F	14.4 °F
Twater-return	61.1 °F	104.3 °F	60.8 °F	125.6 °F
ΔT room - water flow	-18.0 °F	68.0 °F	-18.0 °F	68.0 °F
ΔT Room water average	-16.0 °F	50.2 °F	-16.1 °F	60.8 °F
Q water DID	-3076 BTUH	4465 BTUH	-2856 BTUH	10791 BTUH
Q air DID	-1199 BTUH	-1022 BTUH	-1199 BTUH	-1022 BTUH
Q DID	-4275 BTUH	3443 BTUH	-4055 BTUH	9769 BTUH
ΔP water	13.909 ft WG	0.168 ft WG	9.432 ft WG	7.940 ft WG
ΔP air	0.65 inches WG			
NC (incl. 10 dB absorbtion)	23			

Language
english

Stand : 11.10.2007

vL	93.67 FPM		93.67 FPM	
vH1	7.76 FPM		7.76 FPM	
ΔTL	-5.1 °F		-4.8 °F	
ΔTH1	-1.0 °F		-1.0 °F	
X-crit	12.5 ft		12.5 ft	
Archimedes-number	0.000065		0.000065	
ΔTsupply	-13.6 °F	11.0 °F	-12.9 °F	31.2 °F
Connection-diameter / primary air	5 inches			

support values	
N-active nozzles	60
N-nozzles total	69
Aeff	0.01826 sq ft
veff	3011.96 FPM
H1	4.4 ft
L	7.4 ft
room air dew point-cooling	55.1 °F

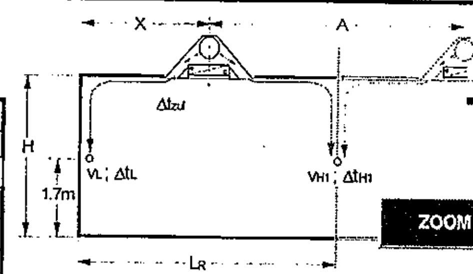
DID 600 calculation

Input DID	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Vwater DID	1.2000 GPM	0.1500 GPM	1.5000 GPM	1.5000 GPM
Unit length	3.5 ft			
Nozzle-type	a			
Vair-primary DID	20.0 CFM			
	9.4 l/s			
No-nozzles active	31			

Project	room-No.	comment
UNE CoP	120	

Input temperatures	cooling		heating	
Tair-primary	55.0 °F		55.0 °F	
Troom / rel. Humidity	75.0 °F	50.0 %	72.0 °F	50.0 %
Twater-flow	57.0 °F		140.0 °F	

Input room measures	
room height	10.0 ft
A	100.0 ft
X	2.0 ft



TROX® TECHNIK
The art of handling air

ZOOM

results	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Δtwater	-2.3 °F	25.2 °F	-1.8 °F	6.9 °F
Twater-return	59.3 °F	114.8 °F	58.8 °F	133.1 °F
ΔT room - water flow	-18.0 °F	68.0 °F	-18.0 °F	68.0 °F
ΔT Room water average	-16.8 °F	55.4 °F	-17.1 °F	64.6 °F
Q water DID	-1383 BTUH	1895 BTUH	-1364 BTUH	5153 BTUH
Q air DID	-436 BTUH	-372 BTUH	-436 BTUH	-372 BTUH
Q DID	-1819 BTUH	1523 BTUH	-1800 BTUH	4781 BTUH
ΔP water	5.210 ft WG	0.037 ft WG	5.391 ft WG	4.651 ft WG
ΔP air	0.31 inches WG			
NC (incl. 10 dB absorbtion)	8			

Stand : 11.10.2007

Language
english

vL	65.35 FPM		65.35 FPM	
vH1	4.65 FPM		4.65 FPM	
ΔTL	-5.3 °F		-5.2 °F	
ΔTH1	-1.0 °F		-1.0 °F	
X-crit	7.6 ft		7.6 ft	
Archimedes-number	0.000094		0.000094	
ΔTsupply	-16.0 °F	13.4 °F	-15.8 °F	42.0 °F
Connection-diameter / primary air	4 inches			

support values	
N-active nozzles	31
N-nozzles total	36
Aeff	0.00943 sq ft
veff	2119.85 FPM
H1	4.4 ft
L	6.4 ft
room air dew point-cooling	55.1 °F

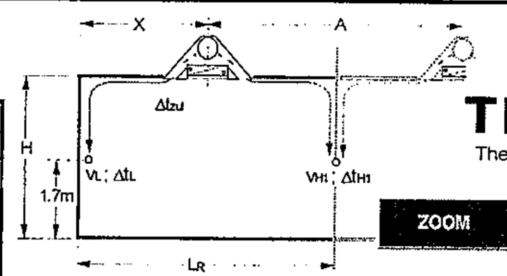
DID 600 calculation

Input DID	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Vwater DID	0.3500 GPM	0.1500 GPM	0.3500 GPM	1.5000 GPM
Unit length	7.5 ft			
Nozzle-type	C			
Vair-primary DID	153.0 CFM			
	72.3 l/s			
No-nozzles active	68			

Project	room-No.	comment
UNE CoP	203	68 Nozzles

Input temperatures	cooling		heating	
Tair-primary	55.0 °F		55.0 °F	
Troom / rel. Humidity	75.0 °F	50.0 %	72.0 °F	50.0 %
Twater-flow	57.0 °F		140.0 °F	

Input room measures	
room height	10.0 ft
A	10.0 ft
X	100.0 ft



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ZOOM

results	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Δtwater	-14.0 °F	55.8 °F	-12.7 °F	17.9 °F
Twater-return	71.0 °F	84.2 °F	69.7 °F	122.1 °F
ΔT room - water flow	-18.0 °F	68.0 °F	-18.0 °F	68.0 °F
ΔT Room water average	-11.0 °F	40.1 °F	-11.7 °F	59.1 °F
Q water DID	-2449 BTUH	4193 BTUH	-2226 BTUH	13433 BTUH
Q air DID	-3335 BTUH	-2843 BTUH	-3335 BTUH	-2843 BTUH
Q DID	-5784 BTUH	1351 BTUH	-5561 BTUH	10590 BTUH
ΔP water	1.008 ft WG	0.069 ft WG	0.683 ft WG	7.968 ft WG
ΔP air	0.56 inches WG			
NC (incl. 10 dB absorbtion)	36			

Language
english

Stand : 11.10.2007

vL	44.56 FPM		44.56 FPM	
vH1	60.23 FPM		60.23 FPM	
ΔTL	-1.0 °F		-1.0 °F	
ΔTH1	-0.3 °F		-0.2 °F	
X-crit	15.3 ft		15.3 ft	
Archimedes-number	0.000147		0.000147	
ΔTsupply	-10.3 °F	2.4 °F	-9.9 °F	18.9 °F
Connection-diameter / primary air	5 inches			

support values	
N-active nozzles	60
N-nozzles total	69
Aeff	0.05749 sq ft
veff	2661.48 FPM
H1	4.4 ft
L	104.4 ft
room air dew point-cooling	55.1 °F

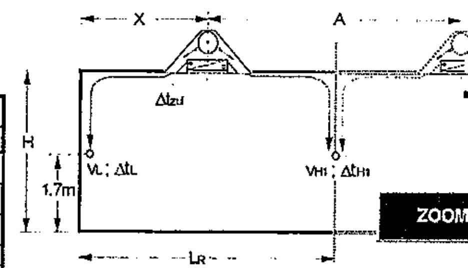
DID 600 calculation

Input DID	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Vwater DID	0.3500 GPM	0.1500 GPM	0.3500 GPM	1.5000 GPM
Unit length	5.5 ft			
Nozzle-type	C			
Vair-primary DID	120.0 CFM			
	56.7 l/s			
No-nozzles active	50			

Project	room-No.	comment
UNE CoP	203	50 Nozzles

Input temperatures	cooling		heating	
Tair-primary	55.0 °F		55.0 °F	
Troom / rel. Humidity	75.0 °F	50.0 %	72.0 °F	50.0 %
Twater-flow	57.0 °F		140.0 °F	

Input room measures	
room height	10.0 ft
A	10.0 ft
X	100.0 ft



TROX® TECHNIK
The art of handling air

ZOOM

results	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Δtwater	-12.7 °F	50.6 °F	-11.4 °F	15.5 °F
Twater-return	69.7 °F	89.4 °F	68.4 °F	124.5 °F
ΔT room - water flow	-18.0 °F	68.0 °F	-18.0 °F	68.0 °F
ΔT Room water average	-11.7 °F	42.7 °F	-12.3 °F	60.3 °F
Q water DID	-2221 BTUH	3800 BTUH	-1992 BTUH	11607 BTUH
Q air DID	-2616 BTUH	-2230 BTUH	-2616 BTUH	-2230 BTUH
Q DID	-4836 BTUH	1570 BTUH	-4608 BTUH	9377 BTUH
ΔP water	0.775 ft WG	0.053 ft WG	0.528 ft WG	6.316 ft WG
ΔP air	0.62 inches WG			
NC (incl. 10 dB absorbtion)	34			

Language
english

Stand : 11.10.2007

vL	44.24 FPM		44.24 FPM	
vH1	59.72 FPM		59.72 FPM	
ΔTL	-1.0 °F		-1.0 °F	
ΔTH1	-0.2 °F		-0.2 °F	
X-crit	14.9 ft		14.9 ft	
Archimedes-number	0.000111		0.000111	
ΔTsupply	-11.0 °F	3.6 °F	-10.5 °F	21.4 °F
Connection-diameter / primary air	4 inches			

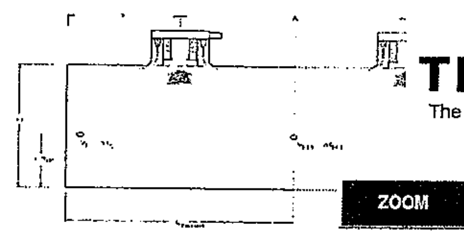
support values	
N-active nozzles	45
N-nozzles total	52
Aeff	0.04227 sq ft
veff	2838.91 FPM
H1	4.4 ft
L	104.4 ft
room air dew point-cooling	55.1 °F

DID 300 calculation

Input DID	4 pipe coil		2 pipe coil		Project	room-No.	comment
	cooling	heating	cooling	heating	UNE CoP	204	
V_{water} DID	0.1500 GPM	0.1500 GPM	0.1500 GPM	0.1500 GPM			
Unit length	8.0 ft						
Nozzle-type	c						
$V_{air\text{-}primary}$ DID	90.0 CFM						
	42.5 l/s						
$N_{o\text{-}nozzles\ active}$	76						

Input temperatures	cooling		heating	
$T_{air\text{-}primary}$	55.0 °F		55.0 °F	
T_{room} / rel. Humidity	75.0 °F	50.0 %	72.0 °F	50.0 %
$T_{water\text{-}flow}$	57.0 °F		140.0 °F	

Input room measures	
room height	10.0 ft
A	6.0 ft
X	2.0 ft



TROX® TECHNIK
The art of handling air

results	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Δt_{water}	-13.1 °F	37.5 °F	-14.0 °F	52.7 °F
$T_{water\text{-}return}$	70.1 °F	102.5 °F	71.0 °F	87.3 °F
ΔT room - water flow	-18.0 °F	68.0 °F	-18.0 °F	68.0 °F
ΔT Room water average	-11.5 °F	49.3 °F	-11.0 °F	41.6 °F
Q water DID	-982 BTUH	2813 BTUH	-1049 BTUH	3961 BTUH
Q air DID	-1962 BTUH	-1672 BTUH	-1962 BTUH	-1672 BTUH
Q DID	-2944 BTUH	1141 BTUH	-3010 BTUH	2289 BTUH
ΔP water	0.160 ft WG	0.047 ft WG	0.209 ft WG	0.187 ft WG
ΔP air	0.22 inches WG			
NC (including 10 dB room absorbtion)	17			

Stand : 11.10.2007

beam face	Language
70% - free, bar grille	english
50% - free, perf grille	

vL	77.98 fpm		77.98 fpm	
vH1	58.03 fpm		58.03 fpm	
ΔTL	-2.2 °F		-2.2 °F	
ΔTH1	-0.5 °F		-0.3 °F	
X-krit	8.6 ft		9.2 ft	
Archimedes-number	0.000396		0.000339	
ΔTsupply	14.1 °F		13.8 °F	
Connection-diameter / primary air	3.9 inches			

support values	
N-active nozzles	76
N-nozzles total	88
Aeff	0.064250 ft²
veff	1400.6 fpm
H1	4.4 ft
L	6.4 ft
room air dew point-cooling	55.1 °F

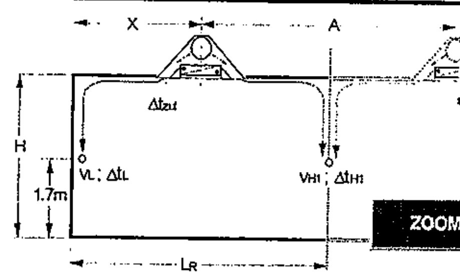
DID 600 calculation

Input DID	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Vwater DID	0.2500 GPM	0.2000 GPM	0.2500 GPM	1.5000 GPM
Unit length	5.5 ft			
Nozzle-type	c			
Vair-primary DID	70.0 CFM			
	33.1 l/s			
No-nozzles active	45			

Project	room-No.	comment
UNE CoP	205	

Input temperatures	cooling		heating	
Tair-primary	55.0 °F		55.0 °F	
Troom / rel. Humidity	75.0 °F	50.0 %	72.0 °F	50.0 %
Twater-flow	57.0 °F		140.0 °F	

Input room measures	
room height	10.0 ft
A	7.0 ft
X	3.0 ft



TROX® TECHNIK
The art of handling air

ZOOM

results	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Δtwater	-11.5 °F	34.6 °F	-11.0 °F	11.7 °F
Twater-return	68.5 °F	105.4 °F	68.0 °F	128.3 °F
ΔT room - water flow	-18.0 °F	68.0 °F	-18.0 °F	68.0 °F
ΔT Room water average	-12.2 °F	50.7 °F	-12.5 °F	62.1 °F
Q water DID	-1440 BTUH	3461 BTUH	-1371 BTUH	8801 BTUH
Q air DID	-1526 BTUH	-1301 BTUH	-1526 BTUH	-1301 BTUH
Q DID	-2966 BTUH	2160 BTUH	-2897 BTUH	7501 BTUH
ΔP water	0.424 ft WG	0.088 ft WG	0.288 ft WG	6.294 ft WG
ΔP air	0.26 inches WG			
NC (incl. 10 dB absorbtion)	21			

Language
english

Stand : 11.10.2007

vL	96.81 FPM		96.81 FPM	
vH1	38.96 FPM		38.96 FPM	
ΔTL	-4.0 °F		-3.9 °F	
ΔTH1	-0.8 °F		-0.8 °F	
X-crit	9.7 ft		9.7 ft	
Archimedes-number	0.000250		0.000250	
ΔTsupply	-11.6 °F	8.4 °F	-11.3 °F	29.3 °F
Connection-diameter / primary air	4 inches			

support values	
N-active nozzles	45
N-nozzles total	52
Aeff	0.03804 sq ft
veff	1840.03 FPM
H1	4.4 ft
L	7.4 ft
room air dew point-cooling	55.1 °F

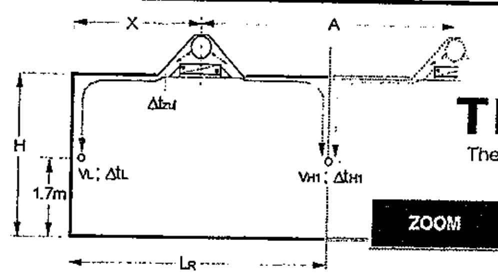
DID 600 calculation

Input DID	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Vwater DID	0.3000 GPM	1.5000 GPM	0.4500 GPM	1.5000 GPM
Unit length	3.5 ft			
Nozzle-type	b			
Vair-primary DID	40.0 CFM			
	18.9 l/s			
No-nozzles active	31			

Project	room-No.	comment
UNE CoP	206	

Input temperatures	cooling		heating	
Tair-primary	55.0 °F		55.0 °F	
Troom / rel. Humidity	75.0 °F	50.0 %	72.0 °F	50.0 %
Twater-flow	57.0 °F		120.0 °F	

Input room measures	
room height	10.0 ft
A	100.0 ft
X	8.0 ft



results	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Δtwater	-8.6 °F	4.1 °F	-5.8 °F	5.9 °F
Twater-return	65.6 °F	115.9 °F	62.8 °F	114.1 °F
ΔT room - water flow	-18.0 °F	48.0 °F	-18.0 °F	48.0 °F
ΔT Room water average	-13.7 °F	45.9 °F	-15.1 °F	45.1 °F
Q water DID	-1290 BTUH	3100 BTUH	-1304 BTUH	4398 BTUH
Q air DID	-872 BTUH	-743 BTUH	-872 BTUH	-743 BTUH
Q DID	-2162 BTUH	2356 BTUH	-2176 BTUH	3655 BTUH
ΔP water	0.411 ft WG	2.611 ft WG	0.591 ft WG	4.800 ft WG
ΔP air	0.41 inches WG			
NC (incl. 10 dB absorbtion)	18			

Stand : 11.10.2007

Language
english

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The art of handling air

vL	72.69 FPM		72.69 FPM	
vH1	7.80 FPM		7.80 FPM	
ΔTL	-2.9 °F		-2.9 °F	
ΔTH1	-0.6 °F		-0.6 °F	
X-crit	9.9 ft		9.9 ft	
Archimedes-number	0.000099		0.000099	
ΔTsupply	-12.3 °F	13.4 °F	-12.3 °F	20.7 °F
Connection-diameter / primary air	4 inches			

support values	
N-active nozzles	31
N-nozzles total	36
Aeff	0.01677 sq ft
veff	2384.84 FPM
H1	4.4 ft
L	12.4 ft
room air dew point-cooling	55.1 °F

206.xls 2/6/2008 FE/WO

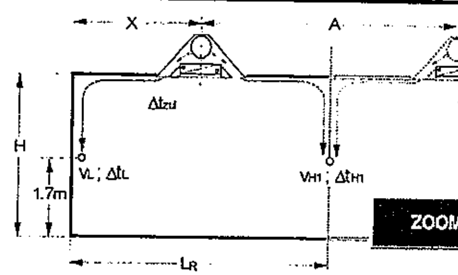
DID 600 calculation

Input DID	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
V_{water} DID	1.5000 GPM	0.1500 GPM	1.5000 GPM	1.5000 GPM
Unit length	5.5 ft			
Nozzle-type	a			
$V_{air-primary}$ DID	30.0 CFM			
	14.2 l/s			
$N_{o-nozzles\ active}$	45			

Project	room-No.	comment
UNE CoP	209,208	

Input temperatures	cooling		heating	
$T_{air-primary}$	55.0 °F		55.0 °F	
T_{room} / rel. Humidity	75.0 °F	50.0 %	72.0 °F	50.0 %
$T_{water-flow}$	57.0 °F		140.0 °F	

Input room measures	
room height	10.0 ft
A	100.0 ft
X	3.0 ft



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ZOOM

results	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Δt_{water}	-2.8 °F	35.1 °F	-2.7 °F	10.2 °F
$T_{water-return}$	59.8 °F	104.9 °F	59.7 °F	129.8 °F
ΔT room - water flow	-18.0 °F	68.0 °F	-18.0 °F	68.0 °F
ΔT Room water average	-16.6 °F	50.5 °F	-16.6 °F	62.9 °F
Q water DID	-2096 BTUH	2634 BTUH	-2033 BTUH	7680 BTUH
Q air DID	-654 BTUH	-557 BTUH	-654 BTUH	-557 BTUH
Q DID	-2750 BTUH	2076 BTUH	-2687 BTUH	7123 BTUH
Δ**P** water	10.891 ft WG	0.052 ft WG	7.416 ft WG	6.286 ft WG
Δ**P** air	0.34 inches WG			
NC (incl. 10 dB absorbtion)	12			

Language
english

Stand : 11.10.2007

vL	64.67 FPM		64.67 FPM	
vH1	5.01 FPM		5.01 FPM	
ΔTL	-5.6 °F		-5.4 °F	
ΔTH1	-1.1 °F		-1.1 °F	
X-crit	8.7 ft		8.7 ft	
Archimedes-number	0.000106		0.000106	
ΔTsupply	-16.1 °F	12.1 °F	-15.7 °F	41.7 °F
Connection-diameter / primary air	4 inches			

support values	
N-active nozzles	45
N-nozzles total	52
Aeff	0.01370 sq ft
veff	2190.52 FPM
H1	4.4 ft
L	7.4 ft
room air dew point-cooling	55.1 °F

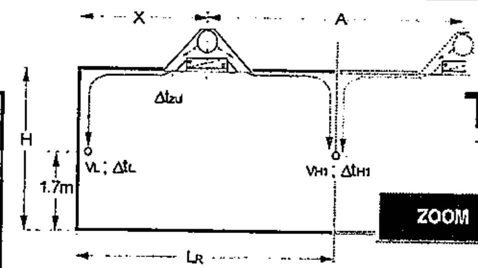
DID 600 calculation

Input DID	4 pipe coil cooling	4 pipe coil heating	2 pipe coil cooling	2 pipe coil heating
Vwater DID	1.5000 GPM	0.1500 GPM	1.5000 GPM	1.5000 GPM
Unit length	3.5 ft			
Nozzle-type	a			
Vair-primary DID	28.0 CFM			
	13.2 l/s			
No-nozzles active	31			

Project	room-No.	comment
UNE CoP	214 215 218 220 221 222 223	

Input temperatures	cooling		heating	
Tair-primary	55.0 °F		55.0 °F	
Troom / rel. Humidity	75.0 °F	50.0 %	72.0 °F	50.0 %
Twater-flow	57.0 °F		140.0 °F	

Input room measures	
room height	10.0 ft
A	100.0 ft
X	2.0 ft



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ZOOM

results	4 pipe coil cooling	4 pipe coil heating	2 pipe coil cooling	2 pipe coil heating
Δtwater	-2.4 °F	30.0 °F	-2.2 °F	8.2 °F
Twater-return	59.4 °F	110.0 °F	59.2 °F	131.8 °F
ΔT room - water flow	-18.0 °F	68.0 °F	-18.0 °F	68.0 °F
ΔT Room water average	-16.8 °F	53.0 °F	-16.9 °F	63.9 °F
Q water DID	-1792 BTUH	2250 BTUH	-1635 BTUH	6177 BTUH
Q air DID	-610 BTUH	-520 BTUH	-610 BTUH	-520 BTUH
Q DID	-2403 BTUH	1730 BTUH	-2245 BTUH	5656 BTUH
ΔP water	7.848 ft WG	0.037 ft WG	5.388 ft WG	4.656 ft WG
ΔP air	0.60 inches WG			
NC (incl. 10 dB absorbtion)	16			

Language
english

Stand : 11.10.2007

vL	91.49 FPM		91.49 FPM	
vH1	6.93 FPM		6.93 FPM	
ΔTL	-5.0 °F		-4.7 °F	
ΔTH1	-1.0 °F		-0.9 °F	
X-crit	10.3 ft		10.3 ft	
Archimedes-number	0.000048		0.000048	
ΔTsupply	-15.1 °F	10.8 °F	-14.1 °F	35.5 °F
Connection-diameter / primary air	4 inches			

support values	
N-active nozzles	31
N-nozzles total	36
Aeff	0.00943 sq ft
veff	2967.79 FPM
H1	4.4 ft
L	6.4 ft
room air dew point-cooling	55.1 °F

214_215_218_220_221_222_223.xls 2/6/2008 FE/WO

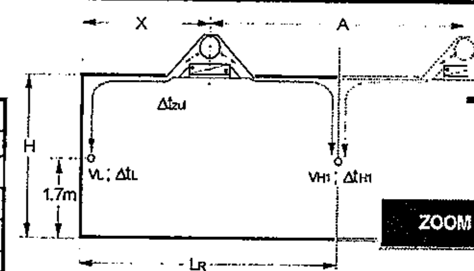
DID 600 calculation

Input DID	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Vwater DID	0.3000 GPM	1.5000 GPM	0.4000 GPM	1.5000 GPM
Unit length	5.5 ft			
Nozzle-type	b			
Vair-primary DID	60.0 CFM			
	28.3 l/s			
No-nozzles active	45			

Project	room-No.	comment
UNE CoP	216	

Input temperatures	cooling		heating	
Tair-primary	55.0 °F		55.0 °F	
Troom / rel. Humidity	75.0 °F	50.0 %	72.0 °F	50.0 %
Twater-flow	57.0 °F		120.0 °F	

Input room measures	
room height	10.0 ft
A	100.0 ft
X	9.0 ft



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ZOOM

results	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Δtwater	-11.6 °F	6.2 °F	-8.8 °F	8.7 °F
Twater-return	68.6 °F	113.8 °F	65.8 °F	111.3 °F
ΔT room - water flow	-18.0 °F	48.0 °F	-18.0 °F	48.0 °F
ΔT Room water average	-12.2 °F	44.9 °F	-13.6 °F	43.7 °F
Q water DID	-1743 BTUH	4623 BTUH	-1757 BTUH	6519 BTUH
Q air DID	-1308 BTUH	-1115 BTUH	-1308 BTUH	-1115 BTUH
Q DID	-3051 BTUH	3509 BTUH	-3065 BTUH	5404 BTUH
ΔP water	0.589 ft WG	3.465 ft WG	0.674 ft WG	6.516 ft WG
ΔP air	0.45 inches WG			
NC (incl. 10 dB absorbtion)	23			

Language
english

Stand : 11.10.2007

vL	74.40 FPM		74.40 FPM	
vH1	8.39 FPM		8.39 FPM	
ΔTL	-3.0 °F		-3.0 °F	
ΔTH1	-0.6 °F		-0.6 °F	
X-crit	11.3 ft		11.3 ft	
Archimedes-number	0.000111		0.000111	
ΔTsupply	-11.5 °F	13.3 °F	-11.6 °F	20.4 °F
Connection-diameter / primary air	4 inches			

support values	
N-active nozzles	45
N-nozzles total	52
Aeff	0.02435 sq ft
veff	2464.33 FPM
H1	4.4 ft
L	13.4 ft
room air dew point-cooling	55.1 °F

216.xls 2/5/2008 FE/WO

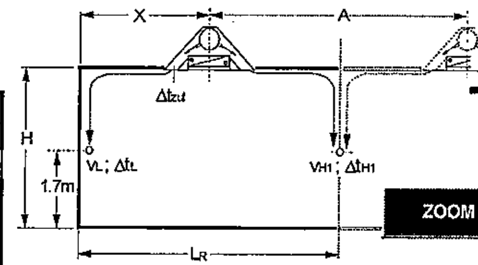
DID 600 calculation

Input DID	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Vwater DID	1.2000 GPM	0.2000 GPM	1.5000 GPM	1.5000 GPM
Unit length	3.5 ft			
Nozzle-type	b			
Vair-primary DID	35.0 CFM			
	16.5 l/s			
No-nozzles active	31			

Project	room-No.	comment
UNE CoP	219	

Input temperatures	cooling		heating	
Tair-primary	55.0 °F		55.0 °F	
Troom / rel. Humidity	75.0 °F	50.0 %	72.0 °F	50.0 %
Twater-flow	57.0 °F		140.0 °F	

Input room measures	
room height	10.0 ft
A	100.0 ft
X	4.0 ft



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ZOOM

results	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Δtwater	-2.9 °F	25.0 °F	-2.0 °F	7.7 °F
Twater-return	59.9 °F	115.0 °F	59.0 °F	132.3 °F
ΔT room - water flow	-18.0 °F	68.0 °F	-18.0 °F	68.0 °F
ΔT Room water average	-16.6 °F	55.5 °F	-17.0 °F	64.1 °F
Q water DID	-1722 BTUH	2503 BTUH	-1535 BTUH	5800 BTUH
Q air DID	-763 BTUH	-650 BTUH	-763 BTUH	-650 BTUH
Q DID	-2485 BTUH	1852 BTUH	-2298 BTUH	5149 BTUH
ΔP water	5.206 ft WG	0.063 ft WG	5.389 ft WG	4.654 ft WG
ΔP air	0.31 inches WG			
NC (incl. 10 dB absorbtion)	15			

Language
english

Stand : 11.10.2007

vL	77.25 FPM		77.25 FPM	
vH1	6.66 FPM		6.66 FPM	
ΔTL	-4.7 °F		-4.3 °F	
ΔTH1	-0.9 °F		-0.9 °F	
X-crit	8.7 ft		8.7 ft	
Archimedes-number	0.000129		0.000129	
ΔTsupply	-16.1 °F	12.0 °F	-14.9 °F	33.4 °F
Connection-diameter / primary air	4 inches			

support values	
N-active nozzles	31
N-nozzles total	36
Aeff	0.01677 sq ft
veff	2086.73 FPM
H1	4.4 ft
L	8.4 ft
room air dew point-cooling	55.1 °F

219.xls 2/6/2008 FE/WO

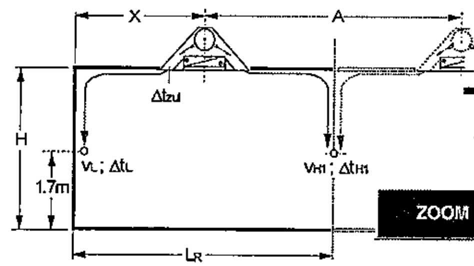
DID 600 calculation

Input DID	4 pipe coil cooling	4 pipe coil heating	2 pipe coil cooling	2 pipe coil heating
Vwater DID	0.3000 GPM	1.5000 GPM	0.4000 GPM	1.5000 GPM
Unit length	3.5 ft			
Nozzle-type	a			
Vair-primary DID	20.0 CFM			
	9.4 l/s			
No-nozzles active	31			

Project	room-No.	comment
UNE CoP	224	

Input temperatures	cooling		heating	
Tair-primary	55.0 °F		55.0 °F	
Troom / rel. Humidity	75.0 °F	50.0 %	72.0 °F	50.0 %
Twater-flow	57.0 °F		120.0 °F	

Input room measures	
room height	10.0 ft
A	100.0 ft
X	3.0 ft



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The art of handling air

ZOOM

results	4 pipe coil cooling	4 pipe coil heating	2 pipe coil cooling	2 pipe coil heating
Δtwater	-6.6 °F	3.1 °F	-5.3 °F	4.8 °F
Twater-return	63.6 °F	116.9 °F	62.3 °F	115.2 °F
ΔT room - water flow	-18.0 °F	48.0 °F	-18.0 °F	48.0 °F
ΔT Room water average	-14.7 °F	46.4 °F	-15.4 °F	45.6 °F
Q water DID	-990 BTUH	2363 BTUH	-1059 BTUH	3637 BTUH
Q air DID	-436 BTUH	-372 BTUH	-436 BTUH	-372 BTUH
Q DID	-1426 BTUH	1991 BTUH	-1495 BTUH	3266 BTUH
ΔP water	0.412 ft WG	2.609 ft WG	0.477 ft WG	4.796 ft WG
ΔP air	0.31 inches WG			
NC (incl. 10 dB absorbtion)	8			

Language
english

Stand : 11.10.2007

vL	60.79 FPM		60.79 FPM	
vH1	4.65 FPM		4.65 FPM	
ΔTL	-3.9 °F		-4.0 °F	
ΔTH1	-0.8 °F		-0.8 °F	
X-crit	7.6 ft		7.6 ft	
Archimedes-number	0.000094		0.000094	
ΔTsupply	-12.5 °F	17.5 °F	-13.1 °F	28.7 °F
Connection-diameter / primary air	4 inches			

support values	
N-active nozzles	31
N-nozzles total	36
Aeff	0.00943 sq ft
veff	2119.85 FPM
H1	4.4 ft
L	7.4 ft
room air dew point-cooling	55.1 °F

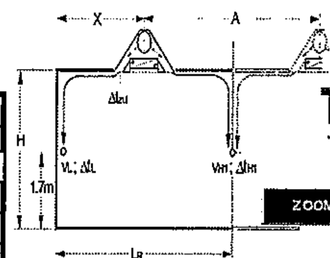
224.xls 2/6/2008 FE/WO

DID 600 calculation

Input DID	4 pipe coil		2 pipe coil		Project	room-No.	comment
	cooling	heating	cooling	heating	UNE CoP	225	
$V_{water\ DID}$	1.2000 GPM	0.1500 GPM	1.5000 GPM	1.5000 GPM			
Unit length	9.5 ft						
Nozzle-type	b						
$V_{air\text{-}primary\ DID}$	90.0 CFM						
	42.5 l/s						
$N_{o\text{-}nozzles\ active}$	73						

Input temperatures	cooling		heating	
$T_{air\text{-}primary}$	55.0 °F		55.0 °F	
T_{room} / rel. Humidity	75.0 °F	50.0 %	72.0 °F	50.0 %
$T_{water\text{-}flow}$	57.0 °F		140.0 °F	

Input room measures	
room height	10.0 ft
A	6.0 ft
X	3.0 ft



TROX® TECHNIK

ZOOM

results	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Δt_{water}	-6.1 °F	53.8 °F	-4.5 °F	17.0 °F
$T_{water\text{-}return}$	63.1 °F	86.2 °F	61.5 °F	123.0 °F
ΔT room - water flow	-18.0 °F	68.0 °F	-18.0 °F	68.0 °F
ΔT Room water average	-15.0 °F	41.1 °F	-15.8 °F	59.5 °F
Q water DID	-3650 BTUH	4040 BTUH	-3374 BTUH	12747 BTUH
Q air DID	-1962 BTUH	-1672 BTUH	-1962 BTUH	-1672 BTUH
Q DID	-5611 BTUH	2367 BTUH	-5336 BTUH	11075 BTUH
ΔP water	11.332 ft WG	0.084 ft WG	11.446 ft WG	9.597 ft WG
ΔP air	0.40 Inches WG			
NC (incl. 10 dB absorbtion)	24			

Language
english

Stand: 11.10.2007

vL	99.07 FPM		99.07 FPM	
vH1	43.87 FPM		43.87 FPM	
ΔTL	-5.6 °F		-5.3 °F	
ΔTH1	-1.1 °F		-1.1 °F	
X-crit	12.0 ft		12.0 ft	
Archimedes-number	0.000166		0.000166	
ΔTsupply	-14.1 °F	6.0 °F	-13.5 °F	27.9 °F
Connection-diameter / primary air	5 Inches			

support values	
N-active nozzles	73
N-nozzles total	88
Aeff	0.03950 sq ft
veff	2278.66 FPM
H1	4.4 ft
L	7.4 ft
room air dew point-cooling	55.1 °F

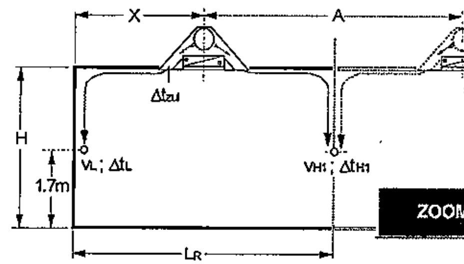
DID 600 calculation

Input DID	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Vwater DID	1.5000 GPM	0.2500 GPM	1.5000 GPM	1.5000 GPM
Unit length	7.5 ft			
Nozzle-type	a			
Vair-primary DID	55.0 CFM			
	26.0 l/s			
No-nozzles active	68			

Project	room-No.	comment
UNE CoP	226	68 Nozzles

Input temperatures	cooling		heating	
Tair-primary	55.0 °F		55.0 °F	
Troom / rel. Humidity	75.0 °F	50.0 %	72.0 °F	50.0 %
Twater-flow	57.0 °F		140.0 °F	

Input room measures	
room height	10.0 ft
A	6.0 ft
X	3.0 ft



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ZOOM

results	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Δtwater	-4.1 °F	35.7 °F	-3.8 °F	14.4 °F
Twater-return	61.1 °F	104.3 °F	60.8 °F	125.6 °F
ΔT room - water flow	-18.0 °F	68.0 °F	-18.0 °F	68.0 °F
ΔT Room water average	-16.0 °F	50.2 °F	-16.1 °F	60.8 °F
Q water DID	-3076 BTUH	4465 BTUH	-2856 BTUH	10791 BTUH
Q air DID	-1199 BTUH	-1022 BTUH	-1199 BTUH	-1022 BTUH
Q DID	-4275 BTUH	3443 BTUH	-4055 BTUH	9769 BTUH
ΔP water	13.909 ft WG	0.168 ft WG	9.432 ft WG	7.940 ft WG
ΔP air	0.51 inches WG			
NC (incl. 10 dB absorbtion)	21			

Language
english

Stand : 11.10.2007

vL	93.67 FPM		93.67 FPM	
vH1	41.05 FPM		41.05 FPM	
ΔTL	-5.1 °F		-4.8 °F	
ΔTH1	-1.0 °F		-1.0 °F	
X-crit	11.5 ft		11.5 ft	
Archimedes-number	0.000088		0.000088	
ΔTsupply	-13.6 °F	11.0 °F	-12.9 °F	31.2 °F
Connection-diameter / primary air	5 inches			

support values	
N-active nozzles	60
N-nozzles total	69
Aeff	0.02070 sq ft
veff	2657.61 FPM
H1	4.4 ft
L	7.4 ft
room air dew point-cooling	55.1 °F

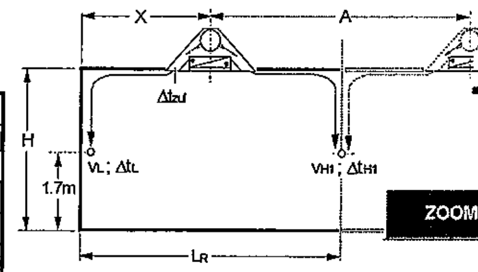
DID 600 calculation

Input DID	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Vwater DID	1.5000 GPM	0.1500 GPM	1.5000 GPM	1.5000 GPM
Unit length	3.5 ft			
Nozzle-type	a			
Vair-primary DID	25.0 CFM			
	11.8 l/s			
No-nozzles active	31			

Project	room-No.	comment
UNE CoP	228	

Input temperatures	cooling		heating	
Tair-primary	55.0 °F		55.0 °F	
Troom / rel. Humidity	75.0 °F	50.0 %	72.0 °F	50.0 %
Twater-flow	57.0 °F		140.0 °F	

Input room measures	
room height	10.0 ft
A	6.0 ft
X	3.0 ft



TROX® TECHNIK
The art of handling air

ZOOM

results	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Δtwater	-2.2 °F	28.3 °F	-2.0 °F	7.7 °F
Twater-return	59.2 °F	111.7 °F	59.0 °F	132.3 °F
ΔT room - water flow	-18.0 °F	68.0 °F	-18.0 °F	68.0 °F
ΔT Room water average	-16.9 °F	53.9 °F	-17.0 °F	64.1 °F
Q water DID	-1657 BTUH	2125 BTUH	-1539 BTUH	5812 BTUH
Q air DID	-545 BTUH	-464 BTUH	-545 BTUH	-464 BTUH
Q DID	-2202 BTUH	1661 BTUH	-2083 BTUH	5348 BTUH
ΔP water	7.850 ft WG	0.037 ft WG	5.389 ft WG	4.654 ft WG
ΔP air	0.48 inches WG			
NC (incl. 10 dB absorbtion)	13			

Language
english

Stand : 11.10.2007

vL	75.99 FPM		75.99 FPM	
vH1	32.04 FPM		32.04 FPM	
ΔTL	-4.8 °F		-4.5 °F	
ΔTH1	-0.9 °F		-0.9 °F	
X-crit	9.3 ft		9.3 ft	
Archimedes-number	0.000060		0.000060	
ΔTsupply	-15.5 °F	11.7 °F	-14.6 °F	37.6 °F
Connection-diameter / primary air	4 inches			

support values	
N-active nozzles	31
N-nozzles total	36
Aeff	0.00943 sq ft
veff	2649.82 FPM
H1	4.4 ft
L	7.4 ft
room air dew point-cooling	55.1 °F

228.xls 2/6/2008 FE/WO

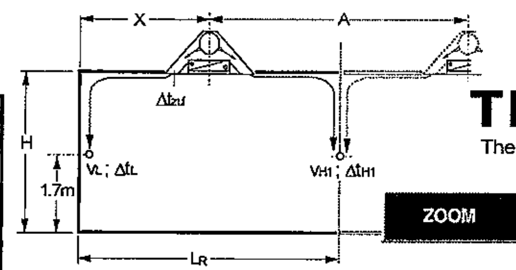
DID 600 calculation

Input DID	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Vwater DID	1.5000 GPM	0.1500 GPM	1.5000 GPM	1.5000 GPM
Unit length	3.5 ft			
Nozzle-type	a			
Vair-primary DID	25.0 CFM			
	11.8 l/s			
No-nozzles active	31			

Project	room-No.	comment
UNE CoP	231	

Input temperatures	cooling		heating	
Tair-primary	55.0 °F		55.0 °F	
Troom / rel. Humidity	75.0 °F	50.0 %	72.0 °F	50.0 %
Twater-flow	57.0 °F		140.0 °F	

Input room measures	
room height	10.0 ft
A	6.0 ft
X	3.0 ft



TROX® TECHNIK
The art of handling air

results	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Δtwater	-2.2 °F	28.3 °F	-2.0 °F	7.7 °F
Twater-return	59.2 °F	111.7 °F	59.0 °F	132.3 °F
ΔT room - water flow	-18.0 °F	68.0 °F	-18.0 °F	68.0 °F
ΔT Room water average	-16.9 °F	53.9 °F	-17.0 °F	64.1 °F
Q water DID	-1657 BTUH	2125 BTUH	-1539 BTUH	5812 BTUH
Q air DID	-545 BTUH	-464 BTUH	-545 BTUH	-464 BTUH
Q DID	-2202 BTUH	1661 BTUH	-2083 BTUH	5348 BTUH
ΔP water	7.850 ft WG	0.037 ft WG	5.389 ft WG	4.654 ft WG
ΔP air	0.48 inches WG			
NC (incl. 10 dB absorbtion)	13			

Language
english

Stand : 11.10.2007

vL	75.99 FPM		75.99 FPM	
vH1	32.04 FPM		32.04 FPM	
ΔTL	-4.8 °F		-4.5 °F	
ΔTH1	-0.9 °F		-0.9 °F	
X-crit	9.3 ft		9.3 ft	
Archimedes-number	0.000060		0.000060	
ΔTsupply	-15.5 °F	11.7 °F	-14.6 °F	37.6 °F
Connection-diameter / primary air	4 inches			

support values	
N-active nozzles	31
N-nozzles total	36
Aeff	0.00943 sq ft
veff	2649.82 FPM
H1	4.4 ft
L	7.4 ft
room air dew point-cooling	55.1 °F

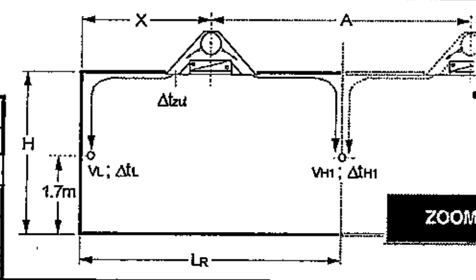
DID 600 calculation

Input DID	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Vwater DID	0.7000 GPM	0.1500 GPM	1.5000 GPM	1.5000 GPM
Unit length	3.5 ft			
Nozzle-type	a			
Vair-primary DID	20.0 CFM			
	9.4 l/s			
No-nozzles active	31			

Project	room-No.	comment
UNE CoP	Offices, 235,234,233,232	

Input temperatures	cooling		heating	
Tair-primary	55.0 °F		55.0 °F	
Troom / rel. Humidity	75.0 °F	50.0 %	72.0 °F	50.0 %
Twater-flow	57.0 °F		140.0 °F	

Input room measures	
room height	10.0 ft
A	6.0 ft
X	3.0 ft



TROX® TECHNIK
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ZOOM

results	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Δtwater	-3.6 °F	25.2 °F	-1.8 °F	6.9 °F
Twater-return	60.6 °F	114.8 °F	58.8 °F	133.1 °F
ΔT room - water flow	-18.0 °F	68.0 °F	-18.0 °F	68.0 °F
ΔT Room water average	-16.2 °F	55.4 °F	-17.1 °F	64.6 °F
Q water DID	-1272 BTUH	1895 BTUH	-1364 BTUH	5153 BTUH
Q air DID	-436 BTUH	-372 BTUH	-436 BTUH	-372 BTUH
Q DID	-1708 BTUH	1523 BTUH	-1800 BTUH	4781 BTUH
ΔP water	1.938 ft WG	0.037 ft WG	5.391 ft WG	4.651 ft WG
ΔP air	0.31 inches WG			
NC (incl. 10 dB absorbtion)	8			

Language
english

Stand : 11.10.2007

vL	60.79 FPM		60.79 FPM	
vH1	24.60 FPM		24.60 FPM	
ΔTL	-4.6 °F		-4.9 °F	
ΔTH1	-0.9 °F		-1.0 °F	
X-crit	7.6 ft		7.6 ft	
Archimedes-number	0.000094		0.000094	
ΔTsupply	-15.0 °F	13.4 °F	-15.8 °F	42.0 °F
Connection-diameter / primary air	4 inches			

support values	
N-active nozzles	31
N-nozzles total	36
Aeff	0.00943 sq ft
veff	2119.85 FPM
H1	4.4 ft
L	7.4 ft
room air dew point-cooling	55.1 °F

232-235Offices.xls 2/6/2008 FE/WO

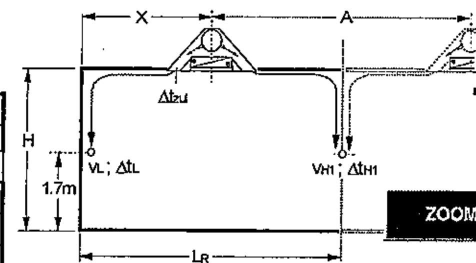
DID 600 calculation

Input DID	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Vwater DID	1.5000 GPM	0.2500 GPM	1.5000 GPM	1.5000 GPM
Unit length	5.5 ft			
Nozzle-type	b			
Vair-primary DID	45.0 CFM			
	21.3 l/s			
No-nozzles active	45			

Project	room-No.	comment
UNE CoP	237	

Input temperatures	cooling		heating	
Tair-primary	55.0 °F		55.0 °F	
Troom / rel. Humidity	75.0 °F	50.0 %	72.0 °F	50.0 %
Twater-flow	57.0 °F		140.0 °F	

Input room measures	
room height	10.0 ft
A	6.0 ft
X	3.0 ft



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ZOOM

results	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Δtwater	-3.1 °F	28.4 °F	-2.8 °F	10.6 °F
Twater-return	60.1 °F	111.6 °F	59.8 °F	129.4 °F
ΔT room - water flow	-18.0 °F	68.0 °F	-18.0 °F	68.0 °F
ΔT Room water average	-16.4 °F	53.8 °F	-16.6 °F	62.7 °F
Q water DID	-2344 BTUH	3559 BTUH	-2104 BTUH	7947 BTUH
Q air DID	-981 BTUH	-836 BTUH	-981 BTUH	-836 BTUH
Q DID	-3325 BTUH	2723 BTUH	-3085 BTUH	7111 BTUH
ΔP water	10.885 ft WG	0.131 ft WG	7.415 ft WG	6.288 ft WG
ΔP air	0.25 inches WG			
NC (incl. 10 dB absorbtion)	15			

Language
english

Stand : 11.10.2007

vL	75.05 FPM		75.05 FPM	
vH1	31.58 FPM		31.58 FPM	
ΔTL	-5.8 °F		-5.4 °F	
ΔTH1	-1.1 °F		-1.1 °F	
X-crit	8.7 ft		8.7 ft	
Archimedes-number	0.000198		0.000198	
ΔTsupply	-16.8 °F	13.7 °F	-15.6 °F	35.9 °F
Connection-diameter / primary air	4 inches			

support values	
N-active nozzles	45
N-nozzles total	52
Aeff	0.02435 sq ft
veff	1848.25 FPM
H1	4.4 ft
L	7.4 ft
room air dew point-cooling	55.1 °F

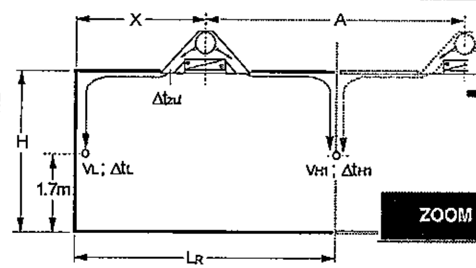
DID 600 calculation

Input DID	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Vwater DID	0.3500 GPM	0.1500 GPM	1.5000 GPM	1.5000 GPM
Unit length	3.5 ft			
Nozzle-type	a			
Vair-primary DID	20.0 CFM			
	9.4 l/s			
No-nozzles active	31			

Project	room-No.	comment
UNE CoP	239	

Input temperatures	cooling		heating	
Tair-primary	55.0 °F		55.0 °F	
Troom / rel. Humidity	75.0 °F	50.0 %	72.0 °F	50.0 %
Twater-flow	57.0 °F		140.0 °F	

Input room measures	
room height	10.0 ft
A	6.0 ft
X	3.0 ft



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ZOOM

results	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Δtwater	-6.0 °F	25.2 °F	-1.8 °F	6.9 °F
Twater-return	63.0 °F	114.8 °F	58.8 °F	133.1 °F
ΔT room - water flow	-18.0 °F	68.0 °F	-18.0 °F	68.0 °F
ΔT Room water average	-15.0 °F	55.4 °F	-17.1 °F	64.6 °F
Q water DID	-1048 BTUH	1895 BTUH	-1364 BTUH	5153 BTUH
Q air DID	-436 BTUH	-372 BTUH	-436 BTUH	-372 BTUH
Q DID	-1484 BTUH	1523 BTUH	-1800 BTUH	4781 BTUH
ΔP water	0.546 ft WG	0.037 ft WG	5.391 ft WG	4.651 ft WG
ΔP air	0.31 inches WG			
NC (incl. 10 dB absorbtion)	8			

Language
english

Stand : 11.10.2007

vL	60.79 FPM		60.79 FPM	
vH1	24.60 FPM		24.60 FPM	
ΔTL	-4.0 °F		-4.9 °F	
ΔTH1	-0.8 °F		-1.0 °F	
X-crit	7.6 ft		7.6 ft	
Archimedes-number	0.000094		0.000094	
ΔTsupply	-13.0 °F	13.4 °F	-15.8 °F	42.0 °F
Connection-diameter / primary air	4 inches			

support values	
N-active nozzles	31
N-nozzles total	36
Aeff	0.00943 sq ft
veff	2119.85 FPM
H1	4.4 ft
L	7.4 ft
room air dew point-cooling	55.1 °F

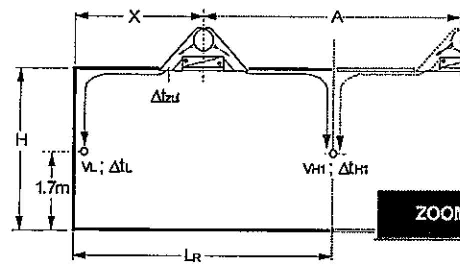
DID 600 calculation

Input DID	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Vwater DID	1.5000 GPM	0.1500 GPM	1.5000 GPM	1.5000 GPM
Unit length	5.5 ft			
Nozzle-type	b			
Vair-primary DID	60.0 CFM			
	28.3 l/s			
No-nozzles active	45			

Project	room-No.	comment
UNE CoP	242	

Input temperatures	cooling		heating	
Tair-primary	55.0 °F		55.0 °F	
Troom / rel. Humidity	75.0 °F	50.0 %	72.0 °F	50.0 %
Twater-flow	57.0 °F		140.0 °F	

Input room measures	
room height	10.0 ft
A	100.0 ft
X	3.0 ft



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ZOOM

results	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Δtwater	-3.8 °F	42.9 °F	-3.3 °F	12.3 °F
Twater-return	60.8 °F	97.1 °F	60.3 °F	127.7 °F
ΔT room - water flow	-18.0 °F	68.0 °F	-18.0 °F	68.0 °F
ΔT Room water average	-16.1 °F	46.6 °F	-16.4 °F	61.9 °F
Q water DID	-2842 BTUH	3221 BTUH	-2445 BTUH	9235 BTUH
Q air DID	-1308 BTUH	-1115 BTUH	-1308 BTUH	-1115 BTUH
Q DID	-4149 BTUH	2106 BTUH	-3752 BTUH	8121 BTUH
ΔP water	10.875 ft WG	0.053 ft WG	7.410 ft WG	6.297 ft WG
ΔP air	0.45 inches WG			
NC (incl. 10 dB absorbtion)	23			

Language
english

Stand : 11.10.2007

vL	100.06 FPM		100.06 FPM	
vH1	8.39 FPM		8.39 FPM	
ΔTL	-5.4 °F		-4.9 °F	
ΔTH1	-1.1 °F		-1.0 °F	
X-crit	11.3 ft		11.3 ft	
Archimedes-number	0.000111		0.000111	
ΔTsupply	-15.7 °F	8.0 °F	-14.2 °F	30.7 °F
Connection-diameter / primary air	4 inches			

support values	
N-active nozzles	45
N-nozzles total	52
Aeff	0.02435 sq ft
veff	2464.33 FPM
H1	4.4 ft
L	7.4 ft
room air dew point-cooling	55.1 °F

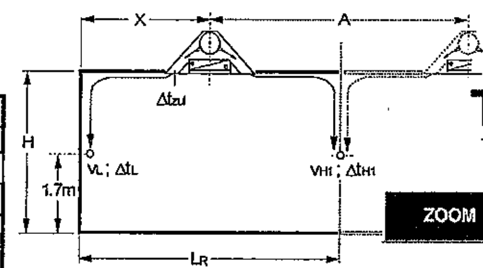
DID 600 calculation

Input DID	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Vwater DID	1.5000 GPM	0.3000 GPM	1.5000 GPM	1.5000 GPM
Unit length	7.5 ft			
Nozzle-type	b			
Vair-primary DID	70.0 CFM			
	33.1 l/s			
No-nozzles active	60			

Project	room-No.	comment
UNE CoP	243	

Input temperatures	cooling		heating	
Tair-primary	55.0 °F		55.0 °F	
Troom / rel. Humidity	75.0 °F	50.0 %	72.0 °F	50.0 %
Twater-flow	57.0 °F		140.0 °F	

Input room measures	
room height	10.0 ft
A	6.0 ft
X	3.0 ft



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ZOOM

results	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Δtwater	-4.1 °F	32.0 °F	-3.6 °F	13.7 °F
Twater-return	61.1 °F	108.0 °F	60.6 °F	126.3 °F
ΔT room - water flow	-18.0 °F	68.0 °F	-18.0 °F	68.0 °F
ΔT Room water average	-16.0 °F	52.0 °F	-16.2 °F	61.2 °F
Q water DID	-3077 BTUH	4812 BTUH	-2715 BTUH	10256 BTUH
Q air DID	-1526 BTUH	-1301 BTUH	-1526 BTUH	-1301 BTUH
Q DID	-4603 BTUH	3512 BTUH	-4241 BTUH	8955 BTUH
ΔP water	13.909 ft WG	0.233 ft WG	9.434 ft WG	7.935 ft WG
ΔP air	0.35 inches WG			
NC (incl. 10 dB absorbtion)	22			

Language
english

Stand : 11.10.2007

vL	92.22 FPM		92.22 FPM	
vH1	40.30 FPM		40.30 FPM	
ΔTL	-5.6 °F		-5.1 °F	
ΔTH1	-1.1 °F		-1.0 °F	
X-crit	10.8 ft		10.8 ft	
Archimedes-number	0.000168		0.000168	
ΔTsupply	-14.9 °F	11.4 °F	-13.7 °F	29.0 °F
Connection-diameter / primary air	5 inches			

support values	
N-active nozzles	60
N-nozzles total	69
Aeff	0.03246 sq ft
veff	2156.29 FPM
H1	4.4 ft
L	7.4 ft
room air dew point-cooling	55.1 °F

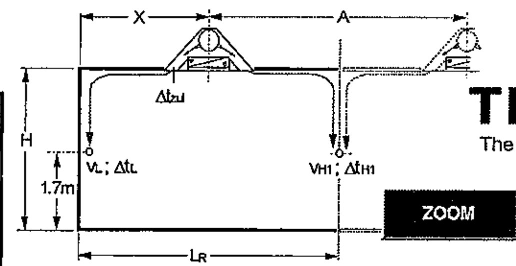
DID 600 calculation

Input DID	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Vwater DID	1.5000 GPM	1.5000 GPM	0.2500 GPM	1.5000 GPM
Unit length	8.5 ft			
Nozzle-type	c			
Vair-primary DID	125.0 CFM			
	59.0 l/s			
No-nozzles active	68			

Project	room-No.	comment
UNE CoP	302	

Input temperatures	cooling		heating	
Tair-primary	55.0 °F		55.0 °F	
Troom / rel. Humidity	75.0 °F	50.0 %	72.0 °F	50.0 %
Twater-flow	57.0 °F		120.0 °F	

Input room measures	
room height	10.0 ft
A	6.0 ft
X	100.0 ft



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results	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Δtwater	-4.9 °F	8.3 °F	-14.3 °F	12.0 °F
Twater-return	61.9 °F	111.7 °F	71.3 °F	108.0 °F
ΔT room - water flow	-18.0 °F	48.0 °F	-18.0 °F	48.0 °F
ΔT Room water average	-15.6 °F	43.8 °F	-10.8 °F	42.0 °F
Q water DID	-3664 BTUH	6269 BTUH	-1793 BTUH	8988 BTUH
Q air DID	-2725 BTUH	-2322 BTUH	-2725 BTUH	-2322 BTUH
Q DID	-6389 BTUH	3947 BTUH	-4517 BTUH	6665 BTUH
ΔP water	15.410 ft WG	4.750 ft WG	0.417 ft WG	9.104 ft WG
ΔP air	0.37 inches WG			
NC (incl. 10 dB absorbtion)	28			

Language
english

Stand : 11.10.2007

vL	33.10 FPM		33.10 FPM	
vH1	57.32 FPM		57.32 FPM	
ΔTL	-1.4 °F		-1.0 °F	
ΔTH1	-0.4 °F		-0.2 °F	
X-crit	12.7 ft		12.7 ft	
Archimedes-number	0.000220		0.000220	
ΔTsupply	-14.0 °F	8.6 °F	-9.9 °F	14.6 °F
Connection-diameter / primary air	5 inches			

support values	
N-active nozzles	68
N-nozzles total	79
Aeff	0.05749 sq ft
veff	2174.41 FPM
H1	4.4 ft
L	104.4 ft
room air dew point-cooling	55.1 °F

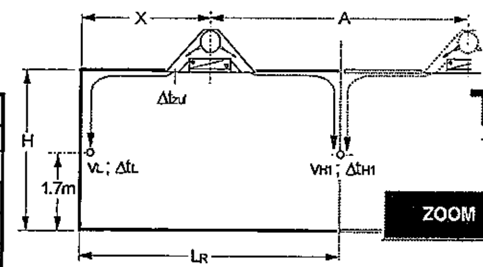
DID 600 calculation

Input DID	4 pipe coil cooling	4 pipe coil heating	2 pipe coil cooling	2 pipe coil heating
Vwater DID	1.5000 GPM	0.5000 GPM	1.5000 GPM	1.5000 GPM
Unit length	7.5 ft			
Nozzle-type	b			
Vair-primary DID	81.0 CFM			
	38.3 l/s			
No-nozzles active	60			

Project	room-No.	comment
UNE CoP	304	

Input temperatures	cooling		heating	
Tair-primary	55.0 °F		55.0 °F	
Troom / rel. Humidity	75.0 °F	50.0 %	72.0 °F	50.0 %
Twater-flow	57.0 °F		140.0 °F	

Input room measures	
room height	10.0 ft
A	100.0 ft
X	4.0 ft



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The art of handling air

ZOOM

results	4 pipe coil cooling	4 pipe coil heating	2 pipe coil cooling	2 pipe coil heating
Δtwater	-4.5 °F	25.1 °F	-3.9 °F	14.7 °F
Twater-return	61.5 °F	114.9 °F	60.9 °F	125.3 °F
ΔT room - water flow	-18.0 °F	68.0 °F	-18.0 °F	68.0 °F
ΔT Room water average	-15.7 °F	55.5 °F	-16.1 °F	60.6 °F
Q water DID	-3384 BTUH	6276 BTUH	-2925 BTUH	11050 BTUH
Q air DID	-1766 BTUH	-1505 BTUH	-1766 BTUH	-1505 BTUH
Q DID	-5149 BTUH	4771 BTUH	-4690 BTUH	9545 BTUH
ΔP water	13.901 ft WG	0.580 ft WG	9.430 ft WG	7.943 ft WG
ΔP air	0.47 inches WG			
NC (incl. 10 dB absorbtion)	25			

Language
english

Stand : 11.10.2007

vL	100.18 FPM		100.18 FPM	
vH1	9.06 FPM		9.06 FPM	
ΔTL	-5.0 °F		-4.6 °F	
ΔTH1	-1.0 °F		-0.9 °F	
X-crit	12.3 ft		12.3 ft	
Archimedes-number	0.000125		0.000125	
ΔTsupply	-14.4 °F	13.4 °F	-13.1 °F	26.7 °F
Connection-diameter / primary air	5 inches			

support values	
N-active nozzles	60
N-nozzles total	69
Aeff	0.03246 sq ft
veff	2495.13 FPM
H1	4.4 ft
L	8.4 ft
room air dew point-cooling	55.1 °F

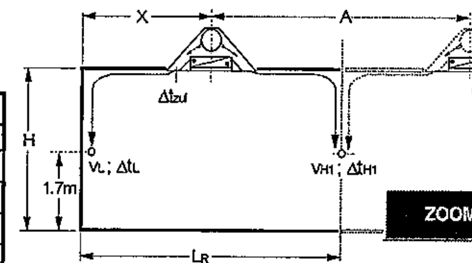
DID 600 calculation

Input DID	4 pipe coil cooling	4 pipe coil heating	2 pipe coil cooling	2 pipe coil heating
Vwater DID	0.6000 GPM	0.1500 GPM	1.5000 GPM	1.5000 GPM
Unit length	3.5 ft			
Nozzle-type	a			
Vair-primary DID	20.0 CFM			
	9.4 l/s			
No-nozzles active	31			

Project	room-No.	comment
UNE CoP	305 308 310 312 314 315	

Input temperatures	cooling		heating	
Tair-primary	55.0 °F		55.0 °F	
Troom / rel. Humidity	75.0 °F	50.0 %	72.0 °F	50.0 %
Twater-flow	57.0 °F		140.0 °F	

Input room measures	
room height	10.0 ft
A	100.0 ft
X	2.0 ft



TROX® TECHNIK
The art of handling air

ZOOM

results	4 pipe coil cooling	4 pipe coil heating	2 pipe coil cooling	2 pipe coil heating
Δtwater	-4.1 °F	25.2 °F	-1.8 °F	6.9 °F
Twater-return	61.1 °F	114.8 °F	58.8 °F	133.1 °F
ΔT room - water flow	-18.0 °F	68.0 °F	-18.0 °F	68.0 °F
ΔT Room water average	-16.0 °F	55.4 °F	-17.1 °F	64.6 °F
Q water DID	-1230 BTUH	1895 BTUH	-1364 BTUH	5153 BTUH
Q air DID	-436 BTUH	-372 BTUH	-436 BTUH	-372 BTUH
Q DID	-1666 BTUH	1523 BTUH	-1800 BTUH	4781 BTUH
ΔP water	1.462 ft WG	0.037 ft WG	5.391 ft WG	4.651 ft WG
ΔP air	0.31 inches WG			
NC (incl. 10 dB absorbtion)	8			

Language
english

Stand : 11.10.2007

vL	65.35 FPM		65.35 FPM	
vH1	4.65 FPM		4.65 FPM	
ΔTL	-4.8 °F		-5.2 °F	
ΔTH1	-0.9 °F		-1.0 °F	
X-crit	7.6 ft		7.6 ft	
Archimedes-number	0.000094		0.000094	
ΔTsupply	-14.6 °F	13.4 °F	-15.8 °F	42.0 °F
Connection-diameter / primary air	4 inches			

support values	
N-active nozzles	31
N-nozzles total	36
Aeff	0.00943 sq ft
veff	2119.85 FPM
H1	4.4 ft
L	6.4 ft
room air dew point-cooling	55.1 °F

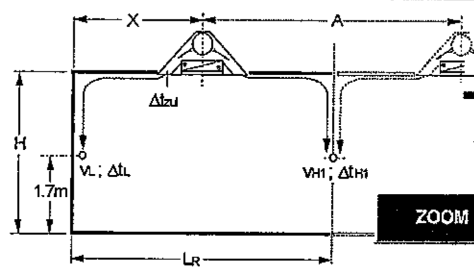
DID 600 calculation

Input DID	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Vwater DID	0.6000 GPM	0.1500 GPM	1.5000 GPM	1.5000 GPM
Unit length	3.5 ft			
Nozzle-type	a			
Vair-primary DID	20.0 CFM			
	9.4 l/s			
No-nozzles active	31			

Project	room-No.	comment
UNE CoP	305 308 310 312 314 315	

Input temperatures	cooling		heating	
Tair-primary	55.0 °F		55.0 °F	
Troom / rel. Humidity	75.0 °F	50.0 %	72.0 °F	50.0 %
Twater-flow	57.0 °F		140.0 °F	

Input room measures	
room height	10.0 ft
A	100.0 ft
X	2.0 ft



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The art of handling air

ZOOM

results	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Δtwater	-4.1 °F	25.2 °F	-1.8 °F	6.9 °F
Twater-return	61.1 °F	114.8 °F	58.8 °F	133.1 °F
ΔT room - water flow	-18.0 °F	68.0 °F	-18.0 °F	68.0 °F
ΔT Room water average	-16.0 °F	55.4 °F	-17.1 °F	64.6 °F
Q water DID	-1230 BTUH	1895 BTUH	-1364 BTUH	5153 BTUH
Q air DID	-436 BTUH	-372 BTUH	-436 BTUH	-372 BTUH
Q DID	-1666 BTUH	1523 BTUH	-1800 BTUH	4781 BTUH
ΔP water	1.462 ft WG	0.037 ft WG	5.391 ft WG	4.651 ft WG
ΔP air	0.31 inches WG			
NC (incl. 10 dB absorbtion)	8			

Language
english

Stand : 11.10.2007

vL	65.35 FPM		65.35 FPM	
vH1	4.65 FPM		4.65 FPM	
ΔTL	-4.8 °F		-5.2 °F	
ΔTH1	-0.9 °F		-1.0 °F	
X-crit	7.6 ft		7.6 ft	
Archimedes-number	0.000094		0.000094	
ΔTsupply	-14.6 °F	13.4 °F	-15.8 °F	42.0 °F
Connection-diameter / primary air	4 inches			

support values	
N-active nozzles	31
N-nozzles total	36
Aeff	0.00943 sq ft
veff	2119.85 FPM
H1	4.4 ft
L	6.4 ft
room air dew point-cooling	55.1 °F

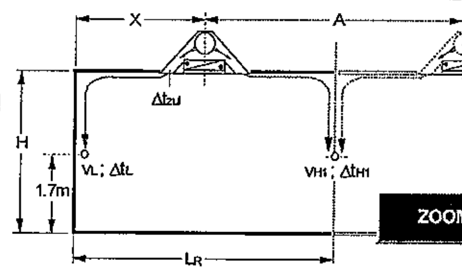
DID 600 calculation

Input DID	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Vwater DID	1.5000 GPM	1.5000 GPM	0.2500 GPM	1.5000 GPM
Unit length	8.5 ft			
Nozzle-type	c			
Vair-primary DID	130.0 CFM			
	61.4 l/s			
No-nozzles active	68			

Project	room-No.	comment
UNE CoP	Entry 309 (east)	

Input temperatures	cooling		heating	
Tair-primary	55.0 °F		55.0 °F	
Troom / rel. Humidity	75.0 °F	50.0 %	72.0 °F	50.0 %
Twater-flow	57.0 °F		120.0 °F	

Input room measures	
room height	10.0 ft
A	6.0 ft
X	100.0 ft



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ZOOM

results	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Δtwater	-5.0 °F	8.5 °F	-14.5 °F	12.2 °F
Twater-return	62.0 °F	111.5 °F	71.5 °F	107.8 °F
ΔT room - water flow	-18.0 °F	48.0 °F	-18.0 °F	48.0 °F
ΔT Room water average	-15.5 °F	43.7 °F	-10.7 °F	41.9 °F
Q water DID	-3757 BTUH	6414 BTUH	-1817 BTUH	9165 BTUH
Q air DID	-2834 BTUH	-2415 BTUH	-2834 BTUH	-2415 BTUH
Q DID	-6591 BTUH	3999 BTUH	-4650 BTUH	6750 BTUH
ΔP water	15.407 ft WG	4.751 ft WG	0.416 ft WG	9.107 ft WG
ΔP air	0.41 inches WG			
NC (incl. 10 dB absorbtion)	29			

Language
english

Stand : 11.10.2007

vL	34.43 FPM		34.43 FPM	
vH1	60.04 FPM		60.04 FPM	
ΔTL	-1.4 °F		-1.0 °F	
ΔTH1	-0.3 °F		-0.2 °F	
X-crit	13.1 ft		13.1 ft	
Archimedes-number	0.000203		0.000203	
ΔTsupply	-13.9 °F	8.4 °F	-9.8 °F	14.2 °F
Connection-diameter / primary air	5 inches			

support values	
N-active nozzles	68
N-nozzles total	79
Aeff	0.05749 sq ft
veff	2261.38 FPM
H1	4.4 ft
L	104.4 ft
room air dew point-cooling	55.1 °F

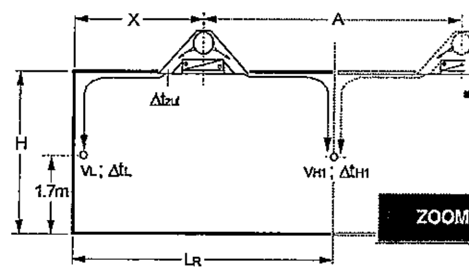
DID 600 calculation

Input DID	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Vwater DID	1.5000 GPM	1.5000 GPM	0.2500 GPM	1.5000 GPM
Unit length	8.5 ft			
Nozzle-type	c			
Vair-primary DID	125.0 CFM			
	59.0 l/s			
No-nozzles active	68			

Project	room-No.	comment
UNE CoP	Entry 309 (west)	

Input temperatures	cooling		heating	
Tair-primary	55.0 °F		55.0 °F	
Troom / rel. Humidity	75.0 °F	50.0 %	72.0 °F	50.0 %
Twater-flow	57.0 °F		120.0 °F	

Input room measures	
room height	10.0 ft
A	6.0 ft
X	100.0 ft



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ZOOM

results	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Δtwater	-4.9 °F	8.3 °F	-14.3 °F	12.0 °F
Twater-return	61.9 °F	111.7 °F	71.3 °F	108.0 °F
ΔT room - water flow	-18.0 °F	48.0 °F	-18.0 °F	48.0 °F
ΔT Room water average	-15.6 °F	43.8 °F	-10.8 °F	42.0 °F
Q water DID	-3664 BTUH	6269 BTUH	-1793 BTUH	8988 BTUH
Q air DID	-2725 BTUH	-2322 BTUH	-2725 BTUH	-2322 BTUH
Q DID	-6389 BTUH	3947 BTUH	-4517 BTUH	6665 BTUH
ΔP water	15.410 ft WG	4.750 ft WG	0.417 ft WG	9.104 ft WG
ΔP air	0.37 inches WG			
NC (incl. 10 dB absorbtion)	28			

Language
english

Stand : 11.10.2007

vL	33.10 FPM		33.10 FPM	
vH1	57.32 FPM		57.32 FPM	
ΔTL	-1.4 °F		-1.0 °F	
ΔTH1	-0.4 °F		-0.2 °F	
X-crit	12.7 ft		12.7 ft	
Archimedes-number	0.000220		0.000220	
ΔTsupply	-14.0 °F	8.6 °F	-9.9 °F	14.6 °F
Connection-diameter / primary air	5 inches			

support values	
N-active nozzles	68
N-nozzles total	79
Aeff	0.05749 sq ft
veff	2174.41 FPM
H1	4.4 ft
L	104.4 ft
room air dew point-cooling	55.1 °F

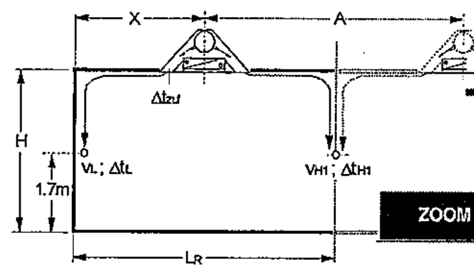
DID 600 calculation

Input DID	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Vwater DID	1.5000 GPM	1.5000 GPM	0.2500 GPM	1.5000 GPM
Unit length	8.5 ft			
Nozzle-type	c			
Vair-primary DID	130.0 CFM			
	61.4 l/s			
No-nozzles active	68			

Project	room-No.	comment
UNE CoP	Entry 309 (east)	

Input temperatures	cooling		heating	
Tair-primary	55.0 °F		55.0 °F	
Troom / rel. Humidity	75.0 °F	50.0 %	72.0 °F	50.0 %
Twater-flow	57.0 °F		120.0 °F	

Input room measures	
room height	10.0 ft
A	6.0 ft
X	100.0 ft



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ZOOM

results	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Δtwater	-5.0 °F	8.5 °F	-14.5 °F	12.2 °F
Twater-return	62.0 °F	111.5 °F	71.5 °F	107.8 °F
ΔT room - water flow	-18.0 °F	48.0 °F	-18.0 °F	48.0 °F
ΔT Room water average	-15.5 °F	43.7 °F	-10.7 °F	41.9 °F
Q water DID	-3757 BTUH	6414 BTUH	-1817 BTUH	9165 BTUH
Q air DID	-2834 BTUH	-2415 BTUH	-2834 BTUH	-2415 BTUH
Q DID	-6591 BTUH	3999 BTUH	-4650 BTUH	6750 BTUH
ΔP water	15.407 ft WG	4.751 ft WG	0.416 ft WG	9.107 ft WG
ΔP air	0.41 inches WG			
NC (incl. 10 dB absorbtion)	29			

Language
english

Stand : 11.10.2007

vL	34.43 FPM		34.43 FPM	
vH1	60.04 FPM		60.04 FPM	
ΔTL	-1.4 °F		-1.0 °F	
ΔTH1	-0.3 °F		-0.2 °F	
X-crit	13.1 ft		13.1 ft	
Archimedes-number	0.000203		0.000203	
ΔTsupply	-13.9 °F	8.4 °F	-9.8 °F	14.2 °F
Connection-diameter / primary air	5 inches			

support values	
N-active nozzles	68
N-nozzles total	79
Aeff	0.05749 sq ft
veff	2261.38 FPM
H1	4.4 ft
L	104.4 ft
room air dew point-cooling	55.1 °F

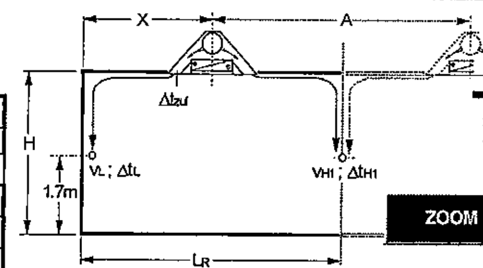
DID 600 calculation

Input DID	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Vwater DID	0.5000 GPM	0.3000 GPM	1.5000 GPM	1.5000 GPM
Unit length	5.5 ft			
Nozzle-type	b			
Vair-primary DID	60.0 CFM			
	28.3 l/s			
No-nozzles active	45			

Project	room-No.	comment
UNE CoP	320	

Input temperatures	cooling		heating	
Tair-primary	55.0 °F		55.0 °F	
Troom / rel. Humidity	75.0 °F	50.0 %	72.0 °F	50.0 %
Twater-flow	57.0 °F		140.0 °F	

Input room measures	
room height	10.0 ft
A	100.0 ft
X	3.0 ft



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ZOOM

results	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Δtwater	-8.7 °F	29.5 °F	-3.3 °F	12.3 °F
Twater-return	65.7 °F	110.5 °F	60.3 °F	127.7 °F
ΔT room - water flow	-18.0 °F	68.0 °F	-18.0 °F	68.0 °F
ΔT Room water average	-13.7 °F	53.2 °F	-16.4 °F	61.9 °F
Q water DID	-2173 BTUH	4437 BTUH	-2445 BTUH	9235 BTUH
Q air DID	-1308 BTUH	-1115 BTUH	-1308 BTUH	-1115 BTUH
Q DID	-3480 BTUH	3322 BTUH	-3752 BTUH	8121 BTUH
ΔP water	1.482 ft WG	0.182 ft WG	7.410 ft WG	6.297 ft WG
ΔP air	0.45 inches WG			
NC (incl. 10 dB absorbtion)	23			

Language
english

Stand : 11.10.2007

vL	100.06 FPM		100.06 FPM	
vH1	8.39 FPM		8.39 FPM	
ΔTL	-4.5 °F		-4.9 °F	
ΔTH1	-0.9 °F		-1.0 °F	
X-crit	11.3 ft		11.3 ft	
Archimedes-number	0.000111		0.000111	
ΔTsupply	-13.2 °F	12.6 °F	-14.2 °F	30.7 °F
Connection-diameter / primary air	4 inches			

support values	
N-active nozzles	45
N-nozzles total	52
Aeff	0.02435 sq ft
veff	2464.33 FPM
H1	4.4 ft
L	7.4 ft
room air dew point-cooling	55.1 °F

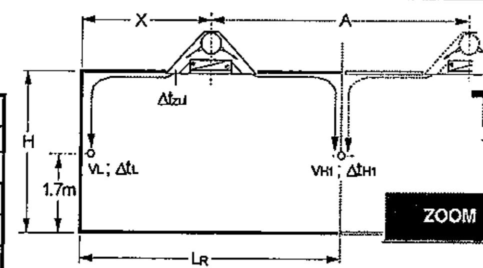
DID 600 calculation

Input DID	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Vwater DID	1.5000 GPM	0.4500 GPM	1.5000 GPM	1.5000 GPM
Unit length	5.5 ft			
Nozzle-type	b			
Vair-primary DID	61.0 CFM			
	28.8 l/s			
No-nozzles active	45			

Project	room-No.	comment
UNE CoP	320	

Input temperatures	cooling		heating	
Tair-primary	55.0 °F		55.0 °F	
Troom / rel. Humidity	75.0 °F	50.0 %	72.0 °F	50.0 %
Twater-flow	57.0 °F		140.0 °F	

Input room measures	
room height	10.0 ft
A	100.0 ft
X	3.0 ft



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ZOOM

results	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Δtwater	-3.8 °F	23.1 °F	-3.3 °F	12.4 °F
Twater-return	60.8 °F	116.9 °F	60.3 °F	127.6 °F
ΔT room - water flow	-18.0 °F	68.0 °F	-18.0 °F	68.0 °F
ΔT Room water average	-16.1 °F	56.5 °F	-16.4 °F	61.8 °F
Q water DID	-2873 BTUH	5197 BTUH	-2466 BTUH	9315 BTUH
Q air DID	-1330 BTUH	-1133 BTUH	-1330 BTUH	-1133 BTUH
Q DID	-4202 BTUH	4063 BTUH	-3795 BTUH	8181 BTUH
ΔP water	10.875 ft WG	0.378 ft WG	7.410 ft WG	6.298 ft WG
ΔP air	0.46 inches WG			
NC (incl. 10 dB absorbtion)	23			

Language
english

Stand : 11.10.2007

vL	101.73 FPM		101.73 FPM	
vH1	8.56 FPM		8.56 FPM	
ΔTL	-5.4 °F		-4.9 °F	
ΔTH1	-1.1 °F		-1.0 °F	
X-crit	11.4 ft		11.4 ft	
Archimedes-number	0.000108		0.000108	
ΔTsupply	-15.6 °F	15.1 °F	-14.1 °F	30.4 °F
Connection-diameter / primary air	4 inches			

support values	
N-active nozzles	45
N-nozzles total	52
Aeff	0.02435 sq ft
veff	2505.40 FPM
H1	4.4 ft
L	7.4 ft
room air dew point-cooling	55.1 °F

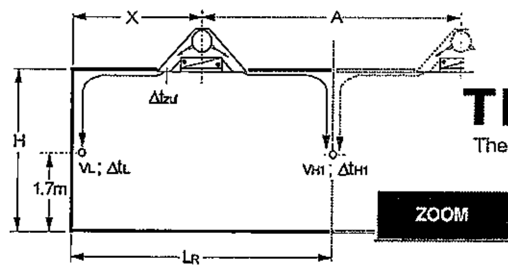
DID 600 calculation

Input DID	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Vwater DID	0.3000 GPM	0.1500 GPM	1.5000 GPM	1.5000 GPM
Unit length	3.5 ft			
Nozzle-type	a			
Vair-primary DID	20.0 CFM			
	9.4 l/s			
No-nozzles active	31			

Project	room-No.	comment
UNE CoP	321	

Input temperatures	cooling		heating	
Tair-primary	55.0 °F		55.0 °F	
Troom / rel. Humidity	75.0 °F	50.0 %	72.0 °F	50.0 %
Twater-flow	57.0 °F		140.0 °F	

Input room measures	
room height	10.0 ft
A	100.0 ft
X	2.0 ft



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results	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Δtwater	-6.6 °F	25.2 °F	-1.8 °F	6.9 °F
Twater-return	63.6 °F	114.8 °F	58.8 °F	133.1 °F
ΔT room - water flow	-18.0 °F	68.0 °F	-18.0 °F	68.0 °F
ΔT Room water average	-14.7 °F	55.4 °F	-17.1 °F	64.6 °F
Q water DID	-990 BTUH	1895 BTUH	-1364 BTUH	5153 BTUH
Q air DID	-436 BTUH	-372 BTUH	-436 BTUH	-372 BTUH
Q DID	-1426 BTUH	1523 BTUH	-1800 BTUH	4781 BTUH
ΔP water	0.412 ft WG	0.037 ft WG	5.391 ft WG	4.651 ft WG
ΔP air	0.31 inches WG			
NC (incl. 10 dB absorbtion)	8			

Language
english

Stand : 11.10.2007

vL	65.35 FPM		65.35 FPM	
vH1	4.65 FPM		4.65 FPM	
ΔTL	-4.1 °F		-5.2 °F	
ΔTH1	-0.8 °F		-1.0 °F	
X-crit	7.6 ft		7.6 ft	
Archimedes-number	0.000094		0.000094	
ΔTsupply	-12.5 °F	13.4 °F	-15.8 °F	42.0 °F
Connection-diameter / primary air	4 inches			

support values	
N-active nozzles	31
N-nozzles total	36
Aeff	0.00943 sq ft
veff	2119.85 FPM
H1	4.4 ft
L	6.4 ft
room air dew point-cooling	55.1 °F

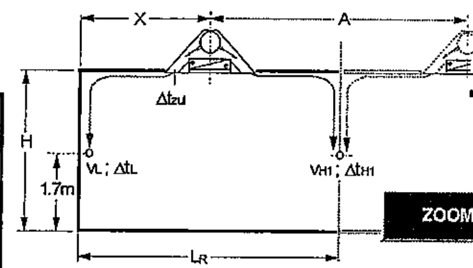
DID 600 calculation

Input DID	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Vwater DID	1.5000 GPM	0.1500 GPM	1.5000 GPM	1.5000 GPM
Unit length	5.5 ft			
Nozzle-type	a			
Vair-primary DID	35.0 CFM			
	16.5 l/s			
No-nozzles active	45			

Project	room-No.	comment
UNE CoP	322	

Input temperatures	cooling		heating	
Tair-primary	55.0 °F		55.0 °F	
Troom / rel. Humidity	75.0 °F	50.0 %	72.0 °F	50.0 %
Twater-flow	57.0 °F		140.0 °F	

Input room measures	
room height	10.0 ft
A	100.0 ft
X	2.0 ft



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ZOOM

results	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Δtwater	-3.1 °F	37.7 °F	-2.9 °F	11.1 °F
Twater-return	60.1 °F	102.3 °F	59.9 °F	128.9 °F
ΔT room - water flow	-18.0 °F	68.0 °F	-18.0 °F	68.0 °F
ΔT Room water average	-16.5 °F	49.2 °F	-16.5 °F	62.5 °F
Q water DID	-2327 BTUH	2831 BTUH	-2204 BTUH	8328 BTUH
Q air DID	-763 BTUH	-650 BTUH	-763 BTUH	-650 BTUH
Q DID	-3090 BTUH	2181 BTUH	-2967 BTUH	7678 BTUH
ΔP water	10.886 ft WG	0.053 ft WG	7.414 ft WG	6.291 ft WG
ΔP air	0.46 inches WG			
NC (incl. 10 dB absorbtion)	16			

Language
english

Stand : 11.10.2007

vL	81.12 FPM		81.12 FPM	
vH1	6.01 FPM		6.01 FPM	
ΔTL	-5.7 °F		-5.5 °F	
ΔTH1	-1.1 °F		-1.1 °F	
X-crit	10.0 ft		10.0 ft	
Archimedes-number	0.000078		0.000078	
ΔTsupply	-15.5 °F	10.9 °F	-14.9 °F	38.5 °F
Connection-diameter / primary air	4 inches			

support values	
N-active nozzles	45
N-nozzles total	52
Aeff	0.01370 sq ft
veff	2555.60 FPM
H1	4.4 ft
L	6.4 ft
room air dew point-cooling	55.1 °F

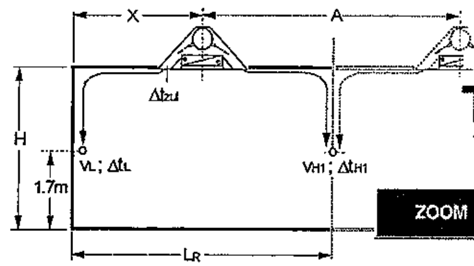
DID 600 calculation

Input DID	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Vwater DID	0.2000 GPM	0.1500 GPM	0.2000 GPM	0.1500 GPM
Unit length	7.5 ft			
Nozzle-type	c			
Vair-primary DID	110.0 CFM			
	51.9 l/s			
No-nozzles active	68			

Project	room-No.	comment
UNE CoP	323 - 8'	

Input temperatures	cooling		heating	
Tair-primary	55.0 °F		55.0 °F	
Troom / rel. Humidity	75.0 °F	50.0 %	72.0 °F	50.0 %
Twater-flow	57.0 °F		140.0 °F	

Input room measures	
room height	10.0 ft
A	5.0 ft
X	100.0 ft



TROX® TECHNIK
The art of handling air

ZOOM

results	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Δtwater	-15.5 °F	49.0 °F	-14.6 °F	62.2 °F
Twater-return	72.5 °F	91.0 °F	71.6 °F	77.8 °F
ΔT room - water flow	-18.0 °F	68.0 °F	-18.0 °F	68.0 °F
ΔT Room water average	-10.3 °F	43.5 °F	-10.7 °F	36.9 °F
Q water DID	-1549 BTUH	3683 BTUH	-1465 BTUH	4673 BTUH
Q air DID	-2398 BTUH	-2044 BTUH	-2398 BTUH	-2044 BTUH
Q DID	-3947 BTUH	1639 BTUH	-3863 BTUH	2630 BTUH
ΔP water	0.370 ft WG	0.068 ft WG	0.251 ft WG	0.133 ft WG
ΔP air	0.29 inches WG			
NC (incl. 10 dB absorbtion)	27			

Language
english

Stand : 11.10.2007

vL	32.04 FPM		32.04 FPM	
vH1	61.43 FPM		61.43 FPM	
ΔTL	-1.0 °F		-1.0 °F	
ΔTH1	-0.2 °F		-0.2 °F	
X-crit	11.3 ft		11.3 ft	
Archimedes-number	0.000284		0.000284	
ΔTsupply	-9.8 °F	4.1 °F	-9.6 °F	6.5 °F
Connection-diameter / primary air	5 inches			

support values	
N-active nozzles	60
N-nozzles total	69
Aeff	0.05749 sq ft
veff	1913.48 FPM
H1	4.4 ft
L	104.4 ft
room air dew point-cooling	55.1 °F

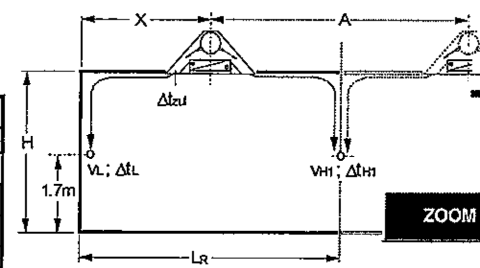
DID 600 calculation

Input DID	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Vwater DID	0.2000 GPM	0.1500 GPM	0.2000 GPM	0.1500 GPM
Unit length	8.5 ft			
Nozzle-type	c			
Vair-primary DID	122.0 CFM			
	57.6 l/s			
No-nozzles active	68			

Project	room-No.	comment
UNE CoP	323 - 9'	

Input temperatures	cooling		heating	
Tair-primary	55.0 °F		55.0 °F	
Troom / rel. Humidity	75.0 °F	50.0 %	72.0 °F	50.0 %
Twater-flow	57.0 °F		140.0 °F	

Input room measures	
room height	10.0 ft
A	5.0 ft
X	100.0 ft



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ZOOM

results	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Δtwater	-16.4 °F	52.6 °F	-15.6 °F	66.0 °F
Twater-return	73.4 °F	87.4 °F	72.6 °F	74.0 °F
ΔT room - water flow	-18.0 °F	68.0 °F	-18.0 °F	68.0 °F
ΔT Room water average	-9.8 °F	41.7 °F	-10.2 °F	35.0 °F
Q water DID	-1646 BTUH	3949 BTUH	-1564 BTUH	4960 BTUH
Q air DID	-2659 BTUH	-2267 BTUH	-2659 BTUH	-2267 BTUH
Q DID	-4305 BTUH	1682 BTUH	-4224 BTUH	2694 BTUH
ΔP water	0.413 ft WG	0.076 ft WG	0.279 ft WG	0.149 ft WG
ΔP air	0.36 inches WG			
NC (incl. 10 dB absorbtion)	28			

Language
english

Stand : 11.10.2007

vL	32.31 FPM		32.31 FPM	
vH1	62.04 FPM		62.04 FPM	
ΔTL	-1.0 °F		-1.0 °F	
ΔTH1	-0.2 °F		-0.2 °F	
X-crit	12.4 ft		12.4 ft	
Archimedes-number	0.000231		0.000231	
ΔTsupply	-9.7 °F	3.8 °F	-9.5 °F	6.0 °F
Connection-diameter / primary air	5 inches			

support values	
N-active nozzles	68
N-nozzles total	79
Aeff	0.05749 sq ft
veff	2122.22 FPM
H1	4.4 ft
L	104.4 ft
room air dew point-cooling	55.1 °F

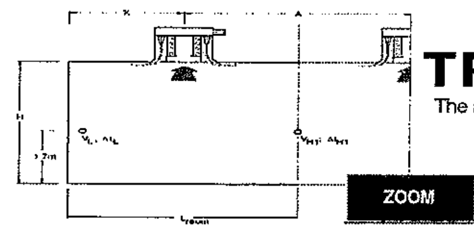
DID 300 calculation

Input DID	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Vwater DID	0.1500 GPM	0.2000 GPM	0.1500 GPM	0.1500 GPM
Unit length	9.0 ft			
Nozzle-type	c			
Vair-primary DID	105.0 CFM			
	49.6 l/s			
No-nozzles active	90			

Project	room-No.	comment
UNE CoP	335 328	90 Nozzles

Input temperatures	cooling		heating	
Tair-primary	55.0 °F		55.0 °F	
Troom / rel. Humidity	75.0 °F	50.0 %	72.0 °F	50.0 %
Twater-flow	57.0 °F		140.0 °F	

Input room measures	
room height	10.0 ft
A	6.0 ft
X	2.0 ft



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results	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Δtwater	-14.3 °F	35.7 °F	-15.2 °F	57.4 °F
Twater-return	71.3 °F	104.3 °F	72.2 °F	82.6 °F
ΔT room - water flow	-18.0 °F	68.0 °F	-18.0 °F	68.0 °F
ΔT Room water average	-10.9 °F	50.1 °F	-10.4 °F	39.3 °F
Q water DID	-1073 BTUH	3577 BTUH	-1142 BTUH	4314 BTUH
Q air DID	-2289 BTUH	-1951 BTUH	-2289 BTUH	-1951 BTUH
Q DID	-3362 BTUH	1626 BTUH	-3431 BTUH	2363 BTUH
ΔP water	0.176 ft WG	0.080 ft WG	0.231 ft WG	0.215 ft WG
ΔP air	0.22 inches WG			
NC (including 10 dB room absorbtion)	19			

beam face	Language
70% - free, bar grille	english
50% - free, perf grille	

Stand : 11.10.2007

vL	80.14 fpm		80.14 fpm	
vH1	59.94 fpm		59.94 fpm	
ΔTL	-2.3 °F		-2.2 °F	
ΔTH1	-0.5 °F		-0.3 °F	
X-krit	9.0 ft		9.7 ft	
Archimedes-number	0.000431		0.000363	
ΔTsupply	13.7 °F		13.4 °F	
Connection-diameter / primary air	3.9 inches			

support values	
N-active nozzles	86
N-nozzles total	100
Aeff	0.076086 ft²
veff	1380.0 fpm
H1	4.4 ft
L	6.4 ft
room air dew point-cooling	55.1 °F

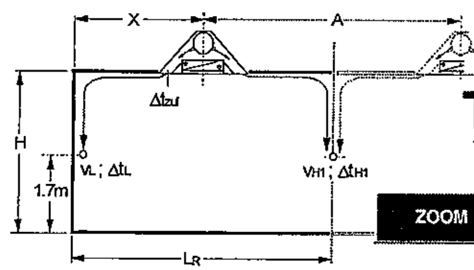
DID 600 calculation

Input DID	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Vwater DID	1.1000 GPM	0.1500 GPM	1.5000 GPM	1.5000 GPM
Unit length	8.5 ft			
Nozzle-type	c			
Vair-primary DID	133.0 CFM			
	62.8 l/s			
No-nozzles active	68			

Project	room-No.	comment
UNE CoP	338 325 343	

Input temperatures	cooling		heating	
Tair-primary	55.0 °F		55.0 °F	
Troom / rel. Humidity	75.0 °F	50.0 %	72.0 °F	50.0 %
Twater-flow	57.0 °F		140.0 °F	

Input room measures	
room height	10.0 ft
A	6.0 ft
X	100.0 ft



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ZOOM

results	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Δtwater	-6.5 °F	54.4 °F	-4.6 °F	17.5 °F
Twater-return	63.5 °F	85.6 °F	61.6 °F	122.5 °F
ΔT room - water flow	-18.0 °F	68.0 °F	-18.0 °F	68.0 °F
ΔT Room water average	-14.8 °F	40.8 °F	-15.7 °F	59.3 °F
Q water DID	-3573 BTUH	4084 BTUH	-3476 BTUH	13132 BTUH
Q air DID	-2899 BTUH	-2471 BTUH	-2899 BTUH	-2471 BTUH
Q DID	-6472 BTUH	1612 BTUH	-6375 BTUH	10661 BTUH
ΔP water	8.813 ft WG	0.076 ft WG	10.432 ft WG	8.784 ft WG
ΔP air	0.42 inches WG			
NC (incl. 10 dB absorbtion)	30			

Language
english

Stand : 11.10.2007

vL	35.22 FPM		35.22 FPM	
vH1	61.69 FPM		61.69 FPM	
ΔTL	-1.4 °F		-1.3 °F	
ΔTH1	-0.3 °F		-0.3 °F	
X-crit	13.4 ft		13.4 ft	
Archimedes-number	0.000194		0.000194	
ΔTsupply	-13.3 °F	3.3 °F	-13.1 °F	21.9 °F
Connection-diameter / primary air	5 inches			

support values	
N-active nozzles	68
N-nozzles total	79
Aeff	0.05749 sq ft
veff	2313.57 FPM
H1	4.4 ft
L	104.4 ft
room air dew point-cooling	55.1 °F

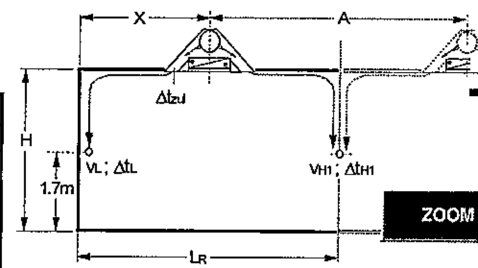
DID 600 calculation

Input DID	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Vwater DID	0.4000 GPM	0.1500 GPM	0.4000 GPM	1.5000 GPM
Unit length	5.5 ft			
Nozzle-type	c			
Vair-primary DID	117.0 CFM			
	55.3 l/s			
No-nozzles active	50			

Project	room-No.	comment
UNE CoP	Labs - Internal	50 nozzles

Input temperatures	cooling		heating	
Tair-primary	55.0 °F		55.0 °F	
Troom / rel. Humidity	75.0 °F	50.0 %	72.0 °F	50.0 %
Twater-flow	57.0 °F		140.0 °F	

Input room measures	
room height	10.0 ft
A	10.0 ft
X	100.0 ft



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ZOOM

results	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Δtwater	-11.7 °F	50.1 °F	-10.5 °F	15.3 °F
Twater-return	68.7 °F	89.9 °F	67.5 °F	124.7 °F
ΔT room - water flow	-18.0 °F	68.0 °F	-18.0 °F	68.0 °F
ΔT Room water average	-12.2 °F	43.0 °F	-12.8 °F	60.4 °F
Q water DID	-2339 BTUH	3761 BTUH	-2095 BTUH	11459 BTUH
Q air DID	-2550 BTUH	-2174 BTUH	-2550 BTUH	-2174 BTUH
Q DID	-4889 BTUH	1588 BTUH	-4646 BTUH	9286 BTUH
ΔP water	0.987 ft WG	0.053 ft WG	0.672 ft WG	6.314 ft WG
ΔP air	0.59 inches WG			
NC (incl. 10 dB absorbtion)	34			

Language
english

Stand : 11.10.2007

vL	43.13 FPM		43.13 FPM	
vH1	57.95 FPM		57.95 FPM	
ΔTL	-1.1 °F		-1.0 °F	
ΔTH1	-0.3 °F		-0.2 °F	
X-crit	14.5 ft		14.5 ft	
Archimedes-number	0.000116		0.000116	
ΔTsupply	-11.4 °F	3.7 °F	-10.9 °F	21.7 °F
Connection-diameter / primary air	4 inches			

support values	
N-active nozzles	45
N-nozzles total	52
Aeff	0.04227 sq ft
veff	2767.94 FPM
H1	4.4 ft
L	104.4 ft
room air dew point-cooling	55.1 °F

main labs - Internal.xls 2/6/2008 FE/WO

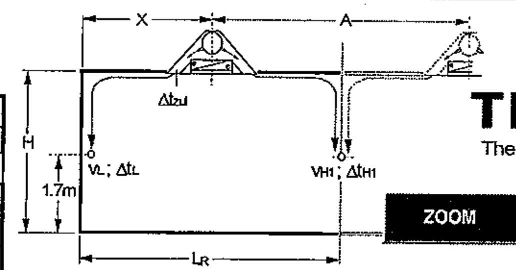
DID 600 calculation

Input DID	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Vwater DID	0.4000 GPM	0.2500 GPM	0.4000 GPM	1.5000 GPM
Unit length	7.5 ft			
Nozzle-type	c			
Vair-primary DID	156.0 CFM			
	73.7 l/s			
No-nozzles active	68			

Project	room-No.	comment
UNE CoP	Labs - Perimeter Corner	68 nozzles

Input temperatures	cooling		heating	
Tair-primary	55.0 °F		55.0 °F	
Troom / rel. Humidity	75.0 °F	50.0 %	72.0 °F	50.0 %
Twater-flow	57.0 °F		140.0 °F	

Input room measures	
room height	10.0 ft
A	12.0 ft
X	100.0 ft



TROX® TECHNIK
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ZOOM

results	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Δtwater	-13.2 °F	44.5 °F	-11.9 °F	18.1 °F
Twater-return	70.2 °F	95.5 °F	68.9 °F	121.9 °F
ΔT room - water flow	-18.0 °F	68.0 °F	-18.0 °F	68.0 °F
ΔT Room water average	-11.4 °F	45.7 °F	-12.0 °F	59.0 °F
Q water DID	-2646 BTUH	5572 BTUH	-2392 BTUH	13563 BTUH
Q air DID	-3400 BTUH	-2898 BTUH	-3400 BTUH	-2898 BTUH
Q DID	-6046 BTUH	2673 BTUH	-5792 BTUH	10664 BTUH
ΔP water	1.281 ft WG	0.170 ft WG	0.868 ft WG	7.969 ft WG
ΔP air	0.58 inches WG			
NC (incl. 10 dB absorbtion)	36			

Language
english

Stand : 11.10.2007

vL	45.43 FPM		45.43 FPM	
vH1	55.32 FPM		55.32 FPM	
ΔTL	-1.1 °F		-1.0 °F	
ΔTH1	-0.3 °F		-0.2 °F	
X-crit	15.5 ft		15.5 ft	
Archimedes-number	0.000141		0.000141	
ΔTsupply	-10.6 °F	4.7 °F	-10.2 °F	18.7 °F
Connection-diameter / primary air	5 inches			

support values	
N-active nozzles	60
N-nozzles total	69
Aeff	0.05749 sq ft
veff	2713.66 FPM
H1	4.4 ft
L	104.4 ft
room air dew point-cooling	55.1 °F

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SECTION 233713 – DIFFUSERS, REGISTERS AND GRILLES

SECTION 233713 - DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes ceiling, wall-mounted floor and displacement diffusers, registers, and grilles.

1.3 DEFINITIONS

A. Diffuser: Circular, square, or rectangular air distribution outlet, generally located in the ceiling and comprised of deflecting members discharging supply air in various directions and planes and arranged to promote mixing of primary air with secondary room air.

B. Grille: A louvered or perforated covering for an opening in an air passage, which can be located in a sidewall, ceiling, or floor.

C. Register: A combination grille and damper assembly over an air opening.

1.4 SUBMITTALS

A. Product Data: For each model indicated, include the following:

1. Data Sheet: For each type of air outlet and inlet, and accessory furnished; indicate construction, finish, and mounting details.
2. Performance Data: Include throw and drop, static-pressure drop, and noise ratings for each type of air outlet and inlet.
3. Schedule of diffusers, registers, and grilles indicating drawing designation, room location, quantity, model number, size, and accessories furnished.
4. Assembly Drawing: For each type of air outlet and inlet; indicate materials and methods of assembly of components.

B. Coordination Drawings: Reflected ceiling plans and wall elevations drawn to scale to show locations and coordination of diffusers, registers, and grilles with other items installed in ceilings and walls.

C. Samples for Initial Selection: Manufacturer's color charts showing the full range of colors available for diffusers, registers, and grilles with factory-applied color finishes.

1.5 QUALITY ASSURANCE

A. Product Options: Drawings and schedules indicate specific requirements of diffusers, registers, and grilles and are based on the specific requirements of the systems indicated. Other manufacturers' products with equal performance characteristics may be considered. Refer to Division 1 Section "Substitutions."

B. NFPA Compliance: Install diffusers, registers, and grilles according to NFPA 90A, "Standard for the Installation of Air-Conditioning and Ventilating Systems."

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Diffusers, registers, and grilles are scheduled on Drawings.

B. Manufacturers: Subject to compliance with requirements, provide diffusers, registers and grilles by one of the following:

1. Titus
2. Metalaire
3. Tuttle and Bailey
4. Price Industries

C. Ceiling Diffusers

1. Diffuser shall be extruded aluminum or steel; with factory finish of baked-on enamel of color to be selected by Architect. Sound level shall NOT exceed NC-30.
2. Unless otherwise noted, provide opposed blade, flow control damper in neck of diffuser. Damper operator shall be accessible at the diffuser.
3. Provide factory-built square-to-round transition, where necessary.

D. Linear Diffusers

1. Diffuser frames shall be high-grade extruded aluminum, with baked enamel finish of color to be selected by Architect. Diffuser shall have integral damper/pattern controller. Controller shall be steel and shall be capable of adjusting airflow 180 degrees without changing NC level, pressure drop, outlet area or appearance. Sound level shall NOT exceed NC-30.
2. Provide installation accessories specific to ceiling type, including: sheet metal screen, hanger brackets, leveling screws, aligning tabs and similar accessories.
3. Provide boot plenum for each four-foot, five-foot and six-foot section. Plenum shall be prefabricated galvanized steel; with an inlet collar centered in each section; with ½" thick, 1.5 pcf fiberglass thermal/acoustic insulation.

E. Floor Diffusers

1. One-piece cores with narrow jet slot openings for safety and attractive appearance.
2. Diffusers shall be of aluminum construction.
3. Locking tabs to eliminate unauthorized removal of diffusers.
4. Standard distributor basket with damper.

F. Displacement Diffusers

1. Diffuser frame and equalization baffle shall be of aluminum.
2. Side, top and bottom panels shall be coated steel.
3. Perforated panel shall be coated steel.
4. Finishes as selected by Architect from manufacture color matrix.

G. Grilles and Registers

1. Frame shall be extruded aluminum or corrosion-resistant stamped steel. Finish shall be baked enamel, of color selected by Architect.
2. Deflecting blades shall be semi-airfoil type, of same material and finish as frame. Blades on supply registers (both horizontal and vertical) shall be fully adjustable. Vertical blades on supply registers shall have a 0-45 degree spread. Horizontal blades on supply registers shall have a 0-20 degree spread.
3. Each register shall have key-operated, opposed blade, volume control damper. Access to damper shall be through register face.
4. Return and exhaust grilles installed less than 7'-0" above floor shall have ½" bar spacing (in lieu of ¾" bar spacing), per NFPA.
5. Sound level shall NOT exceed NC-30.

H. Fire-Rated Ceiling Diffusers and Grilles (combination fire damper/diffuser-grille)

1. Where diffuser/grille penetrates 1-hour or 2-hour fire-rated ceiling assembly, provide fire damper/grille and thermal blanket assembly which maintains ceiling's fire-rating. Assembly shall have UL label verifying UL classification for fire-rated ceiling construction.
2. Assembly shall include insulating the exterior area of the ceiling damper, below the plane of the damper blades and topside of the diffuser/grille, with thermal blanket. Thermal blanket shall be ¼" thick ceramic fiber with minimum 8 pcf density; resistant to thermal shock; retaining the inherent thermal and physical properties after drying from oil/water saturation.

2.2 SOURCE QUALITY CONTROL

A. Testing: Test performance according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install diffusers, registers, and grilles level and plumb, according to manufacturer's written instructions, Coordination Drawings, original design, and referenced standards.

B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practicable. For units installed in lay-in ceiling panels, locate units in the center of the panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. Install diffusers, registers, and grilles with airtight connection to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

3.4 CLEANING

A. After installation of diffusers, registers, and grilles, inspect exposed finish. Clean exposed surfaces to remove burrs, dirt, and smudges. Replace diffusers, registers, and grilles that have damaged finishes.

END OF SECTION 233713

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SECTION 234116 – AIR FILTERS

SECTION 234116 - AIR FILTERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes factory-fabricated air-filter devices and media used to remove particulate matter from air for HVAC applications.

1.3 DEFINITIONS

A. DOP: Dioctyl phthalate or bis-(2-ethylhexyl) phthalate.

B. HEPA: High-efficiency particulate air.

C. ULPA: Ultra low penetration air.

1.4 SUBMITTALS

A. Product Data: Include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; furnished specialties; and accessories for each model indicated.

B. Shop Drawings: Include plans, elevations, sections, and details to illustrate component assemblies and attachments.

1. Show filter rack assembly, dimensions, materials, and methods of assembly of components.
2. Include setting drawings, templates, and requirements for installing anchor bolts and anchorages.
3. Wiring Diagrams: Power, signal, and control wiring.

C. Operation and Maintenance Data: For each type of filter and rack to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of air filters and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."

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

C. Comply with ARI 850.

D. Comply with ASHRAE 52.1 and ASHRAE 52.2 for method of testing and rating air-filter units.

E. Comply with NFPA 70 for installing electrical components.

F. Comply with NFPA 90A and NFPA 90B.

1.6 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

1.7 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Provide one complete set of filters for each filter bank. If system includes prefilters, provide only prefilters.
2. Provide one container of red oil for inclined manometer filter gage.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

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

1. Air Filters, Electrostatic Air Cleaners, and Filter-Holding Systems:

   a. AAF International.
   b. Environmental Air Filter Co.
   c. Farr Co.

2. Filter Gages:

   a. Airguard Industries, Inc.
   b. Dwyer Instruments, Inc.

2.2 PRE-FILTERS

A. Pre-Filters shall be pleated panel type replaceable air filters with holding frames, 2" thick, with UL Class 2 throwaway media material. Filters shall be MERV 8 efficient based on ASHRAE 52.2 test procedures.

2.3 FINAL FILTERS

A. Final-Filters components to consist of glass media, crimped aluminum separators, glass packing sealant and fire retardant, 12" thick, and water resistant hard board cell sides. Cells to be UL 900 Class 1 construction. Flanges and gasketing to permit installation in holding frames providing a non-leaking seal. Filters to have an efficiency rating of MERV 14 as measured by ASHRAE Standard 52.2. Initial resistance not greater than 0.65" of W.G. at 500 feet per minute face velocity.

2.4 FILTER GAGES

A. Description: Diaphragm type with dial and pointer in metal case, vent valves, black figures on white background, and front recalibration adjustment.

1. Diameter: 4-1/2 inches.
2. Range: 0- to 1.0-inch wg.

B. Manometer-Type Filter Gage: Molded plastic with epoxy-coated aluminum scale, logarithmic-curve tube gage with integral leveling gage, graduated to read from 0- to 3.0-inch wg, and accurate within 3 percent of full scale range.

C. Accessories: Static-pressure tips, tubing, gage connections, and mounting bracket.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install filter frames according to manufacturer's written instructions.

B. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.

C. Install filters in position to prevent passage of unfiltered air.

D. Install filter gage for each filter bank.

E. Install filter gage static-pressure tips upstream and downstream from filters to measure pressure drop through filter. Mount filter gages on outside of filter housing or filter plenum in an accessible position. Adjust and level inclined gages.

F. Coordinate filter installations with duct and air-handling unit installations.

G. Electrical wiring and connections are specified in Division 16 Sections.

H. Ground equipment according to Division 16 Section "Grounding and Bonding."

3.2 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components, filter and filter-frame installation, and electrical wiring, and to assist in field testing. Report results in writing.

B. Operate automatic roll filters to demonstrate compliance with requirements.

3.3 CLEANING

A. After completing system installation and testing, adjusting, and balancing air-handling and air-distribution systems, clean filter housings and install new filter media.

END OF SECTION 234116

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SECTION 235700 – HEAT EXCHANGERS

SECTION 235700 - HYDRONIC HEAT EXCHANGERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes shell and tube, and plate heat exchangers.

1.3 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Design Calculations: Calculate requirements for selecting seismic restraints and for designing bases.
2. Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.

C. Coordination Drawings: Equipment room, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Structural members/concrete pads to which heat exchangers will be attached.

D. Manufacturer Seismic Qualification Certification: Submit certification that heat exchanger, accessories, and components will withstand seismic forces defined in Division 15 Section "Mechanical Vibration and Seismic Controls." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

    a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
    b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Operation and Maintenance Data: For heat exchangers to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, performance, and dimensional requirements of heat exchangers and are based on the specific equipment indicated. Refer to Division 1 Section "Product Requirements."

B. ASME Compliance: Fabricate and label heat exchangers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.

C. Registration: Fabricate and label shell-and-tube heat exchangers to comply with the Tubular Exchanger Manufacturers Association's standards.

PART 2 - PRODUCTS

2.1 GASKETED PLATE HEAT EXCHANGERS

A. Manufacturers:

1. Tranter PHE, Inc.
2. Alfa Laval Thermal, Inc.
3. ITT Industries; Bell & Gossett.

B. Configuration: Freestanding assembly consisting of frame support, top and bottom carrying and guide bars, fixed and movable end plates, tie rods, individually removable plates, and one-piece gaskets.

C. Frame:

1. Capacity to accommodate 20 percent additional plates.
2. Painted carbon steel with provisions for anchoring to support.

D. Top and Bottom Carrying and Guide Bars: Painted carbon steel, aluminum, or stainless steel.

1. Fabricate attachment of heat-exchanger carrying and guide bars with reinforcement strong enough to resist heat-exchanger movement during a seismic event when heat-exchanger carrying and guide bars are anchored to building structure.

E. End-Plate Material: Painted carbon steel.

F. Tie Rods and Nuts: Stainless steel.

G. Plate Material: 0.031 inch thick before stamping; Type 304 stainless steel.

H. Gasket Material: Nitrile rubber.

I. Piping Connections:

1. Threaded port for NPS 2 and smaller. For larger sizes, furnish end-plate port with threaded studs suitable for flanged connection.
2. End plate with welded carbon-steel nozzles. Threaded pipe connection for NPS 2 and smaller; carbon-steel flanged pipe connection for larger sizes.
3. Line wetted surfaces with same material as plates.

J. Enclose plates in a solid stainless-steel removable shroud.

K. Capacity and Characteristics:

1. Refer to equipment schedule for unit performance.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas for compliance with requirements for installation tolerances and for structural rigidity, strength, anchors, and other conditions affecting performance of heat exchangers.

1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 HEAT-EXCHANGER INSTALLATION

A. PLATE AND FRAME INSTALLATION

1. Provide isolation valves and unions or flanges on all connections to the exchanger in locations allowing disassembly of the heat exchanger without disturbing system piping.
2. On all four-pipe connections, provide a valve with hose connection between the heat exchanger and the isolation valve to permit flushing of the heat exchanger.
3. Refer to piping diagram for additional requirements.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Maintain manufacturer's recommended clearances for service and maintenance. Install piping connections to allow service and maintenance of heat exchangers.

C. Install shutoff valves at heat-exchanger inlet and outlet connections.

D. Install relief valves on heat-exchanger heated-fluid connection and install pipe relief valves, full size of valve connection, to floor drain.

E. Install vacuum breaker at heat-exchanger steam inlet connection.

F. Install hose end valve to drain shell.

3.4 FIELD QUALITY CONTROL

A. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.5 CLEANING

A. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain heat exchangers. Refer to Division 1 Section "Demonstration and Training."

END OF SECTION 235700

TABLE OF CONTENTS
SECTION 237500 – MODULAR INDOOR AIR-HANDLING UNITS

SECTION 237500 - DEDICATED OUTDOOR AIR SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes custom air-handling units with enthalpy wheel and coils for indoor installations.

B. Related Sections include the following:

1. Division 15 Section "Humidifiers" for steam grid and evaporative humidifiers not an integral part of modular indoor air-handling units specified in this Section.

1.3 SUBMITTALS

A. Product Data: For each type of indoor air-handling unit indicated. Include the following:

1. Certified fan-performance curves with system operating conditions indicated.
2. Certified fan-sound power ratings.
3. Certified coil-performance ratings with system operating conditions indicated.
4. Motor ratings, electrical characteristics, and motor and fan accessories.
5. Material gages and finishes.
6. Filters with performance characteristics.
7. Dampers, including housings, linkages, and operators.

B. Shop Drawings: Signed and sealed by a qualified professional engineer.

1. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.
3. Wiring Diagrams: Power, signal, and control wiring.

C. Manufacturer Seismic Qualification Certification: Submit certification that modular indoor air-handling units, accessories, and components will withstand seismic forces defined in Division 15 Section "Mechanical Vibration and Seismic Controls." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

   a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
   b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Field Quality-Control Test Reports: From manufacturer.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain modular indoor air-handling units through one source from a single manufacturer.

B. Product Options: Drawings indicate size, profiles, and dimensional requirements of modular indoor air-handling units and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."

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

D. NFPA Compliance: Modular indoor air-handling units and components shall be designed, fabricated, and installed in compliance with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."

E. ARI Certification: Modular indoor air-handling units and their components shall be factory tested according to ARI 430, "Central-Station Air-Handling Units," and shall be listed and labeled by ARI.

F. Comply with NFPA 70.

1.5 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 7 Section "Roof Accessories."

C. Coordinate size and location of structural-steel support members.

1.6 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Filters: One set of pre and final filter for each indoor air-handling unit.
2. Fan Belts: One set for each indoor air-handling unit fan.
3. Gaskets: One set for each sectional joint.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Cambridgport
2. Innovent
3. Buffalo Forge
4. Conservatherm
5. Temtrol
6. Webco
7. York Custom
8. York Solution

B. The design has been based on the manufacturer listed in the schedule. Variations in dimensions and connection sizes must be fully coordinated by the contractor with all trades and at no additional cost to the owner.

2.2 GENERAL

A. AHUs shall be entirely of double wall galvanized steel construction. Galvanizing shall be hot dipped conforming to ASTM A525 and shall provide a minimum of 0.90 oz. of zinc per square foot (G90). Unit exterior shall be finish painted.

B. The contractor and the AHU manufacturer shall be responsible for insuring that the unit will not exceed the allocated space and weight as shown on the drawings, including required clearances for service and future overhaul or removal of unit components.

C. AHUs shall be fully assembled by the manufacturer in the factory in accordance with the arrangement shown on the drawings. The unit shall be assembled into the largest sections possible subject to shipping and rigging restrictions. The correct fit of all components and casing sections shall be verified in the factory for all units prior to shipment. Factory tested units shall be fully assembled, tested and then split to accommodate shipment and jobsite rigging. On units not shipped fully assembled, the manufacturer shall tag each section and include air flow direction to facilitate assembly at the jobsite. Lifting lugs or shipping skids shall be provided for each section to allow for field rigging and final placement of unit.

D. Provide the necessary gasketing, caulking, and all screws, nuts, and bolts required for assembly. Clear instructions on how to assemble the unit shall be provided.

E. All door and panel gaskets shall be high quality which seal air tight and retain their structural integrity and sealing capability after repeated assembly and disassembly of bolted panels and opening and closing of hinged components. Bolted sections may use a more permanent gasketing method provided they are not disassembled.

F. Provide structural reinforcement when required by span or loading so that the deflection of the assembled structure shall not exceed L/200 of the span when the unit is operating at a minimum differential static pressure of 8"water gauge. In addition to all mechanical dead loads, exterior units shall be designed to a minimum of a simultaneous 50 psf roof live load and 20 psf wind load, or as required by code, whether or not the unit is operating. At the above stated design parameters, the unit air leakage rate shall be <1% of scheduled air flow @ 8~w.g. pressure.

G. All piping connections for the unit shall be run to outside the casing from the factory. Grommets and other air seals shall be installed by the factory.

2.3 BASE

A. Provide a heavy-duty base for supporting all AHU major components. Bases shall be constructed of a minimum 6" high wide-flange steel I-beams, channels, or minimum 3/16" wall tubular steel base members. Welded or bolted cross members shall be provided as required for lateral stability. Contractor shall provide supplemental steel supports as required to obtain proper operation heights for steam coil condensate and return trap.

B. AHUs shall be completely self-supporting for installation on structural steel support frame as appropriate.

2.4 CASING (INCLUDING WALL, FLOOR AND ROOF)

A. AHU shall be designed and constructed such that removal of any panel shall not affect the structural integrity of the unit. Plug panels may be used to enhance structural stability provided access space is not reduced. Panels shall be removable to allow service access.

B. Units shall be 3" double-wall galvanized steel construction, with inward turned channels. Outer casing shall be .063 inches aluminum. Inner casing shall be .04 inches galvanized steel, 20 gauge in the exhaust air stream. Casings shall be factory-assembled. Unit shall have 3/16" aluminum, diamond plate floor with 8" 11.5 lb/ft structural channel supports, formed or tubular bases not accepted. Minimum 20 gauge bottom cover sheet. Floor sheet to be continuously welded with 2" turned up lip and a drain in each section.

1. Casing to have a minimum R value of 20. Casing shall be insulated with 3" thick polyurethane foam insulation. Floors shall be insulated with 3" polyurethane foam with an R valve of 13. Panel system shall meet NFPA90A.
2. Units shall have solid double wall throughout and thermal break to be no through metal construction using aluminum extrusions with a polyurethane resin thermal bridge. All panel seems to be externally caulked with sealant.
3. Provide unit mounted dial type thermometer at enthalpy wheel and at each heating, cooling and magnehelic pressure gauges at each coil enthalpy wheel and filter bank.

C. Inner panel of floor shall be 16 gauge, with a 20 gauge insulation protector (below unit).

D. Provide blank-offs where required to insure no air bypass between sections, through perforated panels or around coils or filters. Blank-offs shall be installed at each component of the AHU unit and also at the internal panels to prevent recirculation of the air through perforated panels. Seal any holes where bypass occurs.

E. Manufacturer shall provide a written warranty stating the AHU casing shall not condense water on the exterior of the unit at design conditions. Through metal connections between inner and outer panels shall be kept to an absolute minimum. If tubular structural members are used inside of tube shall be insulated equal to casing.

F. Provide adequate structural base members beneath floor in service access sections to support typical service foot traffic and to prevent damage to unit floor or internal insulation. Unit floors in casing sections which may contain water or condensate shall be watertight with drain pan.

G. Exterior and interior panels shall be secured to the support channels with stainless steel or zinc-chromate plated screws and gaskets installed around the panel perimeter. Panels shall be completely removable to allow removal of fan, coils, and other internal components for maintenance, repair, or modifications.

H. Casing construction and finish for outdoor units shall be suitable for exterior installation with no leakage or other weather penetration. Roofs shall be sloped to allow proper draining. Provide a ten year, non-prorated labor and material warranty protecting the owner for water leakage or material rusting.

I. Provide sealed sleeves or grommets with metal or plastic escutcheons for penetrations through casing for pipes, wiring, and pneumatic tubing; coordinate number and location with electrical and temperature control subcontractors. Coordinate lights, switches, duplex outlets and disconnect switch location and mounting. All field penetrations shall be neatly performed by drilling or saw cutting, cutting by torches is not allowed. Neatly seal all openings airtight. All piping connections shall be outside the casing from the factory.

J. Exterior of units shall be primed and painted color as directed by Owner/Owner's representative at time of purchase. Submit color chart.

2.5 ACCESS DOORS

A. Provide at access sections and at fan sections. Doors shall be a minimum of 3"thick with same double wall construction as the unit casing. Doors shall be gasketed, hinged, and latched to provide an airtight seal. Each door shall include a minimum 9" x 9" double thickness tempered glass window in a gasketed frame. Doors shall swing in where installed in positive pressure sections, out for negative pressure systems.

B. Hinges shall be manufacturers standard, designed for door size, weight and pressure classifications. Hinges shall hold door completely rigid with minimum 100 pound weight hung on latch side of door.

C. Latches shall be non-corrosive alloy construction, with interior and exterior operating levers with positive cam action. Doors that do not open against unit operating pressure shall be provided with safety "Ventlock" style latches that allow the door to open approximately three inches and then require approximately 45°further movement of the handle for complete opening. Latch shall be capable of restraining explosive opening of door with a force equal to a minimum of 12" of differential static pressure or 1-1/2 times operating differential pressure, whichever is greater. Latch motion shall not exceed 1 80°and shall seal and pull the unit snug to the frame.

D. Gaskets shall be neoprene bulb-type, continuous around door, positioned for direct compression with no sliding action between the door and gasket. Secure with high quality mastic to eliminate possibility of gasket slipping or coming loose.

Fire and smoke rating limits:	ASTM E84
Flame Spread:	25
Fuel Contributed:	15
Smoke Developed:	20

2.6 INSULATION

A. The walls, roof and floor of the AHU shall be insulated. Insulation shall be held securely in position between the inner and outer skin of casing.

B. Insulation shall completely fill the void of the AHU casing, 1-1/2 pound density for interior units, 3 pound density for exterior units, rigid glass fiber. Alternately, insulation may be 3" thick spray injected foam, minimum R value of 12.5 Btu/hr. Insulation shall meet ASTM 1071 requirements. Secure the insulation to prevent settling or separation.

C. Materials shall meet NFPA 90A flame spread and smoke generation requirements:

2.7 FAN SECTIONS

A. Fans shall be minimum Class II construction, direct drive, vertical plenum fan. All fans shall be factory balanced and rated in accordance with AMCA 210.

B. Provide self-aligning, pillow block, grease type ball-type bearings selected for a B(10) life of not less than 80,000 hours and an L(50) average fatigue life of 400,000 hours per AFBMA Standard 9. Extend bearing grease lines to motor and drive side of fan section. Fan shall be located in air stream to assure proper air flow.

C. Allowable vibration tolerances for fan shall not exceed a self-excited vibration maximum velocity of 0.20" per second RMS, filter in, when measured with a vibration meter on bearing caps of machine in vertical, horizontal and axial directions or measured at equipment mounting feet if bearings are concealed. After field installation, compliance to this requirement shall be demonstrated with field test.

D. Fan Motor, Drive and Mounting Assembly:

1. Provide internally vibration isolated fan, motor and drive, mounted on a common integral bolted or welded structural steel base with adjustable motor slide rail with locking device. Provide flexible duct connections at fan discharge to completely isolate fan assembly.
2. General requirements: In addition to the requirements of DC-Standards Section, "electrical requirements for mechanical systems", the following features are required:

   a. Ball bearings with lube lines extended to accessible location.
   b. Cast iron or steel base with provision for slide adjustment unless direct connected.
   c. Conduit box with ample room for lead terminal connections.
   d. Numbered leads of ample length for connection, terminating in the conduit box.
   e. Permanently stamped nameplate, including motor efficiency.
   f. Single speed, 1750 RPM.
   g. Rated for continuous duty in ambient not exceeding 40°C.
   h. Phase failure detection equal to SSAC WVM Series.
   i. Size motor for 120% of brake horsepower requirement.
   j. Motors shall be direct drive and suitable for use with variable frequency drive.

2.8 INLET AND DISCHARGE SECTIONS

A. Opposed blade dampers shall be of low leak design with metal compressible bronze jamb seals and PVC coated fabric mechanically locked into the blade edge. Blades shall rotate on stainless steel sleeve bearings or bronze bushings. Leakage rate shall not exceed 8 cfm per square foot at 1" W.G. and 12 cfm per square foot at 4" W.G. Damper shall be furnished and mounted in an accessible and easily serviceable location by the air handling unit manufacturer at the factory. Damper operators shall be of same manufacturer as the automatic temperature controls.

B. Provide aerodynamically designed framed discharge openings or spun bellmouth fittings terminating with the metal liner to minimize pressure loss.

2.9 HUMIDIFIER SECTION

A. Provide factory fabricated humidifier section of the same construction and finish as the AHU casing including humidifier supports, and hinged double wall access doors.

B. Provide stainless steel distribution manifold with provision to return condensate to steam trap. Construct with steam nozzles designed to provide even steam distribution over entire length, from 0 to 100% capacity. Provide stainless steel mounting plate for duct attachment and mounting flange for separator attachment.

C. Subject to compliance with requirements, provide jacketed dry steam humidifiers of one of the following:

1. DRI-STEEM Humidifier Co.
2. Nortec Industries, Inc.

2.10 FILTER SECTION

A. Filters shall be per Section 15861.

2.11 COILS

A. Cooling and heating coils shall be factory tested for rating in accordance with ARI 410-Standard for Forced-Circulation Air-Cooling and Air-Heating Coils. Coils shall be designed for a working pressure of 200 psi and tested at 250 psi under water.

B. Coils shall be mounted on hot dipped galvanized steel 16 gage casing to assure proper anchoring of coil and future maintenance. If the unit is a 100 % outside air unit, cooling coil casing shall be made of 304 stainless steel. Coils shall be side removable for future replacement through the access doors or removable panels. Each coil shall be removable without disturbing adjacent coil. Cooling coils shall be designed and installed to insure no condensate carry over. Provide factory installed extended supply, return, drain and vent piping connections.

C. Cooling coils shall have aluminum fins, constructed from flat plate with belled collars for tubes. Fins shall be bonded to tubes by mechanically expanding copper tubes. Steam coils may have maximum fin spacing shall not exceed 12 fins per inch.

D. Seamless copper tubes, 5/8" OD with 0.035" wall.

E. Provide double wall insulated 304 stainless steel condensate pans, and intermediate pans on coils over 48" high. All pans shall be tapered in all directions with a single low point and drain connection for full drainage.

F. Provide bypass for all heating and cooling coils.

2.12 ENTHALPY RECOVERY WHEEL (THERMOTECH IS THE ONLY ACCEPTABLE MANUFACTURER. NO SUBSTITUTIONS WILL BE ALLOWED):

A. HEAT RECOVERY WHEEL SHALL BE: Thermotech Enterprises TF- Series Wheel. No substitution will be allowed.

B. The structural frame and casing shall be designed and manufactured so as to allow a maximum rotor deflection of 1/32 inch, as measured at the outer radius, during maximum rated airflow condition.

C. All sheet metal shall be reinforced as required to provide a solid mounting surface of the peripheral and radial seals in order to maintain a minimum of ¾ inch fixed distance between the rotor surface and any sheet metal or steel parts. There shall be no special requirement to provide any casing side access for future rotor removal and/or service. All such service work shall be possible to perform from inside the duct at the face of the rotor casing.

D. A purge section shall be provided to eliminate transfer of exhaust air into the supply air, and shall be field adjustable.

E. External tapered roller bearings with double set screw locking collars shall be provided and sized for a minimum L-10 life of 219,000 hours of operation and shall be changeable without a complete disassembly of the rotor. Shaft journals shall be machined to proper tolerance as specified by the bearing manufacturer. Shaft shall be machined as to provide a shoulder against the bearings for a positive locked position to eliminate any lateral movement of the rotor due to axial bearing loads. Grease fittings shall be easily accessible.

F. The spokes shall be made of extruded aluminum with an "I" beam shape to limit deflection of the rotor to 1/32 inch for the maximum rated airflow. Spoke surfaces to be serrated for increased friction and air turbulence across the seals. All exposed surfaces in contact with both air streams shall be coated with "THERMOGUARD" corrosion resistant coating.

G. The rim joint shall connect the spoke ends and the rim ends together in such a way that the heat transfer media can be installed under field conditions without any media deformation or misfits causing future problems. The rim joints shall provide a gradual compression of each section by independently applying increased tension of the rim bolts without the use of any special tools or devices.

H. The rims shall be made of two extruded aluminum sections. One inner rim and one outer rim with grooves for the twin "V" belts, and guide flanges for securing the media. The two sections shall be welded together to form a tubular structure for improved strength in order to maintain an accurate radius and rotor roundness during the manufacturing process. All exposed surfaces in contact with both air streams shall be coated with "THERMOGUARD" corrosion resistant coating.

I. The rotor media shall be provided in segments to allow for field erection or replacement of one section of media at a time without side access. No external pullers or other special tooling shall be required for field assembly or replacement. The media shall be machined to fit in between a primary and secondary spoke and a guiding flange of the outside rim. Each media segment shall be compressed independently of all other segments during manufacturing without causing any angular deformation and resulting misfits between the spokes and media parts. The results shall be a wheel with a flatness of +/- 1/32 inch. No adhesive or silicone shall be necessary to secure the media in place.

J. The heat transfer media shall be the industry standard of 200 mm. in depth. Non-standard depths shall be unacceptable. The heat transfer media shall be made out of corrugated aluminum foil with a high surface area per volume and laminar flow to assure that no fouling occurs on the internal heat transfer surface. Dry particles up to 900 microns shall pass freely through the media. This material shall be supplied with a "Balanced Sieve" (4A Molecular Sieve) hygroscopic solid desiccant coating for selective adsorption of water vapor and equal sensible and latent heat transfer. All edges shall have an anti-corrosion epoxy coating. All exposed surfaces in contact with both air streams shall be coated with "THERMOGUARD" corrosion resistant coating.

K. The seals shall be of a maintenance free "non-contact" type to eliminate wear, excessive drag and resulting added horsepower required for the motor drive system, while still being capable of resisting high pressure differences. The seals shall be made in two sections -- an extruded rubber seal of a 4-pass labyrinth "turbine" type design minimum ¾" thick and an extruded aluminum strip with adjustment slots for fastening bolts to the casing frame. The seal system must be able to withstand a pressure difference up to 12 in. wc. without deflecting or causing excessive air leakage. The seals shall be adjustable and set to within 0.05 inch of the rotor surface.

L. The drive system shall be gravity tensioned and shall use two standard "B" section V-belts that ride in a groove in the rotor rim to eliminate any side-to-side movements and slippage. The speed reducer shall be grease lubricated, maintenance free with a flexible Love-Joy input coupling for easy motor separation and for absorption of any shock or vibration. The drive system shall be easily accessible and visible for inspection and maintenance and have a minimum life expectancy of 90,000 hours.

M. The speed control system shall be a variable frequency inverter operating a standard inverter rated AC motor, capable of operating the rotor from 1/4 rpm to 20 rpm or to whatever is required for the type of media used. It shall integrate with the temperature control system to provide the required supply air temperature.

N. The temperature controller shall monitor entering and leaving temperatures for the exhaust and supply air. Adjustable set points shall be for the heating mode discharge temperature, summer/winter change over and for wheel frost control. For multiple rotors in a common air stream each rotor shall provide temperature outputs to the controller in order to get an accurate average discharge temperature.

O. The rotation detector shall be accomplished through the temperature controller. An inductive proximity sensor, shaft target and a relay supplying a dry contract for the controller shall be used to provide RPM readout and wheel stoppage alarm contacts.

P. The entire rotor and wheel assembly shall require only limited maintenance of biannual greasing of the main bearings and inspection of the drive system.

Q. A standard 3-year material and labor warranty shall be provided covering all materials supplied and installed.

R. The heat recovery wheel will be tested for performance based on ASHRAE Standard 84-91 and ARI 1060-2000. Data will be logged from existing temperature sensors. The data will be compared to the proposed wheel performance and be verified to be within specifications. Performance shall be +/-3% of the scheduled performance.

S. The heat wheel will be tested for cross contamination and leakage using SF6 as a tracer and challenge gas. Test will be performed utilizing two Infrared SF6 gas analyzers with accuracy within +/- 2 ppm.

T. Setup procedure: A gas analyzer probe will be positioned in the supply air stream and the return air stream. Base line concentrations of SF6 levels will be recorded and logged once per minute for 5 minutes.

U. Cross contamination test: With the wheel rotating, additional SF6 gas will be added to the return air stream to increase the SF6 level. The SF6 concentration will be monitored and recorded to show what increase of SF6, if any, is present in the supply air stream. Transfer rates of chemicals or compounds shall be within PEL limits.

V. The data will be compared to the proposed wheel cross contamination and leakage limits and be verified to be within specifications.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances, housekeeping pads, and other conditions.

3.2 INSTALLATION, GENERAL

A. Install custom air handling units level and plumb, on structural steel equipment bases or concrete housekeeping pad in accordance with manufacturer's written instructions.

B. Arrange installation of units to provide access space around air-handling units for service and maintenance. Coordinate with owner to verify proper access.

C. Install seismic bracing as required in DC standards “Seismic Restraints For Mechanical Systems And Equipment”.

D. Refer to DC Standards, "Basic Mechanical Materials and Methods" for filter installation requirements.

3.3 MANUFACTURER’S FIELD SERVICE

A. The contractor shall arrange and pay for a factory-authorized service representative to perform the requirements of this section.

B. Inspect the field assembly of components and installation of custom air-handling units including piping, ductwork, and electrical connections.

C. Prepare a written report on findings and recommended corrective actions. Copy of the report shall be left on the site for the contractor to share with the owner.

D. Demonstrate procedures and schedules related to start-up and shut down, troubleshooting, servicing, preventative maintenance, and how to obtain replacement parts.

E. Schedule training with at least 7 days' advance notice.

3.4 FIELD TESTING

A. Provide field test to confirm that fan operates within the allowable vibration tolerances as described in this section. Test must be performed by qualified technicians with a full written report submitted to the engineer.

B. Provide a field pressure test at 1.5 times the scheduled pressure in all air conveying sections. The maximum allowable leak rate is 2% of the airflow. This will be measured by comparing inlet and outlet airflows. If the leak rate is uncertain, testing will be performed by sealing the unit and pumping in a measured air quantity into the unit under maximum design pressure.

C. Notify owner and engineer 7 days in advance of testing. Notice shall include a full schedule of tests with test procedures described.

3.5 ADJUSTING

A. Adjust damper linkages for proper damper operation.

3.6 CLEANING

A. Clean modular indoor air-handling units internally, on completion of installation, according to manufacturer's written instructions. Clean fan interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels, cabinets, and coils entering air face.

B. After completing system installation and testing, adjusting, and balancing modular indoor air-handling and air-distribution systems, clean filter housings and install new filters.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain modular indoor air-handling units. Refer to Division 1 Section "Closeout Procedures."

END OF SECTION 237500

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SECTION 238215 – AIR COILS

SECTION 238215 - AIR COILS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Hot-water re-heat coils

B. Related Sections include the following:

1. Division 23 Section "Control Systems Equipment" for coil temperature-control valve requirements.

1.3 SUBMITTALS

A. Product Data: Include rated capacities of selected models; pressure drop; shipping, installed, and operating weights; installation instructions; and startup instructions for each type of product indicated.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Detail wiring for power, signal, and control systems and differentiate between manufacturer-installed and field-installed wiring.

C. Coordination Drawings: Reflected ceiling plans drawn to scale and coordinating coil location and ceiling-mounted access panels.

D. Maintenance Data: For air coils to include in maintenance manuals specified in Division 1.

1.4 QUALITY ASSURANCE

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

B. Comply with ARI 410, "Standard for Forced-Circulation Air-Cooling and Air-Heating Coils," for components, construction, and rating.

1. Certify coils to ARI 410, "Standard for Forced-Circulation Air-Cooling and Air-Heating Coils."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Water Coils:

a. Aerofin Corporation.
b. Carrier Corporation.
c. Coil Company Inc.
d. Dunham-Bush, Inc.
e. Trane Co. (The).

2.2 HOT-WATER COILS

A. Description: Self-draining coil fabricated to ARI 410.

B. Dampers: Arrangement of coil segments with face-and-bypass dampers and downstream damper.

1. Arrangement: Horizontal coils.
2. Dampers: Extruded-aluminum blades with full-length drive rod.

C. Piping Connections: Threaded, on same end.

D. Tubes: Copper, complying with ASTM B 75.

1. Tube Diameter: 0.625 inch.

E. Tubes: Red brass, complying with ASTM B 111.

1. Tube Diameter: 0.625 inch.
2. Minimum Tube Thickness: 0.025 inch.

F. Tubes: Stainless steel, 0.625-inch diameter.

G. Tubes: Carbon steel, 0.75-inch diameter.

H. Fins: Aluminum with fin spacing per schedule.

I. Fin and Tube Joint: Mechanical bond.

J. Headers: Cast iron with cleaning plugs, and drain and air vent tappings.

K. Frames: Galvanized-steel channel frame, 0.052 inch.

L. Frames: Stainless steel, 0.0625 inch.

M. Ratings: Design tested and rated according to ASHRAE 33 and ARI 410.

    1. Working Pressure Ratings: 200 psig, 325 deg F.

N. Source Quality Control: Test to 300 psig, and to 200 psig underwater.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine ducts, plenums, and units to receive air coils for compliance with requirements for installation tolerances and other conditions affecting coil performance.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before coil installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install coils level and plumb.

B. Install coils in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to coils to allow service and maintenance.

C. Unless otherwise indicated, connect piping with unions and shutoff valves to allow coils to be disconnected without draining piping. Refer to piping system Sections for specific valve and specialty arrangements.

D. Ground equipment.

    1. 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 UL 486B.

3.4 ADJUSTING

A. Adjust initial temperature set points.

B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Straighten bent fins on each air coil.

3.5 CLEANING

A. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

B. Clean coils using materials and methods recommended in writing by manufacturers, and clean inside of casings and enclosures to remove dust and debris.

END OF SECTION 238215

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SECTION 238216 – PROPELLER UNIT HEATERS

SECTION 238216 - PROPELLER UNIT HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes propeller unit heaters with hot-water coils.

1.3 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each unit type and configuration.

B. Shop Drawings: Submit the following for each unit type and configuration:

1. Plans, elevations, sections, and details.
2. Details of anchorages and attachments to structure and to supported equipment.
3. Wiring Diagrams: Power, signal, and control wiring.
4. Equipment schedules to include rated capacities, operating characteristics, furnished specialties, and accessories.

C. Operation and Maintenance Data: For propeller unit heaters to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Airtherm; a Mestek Company.
2. Modine Mfg., Co.
3. Sterling

2.2 UNIT HEATERS

A. Description: An assembly including casing, coil, fan, and motor in horizontal discharge configuration with adjustable discharge louvers.

B. Comply with UL 2021.

2.3 CASING

A. Cabinet: Removable panels for maintenance access to controls.

B. Cabinet Finish: Manufacturer's standard baked enamel applied to factory-assembled and -tested propeller unit heater before shipping.

C. Discharge Louver: Adjustable fin diffuser for horizontal units and conical diffuser for vertical units.

2.4 COILS

A. Test and rate hot-water propeller unit-heater coils according to ASHRAE 33.

B. Hot-Water Coil: Copper tube, minimum 0.025-inch wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 325 deg F, with manual air vent. Test for leaks to 350 psig underwater.

C. Steam Coil: Copper tube, minimum 0.025-inch wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and rated for a minimum working pressure of 75 psig.

2.5 ELECTRIC-RESISTANCE HEATING ELEMENTS

A. Nickel-chromium heating wire, free from expansion noise and 60-Hz hum, embedded in magnesium oxide refractory and sealed in steel or corrosion-resistant metallic sheath with fins no closer than 0.16 inch. Element ends shall be enclosed in terminal box. Fin surface temperature shall not exceed 550 deg F at any point during normal operation.

1. Circuit Protection: One-time fuses in terminal box for overcurrent protection and limit controls for high-temperature protection of heaters.
2. Wiring Terminations: Stainless-steel or corrosion-resistant material.

2.6 FAN

A. Propeller type, aluminum wheel directly mounted on motor shaft in the fan venturi.

2.7 FAN MOTORS

A. Comply with requirements in Division 15 Section "Motors."

B. Motor Type: Permanently lubricated multispeed.

2.8 CONTROLS

A. Control Devices:

1. Unit-mounted, variable fan-speed switch.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive propeller unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in for piping and electrical connections to verify actual locations before propeller unit-heater installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install propeller unit heaters level and plumb.

B. Install propeller unit heaters to comply with NFPA 90A.

C. Suspend propeller unit heaters from structure with all-thread hanger rods and elastomeric hangers. Hanger rods and attachments to structure are specified in Division 23 Section "Hangers and Supports." Vibration hangers are specified in Division 23 Section "Mechanical Vibration and Seismic Controls."

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to machine to allow service and maintenance.

C. Unless otherwise indicated, install union and gate or ball valve on supply-water connection and union and calibrated balancing valve on return-water connection of unit heater. Hydronic specialties are specified in Division 15 Section "Hydronic Piping."

D. Ground equipment according to Division 16 Section "Grounding and Bonding."

E. Connect wiring according to Division 16 Section "Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Testing: Perform the following field quality-control testing and report results in writing:

1. After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
3. Test and adjust controls and safeties.

B. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 238216

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SECTION 238219 – FAN COIL UNITS

SECTION 238219 - FAN-COIL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes fan-coil units and accessories.

1.3 DEFINITIONS

A. BAS: Building automation system.

1.4 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring.

C. Manufacturer Seismic Qualification Certification: Submit certification that fan-coil units, accessories, and components will withstand seismic forces defined in Division 23 Section "Mechanical Vibration and Seismic Controls." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

   a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Operation and Maintenance Data: For fan-coil units to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 Section "Operation and Maintenance Data," include the following:

1. Maintenance schedules and repair part lists for motors, coils, integral controls, and filters.

E. Warranty: Special warranty specified in this Section.

1.5 QUALITY ASSURANCE

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

1.6 COORDINATION

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

B. Coordinate size and location of wall sleeves for outdoor-air intake.

1.7 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components that fail in materials or workmanship within specified warranty period.

1.8 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fan-Coil-Unit Filters: Furnish two (2) sets of filters.
2. Fan Belts: Furnish spare fan belts for each unit installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers:

1. Airtherm; a Mestek Company.
2. Enviro-Tec
3. Dunham-Bush Inc.
4. McQuay International.

2.2 FAN-COIL UNITS

A. Exposed surface mount vertical cabinet:

1. Units shall have a minimum 12" wide extended valve pockets the side opposite the drain connections. Casing shall be G90 16-gauge galvanized steel construction with baked enamel finish of color as selected by the Architect.
2. 1" pleated filters
3. Foil faced fiberglass insulation
4. The discharge grille shall be linear extruded aluminum bar grille.

5. Variable fan speed controller shall be integral to the unit with disconnect switch, fan relay.
6. Primary Stainless steel drain pan with external insulation

B. Recessed mount vertical cabinet:

1. 16-gauge decorative wall panel with baked enamel finish of color as selected by Architect.
2. 1" pleated filters
3. Foil faced fiberglass insulation
4. Variable fan speed controller shall be integral to the unit with disconnect switch, fan relay.
5. Primary Stainless steel drain pan with external insulation

C. Ceiling recessed units shall be equipped with flanged duct connectors for both the supply and return sides. The pre-finished bottom panel shall be designed to provide access to the entire unit and be exposed in the occupied space. The fan selector switch shall be wall mounted.

1. Casing shall be G90 16-gauge galvanized steel construction.
2. 1" pleated filters
3. Foil faced fiberglass insulation
4. The discharge grille shall be linear extruded aluminum bar grille.
5. Electronically commutated motor and variable fan speed controller shall be integral to the unit with disconnect switch, fan relay.
6. Primary Stainless steel drain pan with external insulation
7. Secondary auxiliary stainless steel drain pan-extended length with condensate overflow switch
8. Mixing box with motorized damper spring return closed

D. Owner/Architect shall choose from manufacturer's offering of standard colors. Provide two sets of filters, one for construction, and the other for turnover to the Owner.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive fan-coil units for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in for piping and electrical connections to verify actual locations before fan-coil-unit installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install fan-coil units level and plumb.

B. Install fan-coil units to comply with NFPA 90A.

C. Suspend fan-coil units from structure with elastomeric hangers. Vibration isolators are specified in Division 15 Section "Mechanical Vibration and Seismic Controls."

D. Install new filters in each fan-coil unit within two weeks after Substantial Completion.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:

1. Install piping adjacent to machine to allow service and maintenance.
2. Connect piping to fan-coil-unit factory hydronic piping package. Install piping package if shipped loose.
3. Connect condensate drain to indirect waste.

    a. Install condensate trap of adequate depth to seal against the pressure of fan. Install cleanouts in piping at changes of direction.

B. Ground equipment according to Division 26 Section "Grounding and Bonding."

C. Connect wiring according to Division 26 Section "Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

B. Remove and replace malfunctioning units and retest as specified above.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fan-coil units. Refer to Division 1 Section "Demonstration and Training."

END OF SECTION 238219

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SECTION 238316 – VARIABLE FREQUENCY DRIVES

SECTION 238316 - VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

1. This Section includes a complete Variable Frequency Drive (VFD) consisting of a pulse width modulated (PWM) inverter designed for use on a standard NEMA Design B induction motor. It is required that the drive manufacturer have an existing:

    a. Sales representatives exclusively for HVAC products with expertise in HVAC and pump systems and controls.
    b. An independent service organization.

B. The drive manufacturer shall supply the drive and all necessary controls as herein specified. The manufacturer shall have been engaged in the production of this type of equipment for a minimum of twenty years.

C. Related sections include SEQUENCE OF OPERATIONS FOR HVAC CONTROLS, BASIC MATERIALS AND METHODS sections of Division 23 and BASIC MATERIALS AND METHODS section of Division 26.

1.3 DEFINITIONS

A. BMS: Building management system.

B. IGBT: Integrated gate bipolar transistor.

C. LAN: Local area network.

D. PID: Control action, proportional plus integral plus derivative.

E. PWM: Pulse-width modulated.

F. VFD: Variable frequency drives.

1.4 SUBMITTALS

A. Product Data: For each type of VFD, provide dimensions; mounting arrangements; location for conduit entries; shipping and operating weights; and manufacturer's technical data on features, performance, electrical ratings, characteristics, and finishes.

B. Shop Drawings: For each VFD.

1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:

   a. Each installed unit's type and details.
   b. Nameplate legends.
   c. Short-circuit current ratings of integrated unit.

2. Wiring Diagrams: Power, signal, and control wiring for VFD. Provide schematic wiring diagram for each type of VFD.

C. Calculation of variable frequency drive (VFD) harmonic distortion.

1. Shop drawing shall include manufacturer's full spectrum calculations specific to this installation showing total harmonic distortion and odd order harmonic distortion to at least the 19^{th} order, for:

   a. Both current and voltage
   b. The VFD only
   c. The VFD with corrective equipment required to comply with the maximum permissible harmonic distortions as specified.

2. Shop drawing shall include manufacturer's written statement on company stationery stating that the proposed VFD harmonic characteristics shall NOT compromise the related motor operation, warranties and guarantees.
3. Manufacturer's calculations shall be a computer-aided circuit simulation of total actual system using Engineer/Owner-furnished information on power system. The following assumptions shall be made to perform the calculations.

   a. If the main service transformer(s) rating is not shown on the drawings, estimate the rating to be 60% of the service entrance main over-current protective device rating.
   b. If the main service transformer impedance is not shown on the documents, assume impedance is 5.75%.
   c. Estimate the demand load to be 50% of the service transformer rating.

4. Manufacturer's calculations shall be based on the procedures and guidelines described in IEEE #519, "Guide for Harmonic Control and Reactive Compensation for Static Power Converters", with the following modifications:

   a. The point of common coupling (PCC) is defined to be the load side terminals of separately derived services (i.e., load side terminals of the transformer serving

VFD's, main service transformer). Additional points of common coupling (PCC) are the load side terminals of each generator.

1) Maximum total harmonic voltage distortion shall be 3%.
2) Maximum harmonic current distortion shall be 5%.

b. In addition to the main service transformer, calculations shall show the harmonics do not exceed the following at the input terminals of each 30 HP and above 12 pulse VFD.

1) Maximum total harmonics voltage distortion shall be 5%.
2) Maximum total harmonics current distortion shall be 8%.

D. Submit test reports in triplicate, within five working days of test completion, for review by the Architect/Engineer. Refer to paragraph 3.3.A.

1.5 QUALITY ASSURANCE

A. Referenced Standards:

1. Institute of Electrical and Electronic Engineer (IEEE).

a. Standard 519-1992, IEEE Guide for Harmonic Content and Control.

2. Underwriters Laboratories.

a. UL508C

3. National Electrical Manufacturer's Association (NEMA)

a. ICS 7.0, AC Adjustable Speed Drives

4. IEC 16800 Parts 1 and 2.

B. Manufacturer Qualifications: Maintain, within 200 miles of Project site, a service center capable of providing training, parts, and emergency maintenance and repairs.

C. Testing Agency Qualifications: An independent testing agency, acceptable to authorities having jurisdiction, with the experience and capability to conduct the testing indicated, as documented according to ASTM E 548.

D. Source Limitations: Obtain VFDs of a single type through one source from a single manufacturer.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver VFDs in shipping splits of lengths that can be moved past obstructions in delivery path as indicated.

B. Store VFDs indoors in clean, dry space with uniform temperature to prevent condensation. Protect VFDs from exposure to dirt, fumes, water, corrosive substances, and physical damage.

C. If stored in areas subject to weather, cover VFDs to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers; install electric heating of sufficient wattage to prevent condensation.

PART 2 - PRODUCTS

2.1 GENERAL

A. VFDs shall be furnished and installed under this Section except where provided as part of packaged equipment (such as kitchen hoods). Power circuiting for VFDs shall be done as part of work of DIVISION 23, ELECTRICAL WORK; control wiring shall be done as part of SECTION 230913, HVAC INSTUMENTATION AND CONTROLS.

B. VFD shall be UL or ETL listed, adjustable frequency motor drive, for use powering NEMA Design B alternating current induction motor; by ABB, Allen Bradley or Magnatek/Yaskawa. Vendor shall have factory-trained service organization within 200 miles of jobsite.

1. Refer to paragraph MOTORS in SECTION 230501, MOTORS, for motor specification.

C. The variable frequency drives (Drives) shall be solid state, with a Pulse Width Modulated (PWM) output. The VFD shall employ a full wave rectifier (to prevent input line notching), DC Bus Choke(s), Capacitors, and Insulated Gate Bipolar Transistors (IGBT's) as the output switching device.

1. VFD's 30 HP and larger shall be twelve (12) pulse or greater while VFD for motors 25 HP or less can be six (6) pulse if harmonic distortion requirements can be met.

   a. AC line reactors, DC chokes, KMP transformers and KMP and KFMP filler transformers are acceptable devices for further harmonic mitigation if required. The use of passive filter devices is not permitted.

2.2 VARIABLE FREQUENCY DRIVES

A. The VFD package as specified herein shall be enclosed in a UL Listed Type 1 enclosure, completely assembled and tested by the manufacturer in an ISO9001 facility. The VFD tolerated voltage window shall allow the VFD to operate from a line of +30% nominal, and -35% nominal voltage as a minimum.

1. Environmental operating conditions: 0 to 40°C continuous. VFD's that can operate at 40° C intermittently (during a 24 hour period) are not acceptable and must be oversized. Altitude 0 to 3300 feet above sea level, less than 95% humidity, non-condensing.

B. Provide all VFDs with the following standard features:

1. All VFDs shall have the same customer interface, including digital display, and keypad, regardless of horsepower rating. The keypad shall be removable, capable of remote

mounting and allow for uploading and downloading of parameter settings as an aid for start-up of multiple VFDs.

2. The keypad shall include Hand-Off-Auto selections and manual speed control. The drive shall incorporate "bumpless transfer" of speed reference when switching between "Hand" and "Auto" modes. There shall be fault reset and "Help" buttons on the keypad. The Help button shall include "on-line" assistance for programming and troubleshooting.
3. There shall be a built-in time clock in the VFD keypad. The clock shall have a battery back up with 10 years minimum life span. The clock shall be used to date and time stamp faults and record operating parameters at the time of fault. If the battery fails, the VFD shall automatically revert to hours of operation since initial power up. The clock shall also be programmable to control start/stop functions, constant speeds, PID parameter sets and output relays. The VFD shall have a digital input that allows an override to the time clock (when in the off mode) for a programmable time frame. There shall be four (4) separate, independent timer functions that have both weekday and weekend settings.
4. The VFD's shall utilize pre-programmed application macro's specifically designed to facilitate start-up. The Application Macros shall provide one command to reprogram all parameters and customer interfaces for a particular application to reduce programming time. The VFD shall have two user macros to allow the end-user to create and save custom settings.
5. The VFD shall have cooling fans that are designed for easy replacement. The fans shall be designed for replacement without requiring removing the VFD from the wall or removal of circuit boards. The VFD cooling fans shall operate only when required. To extend the fan and bearing operating life, operating temperature will be monitored and used to cycle the fans on and off as required.
6. The VFD shall be capable of starting into a coasting load (forward or reverse) up to full speed and accelerate or decelerate to setpoint without safety tripping or component damage (flying start).
7. The VFD shall have the ability to automatically restart after an over-current, over-voltage, under-voltage, or loss of input signal protective trip. The number of restart attempts, trial time, and time between attempts shall be programmable.
8. The overload rating of the drive shall be 110% of its normal duty current rating for 1 minute every 10 minutes, 135% overload for 2 seconds. The minimum FLA rating shall meet or exceed the values in the NEC/UL table 430-150 for 4-pole motors.
9. The VFD shall have integral 5% impedance line reactors to reduce the harmonics to the power line and to add protection from AC line transients. The 5% impedance may be from dual (positive and negative DC bus) reactors, or 5% AC line reactors. VFD's with only one DC reactor shall add AC line reactors.
10. The VFD shall include a coordinated AC transient protection system consisting of 4-120 joule rated MOV's (phase to phase and phase to ground), a capacitor clamp, and 5% impedance reactors.
11. The VFD shall be capable of sensing a loss of load (broken belt / broken coupling) and signal the loss of load condition. The drive shall be programmable to signal this condition via a keypad warning, relay output and/or over the serial communications bus. Relay outputs shall include programmable time delays that will allow for drive acceleration from zero speed without signaling a false underload condition.
12. If the input reference (4-20mA or 2-10V) is lost, the VFD shall give the user the option of either (1) stopping and displaying a fault, (2) running at a programmable preset speed, (3) hold the VFD speed based on the last good reference received, or (4) cause a warning to

be issued, as selected by the user. The drive shall be programmable to signal this condition via a keypad warning, relay output and/or over the serial communication bus.

13. The VFD shall have programmable "Sleep" and "Wake up" functions to allow the drive to be started and stopped from the level of a process feedback signal.

C. All VFDs to have the following adjustments:

1. Three (3) programmable critical frequency lockout ranges to prevent the VFD from operating the load continuously at an unstable speed.
2. Two (2) PID Setpoint controllers shall be standard in the drive, allowing pressure or flow signals to be connected to the VFD, using the microprocessor in the VFD for the closed loop control. The VFD shall have 250 ma of 24 VDC auxiliary power and be capable of loop powering a transmitter supplied by others. The PID setpoint shall be adjustable from the VFD keypad, analog inputs, or over the communications bus. There shall be two parameter sets for the first PID that allow the sets to be switched via a digital input, serial communications or from the keypad for night setback, summer/winter setpoints, etc. There shall be an independent, second PID loop that can utilize the second analog input and modulate one of the analog outputs to maintain setpoint of an independent process (ie. valves, dampers, etc.). All setpoints, process variables, etc. to be accessible from the serial communication network. The setpoints shall be set in Engineering units and not require a percentage of the transducer input.
3. Two (2) programmable analog inputs shall accept current or voltage signals.
4. Two (2) programmable analog outputs (0-20ma or 4-20 ma). The outputs may be programmed to output proportional to Frequency, Motor Speed, Output Voltage, Output Current, Motor Torque, Motor Power (kW), DC Bus voltage, Active Reference, and other data.
5. Six (6) programmable digital inputs for maximum flexibility in interfacing with external devices, typically programmed as follows: There shall be a run permissive circuit for damper or valve control. Regardless of the source of a run command (keypad, input contact closure, time-clock control, or serial communications) the VFD shall provide a dry contact closure that will signal the damper to open (VFD motor does not operate). When the damper is fully open, a normally open dry contact (end-switch) shall close. The closed end-switch is wired to a VFD digital input and allows VFD motor operation. Two separate safety interlock inputs shall be provided. When either safety is opened, the motor shall be commanded to coast to stop, and the damper shall be commanded to close. The keypad shall display "start enable 1 (or 2) missing". The safety status shall also be transmitted over the serial communications bus. All digital inputs shall be programmable to initiate upon an application or removal of 24 VDC.
6. Three (3) programmable digital Form-C relay outputs. The relays shall include programmable on and off delay times and adjustable hysteresis. Default settings shall be for run, not faulted (fail safe), and run permissive. The relays shall be rated for maximum switching current 8 amps at 24 VDC and 0.4 A at 250 VAC; Maximum voltage 300 VDC and 250 VAC; continuous current rating 2 amps RMS. Outputs shall be true form C type contacts; open collector outputs are not acceptable.
7. Seven (7) programmable preset speeds.
8. Two independently adjustable accel and decel ramps with 1 – 1800 seconds adjustable time ramps.

9. The VFD shall include a motor flux optimization circuit that will automatically reduce applied motor voltage to the motor to optimize energy consumption and audible motor noise.
10. The VFD shall include a carrier frequency control circuit that reduces the carrier frequency based on actual VFD temperature that allows the highest carrier frequency without derating the VFD or operating at high carrier frequency only at low speeds.
11. The VFD shall include password protection against parameter changes.

D. The Keypad shall include a backlit LCD display. The display shall be in complete English words for programming and fault diagnostics (alpha-numeric codes are not acceptable). The keypad shall utilize the following assistants:

1. Start-up assistants.
2. Parameter assistants
3. Maintenance assistant
4. Troubleshooting assistant

E. All applicable operating values shall be capable of being displayed in engineering (user) units. A minimum of three operating values from the list below shall be capable of being displayed at all times. The display shall be in complete English words (alpha-numeric codes are not acceptable):

1. Output Frequency
2. Motor Speed (RPM, %, or Engineering units)
3. Motor Current
4. Calculated Motor Torque
5. Calculated Motor Power (kW)
6. DC Bus Voltage
7. Output Voltage

F. The VFD shall include a fireman's override input. Upon receipt of a contact closure from the fireman's control station, the VFD shall operate at an adjustable preset speed. The mode shall override all other inputs (analog/digital, serial communication, and all keypad commands) and force the motor to run at the adjustable, preset speed. "Override Mode" shall be displayed on the keypad. Upon removal of the override signal, the VFD shall resume normal operation.

G. Serial Communications

1. The VFD shall have an RS-485 port as standard. The standard protocols shall be Modbus, Johnson Controls N2 bus, and Siemens Building Technologies FLN. Optional protocols for LonWorks, BACnet, Profibus, Ethernet, and DeviceNet shall be available. Each individual drive shall have the protocol in the base VFD. The use of third party gateways and multiplexers is not acceptable. All protocols shall be "certified" by the governing authority. Use of non-certified protocols is not allowed.
2. Serial communication capabilities shall include, but not be limited to; run-stop control, speed set adjustment, proportional/integral/derivative PID control adjustments, current limit, accel/decel time adjustments, and lock and unlock the keypad. The drive shall have the capability of allowing the DDC to monitor feedback such as process variable feedback, output speed / frequency, current (in amps), % torque, power (kW), kilowatt hours (resettable), operating hours (resettable), and drive temperature. The DDC shall

also be capable of monitoring the VFD relay output status, digital input status, and all analog input and analog output values. All diagnostic warning and fault information shall be transmitted over the serial communications bus. Remote VFD fault reset shall be possible. The following additional status indications and settings shall be transmitted over the serial communications bus – keypad "Hand" or "Auto" selected, bypass selected, the ability to change the PID setpoint, and the ability to force the unit to bypass (if bypass is specified). The DDC system shall also be able to monitor if the motor is running in the VFD mode or bypass mode (if bypass is specified) over serial communications. A minimum of 15 field parameters shall be capable of being monitored.

3. The VFD shall allow the DDC to control the drive's digital and analog outputs via the serial interface. This control shall be independent of any VFD function. For example, the analog outputs may be used for modulating chilled water valves or cooling tower bypass valves. The drive's digital (relay) outputs may be used to actuate a damper, open a valve or control any other device that requires a maintained contact for operation. In addition, all of the drive's digital and analog inputs shall be capable of being monitored by the DDC system.
4. The VFD shall include an independent PID loop for customer use. The independent PID loop may be used for cooling tower bypass value control, chilled water value control, etc. Both the VFD control PID loop and the independent PID loop shall continue functioning even if the serial communications connection is lost. The VFD shall keep the last good set-point command and last good DO & AO commands in memory in the event the serial communications connection is lost.

H. EMI / RFI filters. All VFD's shall include EMI/RFI filters. The onboard filters shall allow the VFD assemble to be CE Marked and the VFD shall meet product standard EN 61800-3 for the First Environment restricted level.

I. All VFD's through 50HP shall be protected from input and output power mis-wiring. The VFD shall sense this condition and display an alarm on the keypad.

J. Provide all VFD's with the following optional features. Optional features shall be furnished and mounted by the drive manufacturer. All optional features shall be UL Listed by the drive manufacturer as a complete assembly and carry a UL508 label.

1. Door interlocked, padlockable circuit breaker that will disconnect all input power from the drive and all internally mounted options.
2. Fused VFD only disconnect (service switch). Fast acting fuses exclusive to the VFD – fast acting fuses allow the VFD to disconnect from the line prior to clearing upstream branch circuit protection,
3. The drive shall provide single-phase motor protection.

4. The following indicating lights (LED type) shall be provided. A test mode or push to test feature shall be provided.

   a. Power-on (Ready)
   b. Run enable (safeties) open
   c. Drive mode select damper opening
   d. Drive running
   e. Drive fault

f. Safety open
g. Damper opening
h. Damper end-switch made

5. The following relay (form C) outputs from the bypass shall be provided:

a. System started
b. System running
c. Drive fault

6. The digital inputs for the system shall accept 24V or 115VAC (selectable). The bypass shall incorporate internally sourced power supply and not require an external control power source.
7. Customer Interlock Terminal Strip – provide a separate terminal strip for connection of freeze, fire, smoke contacts, and external start command. All external safety interlocks shall remain fully functional whether the system is in Hand, Auto, or Bypass modes (not functional in Fireman's Override 2). The remote start/stop contact shall operate in VFD and bypass modes.

8. The VFD shall include a "run permissive circuit" that will provide a normally open contact whenever a run command is provided (local or remote start command). The VFD system shall not operate the motor until it receives a dry contact closure from a damper or valve end-switch. When the VFD system safety interlock (fire detector, freezestat, high static pressure switch, etc) opens, the motor shall coast to a stop and the run permissive contact shall open, closing the damper or valve.
9. Class 20 or 30 (selectable) electronic motor overload protection shall be included.

PART 3 - EXECUTION

3.1 INSTALLATION OF VFDs

A. VFD's shall be furnished by Division 23 and installed by Division 26. Power wiring from source to VFD by Division 26. Power wiring between VFD and motors by Division 26, control wiring by Division 23.

B. Install VFD with manufacturer-recommended clearances and NEC-required clearances, with NO equipment below VFD.

C. Line conductors, load conductors and other power connections shall be installed in separate raceways and shall NOT be installed in a common enclosure other than the VFD.

3.2 STARTUP AND ADJUSTMENT OF VFDs

A. Startup of equipment shall be performed according to manufacturer's recommendations. Startup and adjustment shall include services required to check out, test and balance devices to ensure proper sequencing of operation, prior to instruction of the Owner's maintenance personnel.

B. Prior to startup, equipment shall be checked for physical damage, loose connections, loose parts, leaks and other defects and defects shall be corrected.

C. Furnish startup/adjustment services by manufacturer. Manufacturer shall be responsible for supervising and inspecting equipment installation and for equipment startup and adjustment.

D. Output power shall NOT be applied to VFD until VFD installation has been inspected and approved by manufacturer. Equipment powered from VFD shall NOT be operated until VFD has been checked, adjusted and approved by VFD manufacturer.

E. VFD adjustments shall be done after work of SECTION 230593, TESTING, ADJUSTING AND BALANCING. VFD shall be set at 60 Hz during balancing.

F. Motor tests: for a motor powered by VFD, include information for motor operation by VFD power and for motor operation by bypass (building) power. Refer to SECTION 230500, GENERAL REQUIREMENTS FOR MECHANICAL WORK, paragraph on TESTS.

3.3 HARMONIC TESTING

A. Furnish services of an independent testing firm to provide on-site harmonic measurements. Testing firm shall be an active member of INETA.

1. Harmonic measurements shall be done with a power quality meter with waveform analysis capability. Meter shall be a Dranetz Model 658 or acceptable equivalent.
2. Measurements shall be taken at the defined points of common coupling (PCCs) and tabulated through the 50th harmonic for voltage and current. Measurements shall be taken with all new and existing VFD powered equipment operating at fully loaded condition.
3. Furnish calculations showing the total harmonic distortion (voltage) and the current distortion by frequency band, per Tables 10.1 and 10.2 of IEEE Standard 519.
4. If measured values and calculations at the defined point of common coupling (PCC) result in higher values than the maximum total harmonic voltage and/or current distortion limits defined in Part 1 "Special Submittals", on-site measurements shall be taken with all new VFDs in by-pass and all existing VFD's operating at fully loaded speeds.
5. Measurements and calculations shall be submitted as test reports and shall be used to demonstrate VFD compliance with the maximum allowable voltage and current distortions. Refer to paragraphs 1.2.B and 1.2.C. For submittal requirements, refer to "special submittal" in Part 1.

B. VFD manufacturer shall provide remedial measures required, including materials, labor and testing, to bring the VFD drives into compliance.

END OF SECTION 238316

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SECTION 260010 - GENERAL REQUIREMENTS FOR ELECTRICAL WORK

PART 1 - GENERAL

1.01 REFERENCES

A. Refer to the GENERAL CONDITIONS, SUPPLEMENTARY CONDITIONS and applicable parts of DIVISION 1 for other general requirements.

B. GENERAL CONDITIONS, SUPPLEMENTARY CONDITIONS and DIVISION 1 paragraphs may be repeated in this Division for emphasis or for inclusion of more stringent/additional related requirements. Such repetition shall NOT be construed to reduce the requirements of those Divisions NOR to eliminate other requirements under those Divisions.

C. Refer to other Sections of this Division for detailed specifications on the work of this Division.

D. This project will be commissioned. Refer to commissioning specification sections for commissioning information and responsibilities. The commissioning process will require additional labor, material and/or other costs which must be provided by the electrical contractor as part of this project.

1.02 INTENT

A. It is the intent of the Contract Documents to require finished work, tested and ready for operation.

B. It is not intended that Contract Documents show every pipe, wire, conduit, fitting and appurtenance; however, such parts as may be necessary to complete the systems in accordance with best trade practice and Code requirements and to Architect's satisfaction shall be deemed to be included.

C. Drawings are diagrammatic and indicate the general arrangement of systems and work included in the Contract. DO NOT SCALE THE DRAWINGS.

1.03 EXAMINATION OF SITE AND CONTRACT DOCUMENTS

A. Before submitting prices or beginning work, thoroughly examine the site and the Contract Documents.

B. No claim for extra compensation will be recognized if difficulties are encountered which would have been revealed by examination of site conditions and Contract Documents prior to executing Contract.

C. Where discrepancies occur within Contract Documents, notify Architect, in writing, of discrepancy and request clarification. Until notified of Architect's decision, include item or arrangement of better quality, greater quantity or higher cost in Contract price.

D. For material, device and equipment identified on Contract Drawings by manufacturer and model: Check Specification for ancillary requirements such as pilot lights or alarms, and include same with furnished item. If Specifications require different model, notify Engineer of discrepancy and request clarification.

E. Notify Engineer, in writing, of materials and apparatus believed to be omitted, inadequate or unsuitable, or in violation of laws, ordinances, rules or regulations of authorities having jurisdiction. In absence of such written notice, it is mutually agreed that bid price for work under each Section has included the cost of items required for acceptable satisfactory functioning of entire system.

1.04 DEFINITIONS

A. Where more than one material, item, or grade is listed in same paragraph, first one named is preferred choice.

B. The following terms are used in this Division and are defined as follows:

1. "Indicated", "shown", "noted", "scheduled", "specified": These terms are a cross-reference to graphics, notes or schedules on the Drawings, to other paragraphs or schedules in the Specifications, and to similar means of recording requirements in Contract Documents. NO limitation of location is intended except as specifically noted.
2. "Directed", "requested", "authorized", "selected", "required", "permitted": Where not otherwise explained, these terms mean "directed by the Engineer", "requested by the Engineer", etc. However, NO such implied meaning will be interpreted to extend the Engineer's responsibility into Contractor's area of construction supervision.
3. "Provide": To furnish and install, ready for safe and regular operation the item, material or service indicated.
4. "Furnish": To purchase, acquire and deliver to the site, complete with related accessories.
5. "Install": To erect, mount and connect completely, by acceptable methods.
6. "Work": Labor, materials, equipment, apparatus, controls and accessories required for proper and complete installation.
7. "Concealed": Embedded in masonry or other construction; or installed in furred spaces, trenches or crawl spaces; or installed within double partitions or hung ceilings; or in enclosures.
8. "Exposed": Visible to building occupants, excluding mechanical room and utility tunnel locations.
9. "Acceptable equivalent" or "Equal": Of weight, size, design, capacity and efficiency to meet requirements specified and shown, and of acceptable manufacture, as determined in the opinion of the Architect.
10. "Acceptable": Acceptable, as determined in the opinion of the Architect.
11. "Contractor": General Contractor.
12. "Named" Product: Manufacturer's name for product, as recorded in published documents of latest issue as of date of Contract Documents. Obtain Architect's permission before using products of later or earlier model.

C. Standards, specifications and tests of following technical societies, organizations and governmental bodies, as referenced in Contract Documents, are hereby made part of Contract Documents.

1. IES: Illuminating Engineering Society.
2. ANSI: American National Standards Institute

3. ASTM: American Society for Testing and Materials
4. EPA: Environmental Protection Agency
5. FSSC: Federal Specification
6. IEEE: Institute of Electrical and Electronics Engineers
7. IRI: Industrial Risk Insurers
8. ISO: Insurance Services Office
9. NBS: National Bureau of Standards
10. NEC: National Electrical Code.
11. NEMA: National Electrical Manufacturers Association
12. NFPA: National Fire Protection Association
13. NSC: National Safety Council
14. OSHA: Occupational Safety and Health Administration
15. UL: Underwriters Laboratories
16. CODE: Codes and regulations of the Federal, State and local governments and of utility companies having jurisdiction, as appropriate.

D. Use of singular or plural reference form in these Specifications shall not be construed to limit number of units required. Specifications are intended to define quality and performance characteristics; quantity of units supplied shall be as needed to meet requirements as specified and as shown on Contract Documents.

1.05 PERMITS, LAWS, ORDINANCES AND CODES

A. Contractor shall obtain and pay for permits, inspections, licenses and certificates required for work under this Division.

B. Complete Utility connections as indicated or needed, extension to Project, metering as required, and connection to building systems, including:

1. Apply for all services and pay for all fees, assessments and charges of the Utility for each connection, all in a timely manner and according to the Project Schedule.
2. Provide and install all metering equipment and accessories as required by Utility. Install entire service in accordance with the Utility's requirements or other applicable regulation.
3. Coordinate with Utility to determine scope of work provided by Utility and the part provided by Contractor so that a complete Utility connection is made.
4. Schedule all work required by utility companies in order to maintain project schedule.

C. Owner shall pay utility company charges associated with work of this Division.

D. Contractor shall comply with laws, ordinances, rules and regulations of Local, State and Federal authorities having jurisdiction; and shall comply with rules and regulations of National Board of Fire Underwriters, National Electrical Code and local utility companies.

E. Contract Documents shall govern whenever they are more stringent than Code requirements.

1.06 SHOP DRAWING SUBMITTALS

A. Prepare and submit Shop Drawings through the Contractor to the Architect for review.

B. The selection and intention to use a product specified by name shall NOT excuse the need for timely submission of shop drawings for that product.

C. Prior to submitting shop drawings, submit for review preliminary list of intended or proposed manufacturers for all items for which shop drawings are required.

D. Submission of shop drawings of an unnamed manufacture or shop drawings at variance with the Contract Documents is NOT a proper request for substitution.

E. Samples that are submitted in lieu of shop drawings shall be clearly identified and shall be submitted in duplicate. Only one sample will be returned and that accepted sample shall be kept available at appropriate job site office. Accepted sample retained by Architect/Engineer will be kept available at Architect's/Engineer's home office.

F. Upon completion of shop drawing review, shop drawings will be returned, marked with one of following notations: Furnish as submitted, Furnish as corrected, Revise and Resubmit, Rejected, or Submit Specified Item. Only products whose shop drawings are marked "Furnish as submitted" or "Furnish as corrected" shall be used on the project.

G. Submittals shall include the following information:

1. Descriptive and product data necessary to verify compliance with Contract Documents.
2. Manufacturer's specifications including materials of construction, metal gauge, thickness and finish.
3. Certified dimensional drawings including clearances required for maintenance or access.
4. Performance data, ratings, operating characteristics, and operating limits.
5. Electrical ratings and characteristics.
6. Wiring and control diagrams, where applicable.
7. Certifications requested, including UL label or listing.
8. List of accessories which are required but are NOT being provided by the product manufacturer or are NOT being furnished under this Section. Identify the Section(s) under which the accessories are being furnished.

H. In addition, submittals shall be clearly marked for the following:

1. Specification Section and Paragraph, or Drawing Schedule/Note /Detail/etc., where equipment is specified.
2. Equipment or fixture identification corresponding to that used in Contract Documents.
3. Accessories and special or non-standard features and materials which are being furnished.

1.07 PRODUCT SELECTION

A. Contractor's options for selecting products are limited by Contract Document requirements and governing regulations and are NOT controlled by industry traditions or procedures experienced by Contractor on previous construction projects. Required procedures include, but are NOT necessarily limited to, following various methods of specifying:

1. Single Product Manufacturer Named: Provide product indicated.
2. Two or More Manufacturers' Products Named: Provide one of the named products, at Contractor's option, but excluding products which do NOT comply with requirements.
3. "Acceptable equivalent" or "Or Equal": Where named products are accompanied by this term or words of similar effect, provide one of named products or propose substitute product according to paragraph 1.8, SUBSTITUTIONS.

4. Standards, Codes and Regulations: Where specification requires only compliance with a standard, code or regulation, Contractor may select any product which complies with requirements of that standard, code or regulation.
5. Performance Requirements: Provide products which comply with specific performances indicated and which are recommended by manufacturer (in published product literature or by individual certification) for application intended. Overall performance of product is implied where product is specified with only certain specific performance requirements.
6. Prescriptive Requirements: Provide products which have been produced in accordance with prescriptive requirements using specified materials and components, and complying with specified requirements for fabricating, finishing, testing and other manufacturing processes.
7. Visual Matching: Where matching with an established material is required, Architect's judgment of whether proposed product matches established material shall be final.
8. "Color as Selected by Architect": Unless otherwise noted, where specified product requirements include "color as selected by Architect" or words of similar effect, the selection of manufacturer and basic product complying with Contract Documents is Contractor's option and subsequent selection of color is Architect's option.

B. Inclusion by name, of more than one manufacturer or fabricator, does NOT necessarily imply acceptability of standard products of those named. All manufacturers, named or proposed, shall conform, with modification as necessary, to criteria established by Contract Documents for performance, efficiency, materials and special accessories.

1.08 SUBSTITUTIONS

A. Contractor's request for substitution may be submitted only after award of Contract. Requests shall be in writing on Contractor's letterhead and shall include:

1. Contractor's detailed comparison of significant qualities between specified item and proposed substitution.
2. Statement of effect on construction time, coordination with other affected work, and cost information or proposal.
3. Contractor's statement to the effect that proposed substitution will result in overall work equal to, or better than, work originally intended.

B. Substitution requests will be considered: if extensive revisions to Contract Documents are NOT required; if changes are in keeping with general intent of Contract Documents; if submitted in timely and proper manner, fully documented; and if one or more of following conditions is satisfied; all as judged by Architect:

1. Where request is directly related to "acceptable equivalent" clause, "or equal" clause or words of similar effect in Contract Documents.
2. Where specified product, material or method CANNOT be provided within Contract Time, but NOT as a result of Contractor's failure to pursue the work promptly or to coordinate various activities properly.
3. Where substantial advantage is offered Owner; in terms of cost, time, energy conservation or other valuable considerations; after deducting offsetting responsibilities that Owner may be required to bear, including additional compensation to Architect for redesign and evaluation services, increased cost of other work by Owner or separate contractors, and similar considerations.

C. The burden is upon the Contractor, supplier and manufacturer to satisfy Architect that:

1. Proposed substitute is equal to, or superior to, the item specified.
2. Intent of the Contract Documents, including required performance, capacity, efficiency, quality, durability, safety, function, appearance, space clearances and delivery date, will be equaled or bettered.

D. Submission of shop drawings of unspecified manufacture or shop drawings at variance with the Contract Documents is NOT a proper request for substitution.

E. Changes in work of other trades, such as structural supports, which are required as a result of substitution and the associated costs for such changes shall be the complete responsibility of Contractor proposing substitution. Except as noted in subparagraph 1.8.C.3 above, there shall be NO additional expense to the Owner.

1.09 SAMPLES

A. Submit samples as requested by Architect.

1.10 RECORD DRAWINGS

A. Furnish and keep on the job at all times, one complete and separate set of Contract Documents of the Electrical work.

B. As work progresses, record changes, revisions and additions to Architectural and Electrical work clearly, neatly, accurately and promptly. Items to be indicated include but are not limited to:

1. Dimensional change
2. Revision to Drawing detail
3. Location and depth of underground utility
4. Revision to conduit routing
5. Revision to electrical circuitry
6. Actual equipment location
7. Ductbank size and routing
8. Location of concealed internal utility
9. Changes made by Change Order
10. Details not on original Contract Drawing
11. Information on concealed elements which would be difficult to identify or measure later

C. Indicate daily progress on these prints by coloring in the various lines, fixtures, apparatus and associated appurtenances as they are erected.

D. Approval of requisition for payment for work installed will NOT be given unless supported by record prints as required above.

E. At the conclusion of work, prepare record CAD drawings with accompanying electronic files. Submit record drawings for review by Architect. Refer to DIVISION 1, GENERAL CONDITIONS and SUPPLEMENTARY CONDITIONS for further requirements.

1.11 OPERATING AND MAINTENANCE MANUALS

A. Submit for review operating and maintenance manuals for each system or piece of equipment, at least two weeks prior to request for acceptance of same. Upon acceptance, furnish six copies of each manual (or greater quantity if otherwise specified under DIVISION 1) to the Architect for transmittal to Owner. Operating and maintenance manual shall include:

1. Description of Unit (System) and Component Parts, including function, normal operating characteristics and limiting conditions, performance curves, engineering data and tests, and complete nomenclature and manufacturer's number for replaceable parts.
2. Operating Procedures, including start-up, break-in, routine and normal operating instructions; regulation, control, stopping, shutdown and emergency instructions; summer and winter operating instructions; and any special operating instructions.
3. Maintenance Procedures, including routine operations, guide to trouble-shooting; disassembly, repair and reassembly; alignment, adjusting and checking; servicing and lubrication schedule, and list of lubricants; manufacturer's installation and maintenance bulletins and related information.
4. Sequence of Operation and Control Diagrams, corrected for as-built conditions.
5. Parts List, including illustrations, assembly drawings and diagrams required for maintenance, predicted life of parts subject to wear, and recommendations for stocking spare parts.
6. Copies of accepted shop drawings, charts and diagrams.
7. Names, addresses and telephone numbers of manufacturer's representative and service company.
8. Other data, as required under pertinent Sections of these Specifications.
9. Letters from each manufacturer certifying that his equipment was properly installed and is operating in accordance with manufacturer's intent.
10. Copies of equipment test reports including field test reports and manufacturer factory test reports.

1.12 GUARANTEE

A. Furnish standard manufacturers' guarantees for work under this Division. Such guarantees shall be in addition to, and NOT in lieu of, other liabilities under the law or by other provisions of the Contract Documents.

B. Materials, equipment and workmanship shall carry the standard warranty against defects in material and workmanship. Failure which may develop due to defective or improper material, equipment, workmanship or design shall be made good, forthwith, by and at the expense of the Contractor, including damage done to areas, materials and other systems resulting from this failure.

C. Guarantee that all elements of the systems are of sufficient capacity to meet the specified performance requirements as set forth in Contract Documents.

D. Upon receipt of notice from Owner of a failure of system(s) or component(s) during the guarantee period, replace affected components within reasonable time period at no additional cost.

E. Guarantee period shall extend for one year from Date of Substantial Completion.

F. Before final request for payment, furnish written guarantee covering above requirements.

PART 2 - PRODUCTS

2.01 GENERAL PRODUCT REQUIREMENTS

A. Products shall be undamaged and unused at time of installation and shall be complete with accessories, trim, finish, safety guards and other devices and details needed for complete installation and for intended use.

B. Where available, products shall be standard products of types which have been produced and used previously and successfully on other projects and in similar applications.

C. Labels and stamps which are required for observation after installation shall be located on accessible surfaces which, in occupied spaces, are NOT conspicuous. Other labels and stamps shall be located on concealed surfaces.

PART 3 - EXECUTION

3.01 ARRANGEMENT OF WORK

A. Consult Architectural Contract Drawings and Details for exact locations of fixtures and equipment. If exact location is not given, obtain information from Architect. Verify measurements in field. Base measurements on Architect's established benchmarks.

B. Install work as closely as possible to layouts shown on Contract Drawings. Modify work as necessary to:

1. Provide maximum possible headroom and space clearance on each side.
2. Provide adequate clearance and ready access to all parts of the work, for inspection, operation, safe maintenance and repair, and code conformance.
3. Coordinate and arrange work to avoid conflicts with work of other trades, to avoid unnecessary cutting and patching, and as needed for satisfactory space conditions shown on coordination drawing submittals.
4. Where space appears inadequate, consult Architect before proceeding with installation.

C. Work shall present a neat coordinated appearance.

3.02 COORDINATION

A. Examine Contract Documents and coordinate with Contractor and other trades as necessary to facilitate the progress of the work.

B. Each trade shall keep Contractor and other trades fully informed as to shape, size, and locations of openings, chases, equipment, panels, access doors, sleeves, inserts and anchor bolts required; whether temporary or permanent. Coordinate sizes, depths, fill and bedding requirements with excavation trades. Give sufficient advance notice so that coordination may be completed in advance. If information is not furnished in proper and timely fashion, the trade involved shall do own cutting and patching or have same done by Contractor, without additional cost to Owner.

C. Particular emphasis is placed on timely installation of major apparatus and furnishing of other trades and Contractor with relevant information.

D. Do NOT install a system until critical components of system and related systems have been coordinated and applicable shop drawings have been accepted.

3.03 WORKMANSHIP

A. Work covered under this Division shall be constructed and finished in every respect in a workmanlike and substantial manner.

B. Equipment and materials shall be new, of first quality, selected and arranged to fit properly into spaces indicated.

C. Obtain detailed information from manufacturer as to proper methods for installation and connections. This includes such tests as equipment manufacturer recommends. Where documentation regarding installation is NOT obtainable, work shall be installed in accordance with best trade practice.

1. Unless specifically indicated otherwise on Contract Documents, equipment and materials shall be installed in accordance with manufacturer's recommendations.
2. Notify Architect of conflicts between manufacturer's recommendations and Contract Documents requirements, and request clarification before proceeding with installation.

D. Where equipment, piping, ductwork, conduit, etc. is exposed, color of finish or paint shall be as selected by Architect.

3.04 OPERATION OF SERVICES AND UTILITIES

A. During the construction period and until finally inspected, tested and accepted, maintain new services and utilities.

B. Shutdown of existing services and utilities shall, without exception, be coordinated with the Owner as to date, time of day, and duration.

1. Notify Architect and Owner of estimated duration of shutdown period at least ten days in advance of date when shutdown is proposed. Approval of shutdown shall be obtained from proper utility and Owner, before any service is interrupted.
2. Work during shutdown period shall be arranged for continuous performance, including overtime if required, to ensure that existing operating services will be shut down only for time actually necessary to complete connections.

3.05 PROTECTION

A. Contractor shall be responsible for work and equipment until fully inspected, tested and accepted. Carefully store materials and equipment which are not immediately installed after delivery to site. Close open ends of work with temporary covers or plug during construction to prevent entry of obstructing material or damaging water.

B. Protect work and material of other trades from damage that might be caused by electrical work and make good damage thus caused.

3.06 IDENTIFICATION

A. Basic materials such as piping, tubing, sheet metal, insulation, etc., shall have following information clearly printed on the material: manufacturer's name, material grade, gauge, thickness, type, and data to identify required methods of attachment; as applicable. Unmarked material shall NOT be used.

B. Permanent nameplates shall be provided on each piece of service-connected or power-operated equipment, on easily accessible surface. Nameplate shall include product name, model number, serial number, capacity, speed, ratings, and similar essential operating data.

1. Manufacturer's nameplate, name, trademark and address shall be attached permanently to equipment and material furnished. Nameplate showing distributor or Contractor will NOT be permitted.
2. Unless otherwise specified or requested, letters and numbers shall be 1/2□ high.
3. Attach nameplates with screws or rivets. Wherever covers of adjacent units are interchangeable, attach nameplates to wall or backboard rather than covers.

C. Identification labels shall be provided to number equipment according to designations used in Contract Documents. Label shall be plastic nameplate with letters and numbers 1-1/2□ high. Furnish directory indicating number, location and use of each item. After finish painting is completed, apply identification label where it will be readily visible from normal operating position on floor.

3.07 LUBRICATION

A. Equipment shall be furnished and installed so that lubrication points are conveniently and readily accessible for maintenance. Make these provisions by whatever means is appropriate: extended fittings, access doors, equipment location, etc.

B. No equipment shall be operated for temporary service or for testing purposes without proper lubrication. Items requiring lubrication shall be left freshly and fully lubricated at time of substantial completion.

C. Prior to substantial completion, deliver to Owner, along with itemized list: one complete new set of special lubrication devices required for servicing, such as grease guns, fittings and adapters.

3.08 ATTACHMENT OF SUPPORTS TO BUILDING STRUCTURE

A. Equipment shall be securely attached to building structure in acceptable manner. Attachments shall be of strong and durable nature as determined by Architect.

B. Attachment of supports to roof decking is NOT permitted. Pipes, ducts, boxes, etc. must be supported from bar joists or steel construction or additional members spanning roof steel as determined by structural engineer.

3.09 TESTS

A. Make final adjustments to equipment before testing. Manufacturer's authorized representative shall verify proper installation and adjustment prior to startup of major equipment; refer to paragraph 1.11.A.9.

B. Furnish labor, materials, instruments, supplies and services necessary for testing required under this Division. Correct defects appearing during tests, and repeat tests until no defects are disclosed. Final tests shall be made in Architect's presence.

C. Use true RMS ammeter to measure current, for equipment which may have harmonic (non-linear) load component.

D. Notify Owner, Architect and Engineer of testing schedule at least 48 hours in advance of tests.

E. Perform specified tests and tests required by legal authorities and by agencies having jurisdiction over this Work. Tests shall be performed to the satisfaction of legal authorities, agencies having jurisdiction, and Owner.

F. Each piece of equipment, including motors and controls, shall be operated continuously for minimum test period of one hour.

G. If manufacturer's startup services are specified under other Sections in this Division, furnish services of factory-trained service engineering representative to provide following. If manufacturer's startup services are not required, Contractor shall furnish following services.

1. Inspection of equipment/system installation.
2. Assistance in initial startup and adjustment of equipment; including necessary time to achieve proper installation and adjustments.
3. Instruction of Owner's staff; see paragraph 3.10, INSTRUCTIONS.

H. Upon completion of tests, demonstrate the following:

1. Equipment and systems are installed and operating in accordance with manufacturer's specifications and instructions and with Contract Documents.
2. Proper adjustment of equipment and systems.
3. Systems are properly cleaned and free of contaminants.
4. Systems are properly phase balanced.
5. Circuits and motorized equipment are equipped with proper overload protection and are not operating under overload.
6. Instruments are recording properly.

3.10 INSTRUCTIONS

A. Arrange for each installer of work requiring continuing maintenance or operation, to meet with Owner's personnel at project site and instruct them in the operation and maintenance. Include instruction by manufacturer's representatives where installers are not expert in the required procedures. Instruction periods for all trades shall be minimum of 8 hours total; refer to individual SECTIONS for further requirements.

B. Instruction shall include review of maintenance manuals, record documentation, tools, spare parts and materials, lubricants, fuels, identification system, control sequences, hazards, cleaning and similar procedures and facilities.

C. Start-up, shut down, emergency operations, noise and vibration adjustment, safety, economy/efficiency adjustments, and similar operations shall be demonstrated.

D. Applicable warranties shall be reviewed.

E. Procedures for routine maintenance shall be demonstrated at the equipment involved, to ensure accessibility to components involved.

3.11 QUIET OPERATION

A. Equipment and material provided as part of the Work shall NOT produce sound level greater than required by Code in adjacent occupied areas. Sound level shall be as measured on A-weighting scale of sound level meter or sound survey meter.

B. Methods described in ASHRAE guide and data books may be used to determine sound level of equipment when total of background sound and equipment sound exceeds the required minimum.

C. Contractor shall ensure that equipment and materials provided as part of the Work do NOT produce excessive noise/vibration and do NOT transmit excessive noise/vibration to occupied spaces. If objectionable noise/vibration occurs, Contractor shall provide systems, devices, and equipment necessary to eliminate objectionable noise/vibration at no additional cost to Owner.

D. Refer to SECTION 260548 – VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS for further requirements.

3.12 FINAL CLEANING

A. Clean each surface of each unit of work, to normal "clean" condition expected for a first-class building cleaning and maintenance program. Comply with manufacturer's instructions for cleaning operations. The following are examples, but not limitations, of cleaning required:

1. Remove labels which are not required as permanent labels.
2. Clean transparent materials, removing substances which are noticeable as vision-obscuring.
3. Clean exposed hard-surfaced finishes, until free of dust, stains, films and similar noticeable substances.

4. Wipe surfaces of mechanical and electrical equipment clean, remove excess lubrication and other substances.
5. Remove debris and surface dust from limited-access spaces such as plenums, shafts, and ceiling spaces.
6. Clean lighting fixtures and lamps; removing dust, smudge marks and protective wraps; so as to function with full efficiency.

END OF SECTION 260010

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SECTION 260500 – BASIC MATERIALS & METHODS – ELECTRICAL

SECTION 260500 - BASIC MATERIALS & METHODS - ELECTRICAL

PART 1 - GENERAL

1.01 REFERENCES

A. This Section covers the specification of basic materials and methods for electrical work. Refer to GENERAL CONDITIONS, SUPPLEMENTARY CONDITIONS and applicable parts of DIVISION 1 for other general requirements.

1.02 SCOPE

A. Provide labor, materials, services, equipment and transportation necessary for complete and operational electrical systems as indicated on Contract Drawings and specified herein, including but not limited to following:

1. Complete secondary service and distribution system, including:
    a. Secondary service cables
    b. Main distribution panel
    c. Panelboards
    d. Conduits, wires and cables
    e. Feeders and branch circuits
    f. Distribution transformers
    g. Switches, boxes and motors
    h. Power and control wiring
    i. Wiring devices
2. Complete emergency power service and distribution system, including:
    a. Engine-generator set
    b. Automatic transfer switches
    c. Emergency distribution panel
    d. Emergency power panelboards
    e. Conduits, wires and cables
    f. Feeders and branch circuits
    g. Distribution transformers
    h. Power and control wiring
    i. Wiring devices
3. Lighting fixtures
4. Dimming system
5. Programmable lighting controls
6. Empty telecommunication raceway systems
7. Elevator wiring
8. Elevator recall
9. Emergency fan shutdown system
10. Fire alarm system
11. New motor control sections in Chiller Plant

12. Disconnects, controls and starters not integral with or specialized for mechanical equipment provided under DIVISION 23, MECHANICAL WORK.
13. Installation of, and power wiring to and from: disconnects, controls and starters furnished under DIVISION 23, MECHANICAL WORK.
14. Hangers and supports
15. System identification
16. Record drawings
17. Operating and maintenance manuals
18. Systems Commissioning

1.03 SUBMITTALS

A. Submit, for review, list of manufacturers and grade or type of material proposed, including wire, wiring devices, terminating systems, connectors, conduit, wireway and fittings. Submit samples if requested.

B. Submit for review shop drawings for the following equipment and materials specified under this Section:

1. Safety switches and fuses
2. Motor starters
3. Fan emergency shutdown components
4. Backboards
5. Access doors
6. Cabinets and boxes
7. Conduit, raceways and fittings
8. Wire, cable and splices
9. Wall duct
10. Cable ladder or tray
11. Hangers and supports
12. Switches, receptacles, and wall plates
13. Light dimmers
14. Lighting control relays

C. Prior to final inspection, submit test reports in triplicate to Architect for review.

D. Upon completion of job, furnish reproducible copies of wiring and interconnection diagrams required for clear and permanent record of interconnected equipment, such as alarms and annunciator panels.

1.04 COORDINATION DRAWINGS

A. Before materials are purchased or work is begun, prepare Coordination Drawings showing size and location of mechanical pipes, ducts, equipment and appurtenances, relative to work of other trades.

B. Submit, for review, coordination CAD drawings with accompanying electronic files. Hard copy of drawings shall be signed by the following trades: sheet metal, plumbing, fire protection, electrical and other HVAC trades. Electronic (CAD) drawing files shall be produced with each trade represented by separate layers.

C. Preliminary coordination drawings shall be prepared as follows:

1. First: Sheet metal trade shall prepare drawings to be used as composite construction floor plans for coordination of trades. Drawings shall show duct layouts superimposed on floor plans; ceiling heights and duct heights above finished floors; duct sizes, including insulation; diffusers, registers and grilles; and light fixtures. Prepare drawings at the scale of 1/4" = 1'-0". In addition, where the coordination drawings require supplemental drawings to legible show the work, prepare the supplemental drawings at the scale of 3/8" = 1'-0" or ½" = 1'-0".
2. Second: As part of work of SECTION 23300, fire protection trade shall draw fire protection piping, etc., on coordination drawings prepared by sheet metal trade.
3. Third: As part of DIVISION 26, ELECTRICAL WORK, electrical trade shall draw electrical distribution conduits, wires, panels, light fixtures, duct smoke detectors and other electrical work which must be coordinated with other trades; on coordination drawings which have been prepared by fire protection trade.
4. Fourth: As part of work of SECTION 23400, plumbing trade shall draw waste piping, vent piping, water piping, risers and other plumbing work which must be coordinated with other trades; on coordination drawings which have been prepared by electrical trade.
5. Fifth: As part of work of SECTION 23500, HVAC trades shall draw HVAC piping work which must be coordinated with other trades; on coordination drawings which have been prepared by plumbing trade.
6. Each trade shall use a different color code.

D. Coordination Meeting and Drawing Revisions

1. Sixth: Contractor shall hold a coordination meeting with sheet metal, HVAC, fire protection, electrical and plumbing trades and shall resolve conflicts between trades. Coordination drawings are to assist in identifying trade conflicts.
2. Seventh: Sheet metal trade shall revise coordination drawings to reflect revisions to the various trade work (including sheet metal, HVAC, fire protection, electrical and plumbing trades), as determined by coordination meeting.
3. Eighth: Sheet metal, HVAC, fire protection, electrical and plumbing trades shall sign the revised coordination drawings as indication of their acceptance of the construction layout shown thereon.

E. Sheet metal trade shall submit the revised coordination drawings to Architect for review.

F. Coordination Drawings are for Contractor's and Engineer's use during construction and shall not be construed as replacing shop, "as-built" or record drawings required elsewhere in the Contract Documents.

1.05 STANDARDS

A. All work of this Division shall conform to following standards:

1. IES: Lighting Handbook.
2. NEMA Standards.
3. ANSI Standard CI: National Electrical Code (NFPA 70).
4. ANSI Standard C50: Rotating Electrical Machinery.
5. ANSI Standard C501-1: Construction and guide for selection, installation and use of electric motors.

6. ANSI Standard C52.1: Motors and generators (NEMA MG1).
7. ADA: Americans with Disabilities Act

1.06 UNDERWRITERS LABORATORIES LABELS

A. Equipment, materials and components, for which there are listings in UL Product Directories, shall bear UL labels.

PART 2 - PRODUCTS

2.01 CONDUIT, CABLE AND FITTINGS

A. Rigid conduit (RMC) shall be UL listed, hot dipped galvanized steel with full cut hot dipped galvanized NPT threads. RMC shall be chromated on all surfaces for corrosion and abrasion protection. Connectors and couplings shall be galvanized steel threaded type listed for RMC use. Conduits that enter the bottom of the control panels in mechanical spaces shall be rigid.

B. Intermediate metal conduit (IMC) shall be UL listed, hot galvanized steel with full cut hot galvanized NPT threads and factory-applied interior coating or lining for ease in pulling wires. Connectors and couplings shall be galvanized steel threaded type listed for IMC use.

C. Electric metallic tubing (EMT) shall be UL listed, hot galvanized steel with factory-applied interior coating or lining for ease in pulling wires. Connectors and couplings shall be galvanized steel, either compression type or heavy-duty set screw-type, listed for EMT use. Indent or crimp-type connectors are NOT allowed.

D. Flexible metal conduit (FMC) shall be UL listed, single strip, spirally wound, corrosion-resistant, galvanized steel acceptable equivalent to Liquatite "Type BR". Use galvanized steel fittings and clamps listed for FMC use.

E. Liquid tight flexible metal conduit (LFMC) shall be UL listed, with a flexible core of single spiral wound strip of hot dipped galvanized steel and a liquid-tight jacket of flame-retardant, sun/oil/acid-resistant flexible PVC: Acceptable equivalent to Liquatite "Type LA". Connectors and couplings shall be zinc-plated malleable iron or steel, with engagement inspection window, locknut and sealing ring; liquid-, oil-, and rain-tight; suitable for wet locations; listed for LFMC use: acceptable equivalent to O-Z/Gedney "Type 4Q".

1. Blue Type LA liquid-tight flexible metal conduit (LFMC) shall be used for all wiring beneath raised floor.
2. Grey/Tan Type LA liquid-tight flexible metal conduit (LFMC) shall be used for final connections to vibrating equipment and to partition furniture systems.

F. Wireways shall be steel, UL listed, with hinged or screwed covers by Lee Products, Keystone or acceptable equivalent.

G. Surface raceways shall be UL labeled, steel with standard buff finish, acceptable equivalent to Wiremold. Sizes and types shall be as shown on Contract Drawings or as required by Architect.

H. Type MC cable shall be UL listed, 600 V, 90°C rated, flexible metal encased multi-conductor assembly; with cable sheath of interlocked aluminum or galvanized steel strip, copper conductors with Code gauge THHN insulation, and internal green insulated ground. Connectors and fittings shall be listed for MC cable use.

I. Non-metallic conduit (NMC) shall be rigid PVC, heavy-wall Schedule 40, UL rated, acceptable equivalent to Carlon "Type 40". Where non-metallic conduit is installed below paved areas, conduit shall be rigid PVC, heavy wall Schedule 80, UL rated and of same manufacturer as the Schedule 40 conduit.

J. Minimum Sizes shall be as follows:

1. Conduit and EMT: ¾" unless otherwise noted.
2. Flexible metal conduit: ¾".
3. Wireway: 4"x4".
4. Cable tray: 12".

K. Special Fittings

1. Where conduit penetrates air handling unit walls or plenums and in hazardous (classified) locations: provide sealing fittings acceptable equivalent to Crouse-Hinds "EYS Series".
2. Where conduit penetrates waterproof foundation, floor or roof: provide through-wall seals acceptable equivalent to O.Z./Gedney "Type FSK".
3. Where conduit from underground distribution system enters building, provide cable terminators acceptable equivalent to O.Z./Gedney "Type CSB".
4. Where conduit is exposed at building expansion joint: provide expansion fittings acceptable equivalent to O.Z./Gedney "Type EX" or "Type EXE".
5. Where conduit is in concrete at building expansion or seismic joint and where conduit is exposed at seismic joint: provide expansion/deflection fittings acceptable equivalent to O.Z./Gedney "Type DX".
6. Where single cable/conduit must penetrate fire-rated walls, ceilings or floors: seal with Dow-Corning #3-6548-RTV silicon foam, according to manufacturer's instructions; or

   a. For conduits in cored holes: provide fire seals acceptable equivalent to O.Z./Gedney "Type CFS".
   b. For cables in cored holes: provide O.Z./Gedney "Type CAFS".
   c. Where penetrations are required for floor outlets: provide fire seal poke-through devices acceptable equivalent to O.Z./Gedney "Type PTFS".

7. Where multiple cables/conduits must penetrate fire-rated walls, ceilings or floors: seal with Dow-Corning #3-6548-RTV silicone foam according to manufacturer's instructions; or provide through-wall sealing fittings acceptable equivalent to Crouse-Hinds "TW Series Thru-Wall Barrier", with following provisions:

   a. Assemblies shall be complete with Crouse-Hinds TWF mounting frames, Crouse-Hinds TWB sealing block assemblies, Crouse-Hinds TWP plugs, Crouse-Hinds TWR reducers, Crouse-Hinds TWK anchors, and Crouse-Hinds TWL lubricant.
   b. Provide sizes and quantities required for application with ample spare capacity or as directed by Architect where provisions are being made for future use by Owner.

8. Provide cable supports per NEC ARTICLE 300.19, acceptable equivalent to O.Z./Gedney "Type R" for large cables and Kellems "Grips" for bundles of smaller wires.

L. Applications shall be as follows:

1. RMC: buried in floor slabs, in concrete walls, concealed in exterior masonry walls, wiring in fire pump rooms, below 7' in Mechanical/Electrical spaces, and where subject to damage.
2. IMC: as specified for rigid conduit, except not in hazardous locations, fire pump rooms or applications over 600 V.
3. EMT: unless otherwise noted:

   a. Feeders
   b. Power wiring in mechanical rooms
   c. Wiring for fire alarm systems
   d. Wiring for emergency and exit lighting
   e. Wiring for emergency communication, security and alarm systems
   f. Branch circuits
   g. Control wiring, including work done under Division 23
   h. Wiring above non-accessible ceilings
   i. Light fixture branch wiring

4. LFMC: final connections to motors and equipment-mounted controls from minimum of 18" to maximum of 6 feet lengths.
5. FMC: light fixture whips above accessible ceilings, except not in damp or wet locations and limited to maximum lengths of 6 feet.
6. NMC: sleeves through interior walls, below slab-on-grade, electrical ductbanks, and below grade unless otherwise noted. Rigid non-metallic conduit (Schedule 40) shall be used for enclosing all grounding electrode conductors throughout the building, (Schedule 80) shall be used when direct buried to serve walkway and parking lot lighting. The minimum size of these raceways shall be 1 inch. Minimum depth below finished grade shall be 24 inches. Rigid non-metallic conduit shall be assembled using approved cleaner and cement.
7. MC cable: light fixture whips above accessible ceilings, except not in damp or wet locations and limited to maximum lengths of 6 feet. Leave sufficient slack for future removal or servicing of fixtures in finished ceiling.
8. Wiremold, cable tray: as shown on Contract Drawings.
9. In any case not specifically covered, rigid conduit shall be used unless otherwise approved by Architect.
10. EMT is NOT permitted as a substitute for rigid conduit; MC is NOT permitted as a substitute for flexible metal conduit.
11. AC (BX) cable shall NOT be used.

2.02 PULL BOXES AND JUNCTION BOXES

A. Boxes shall be heavy, stamped steel with covers attached by screws. Provide locknuts for conduit size to which boxes are connected. In finished areas, boxes shall have neatly mitered frame and flush steel cover screwed to the frame.

B. Boxes shall be sized according to NEC.

C. Boxes shall be flush mounted where installed with concealed conduit, and surface mounted elsewhere.

D. Low Voltage Boxes: refer to Section 260525.

2.03 OUTLET BOXES

A. Outlet boxes for light fixtures in concrete walls or slabs shall be 4" octagonal mud boxes, not less than 2-1/2" deep; other outlet boxes shall be 4" octagonal boxes not less than 2-1/8" deep. Include fixture studs where required.

B. Switch and receptacle outlet boxes in masonry walls and partitions where wiring is concealed shall be standard 4" square, 1-1/2" deep, galvanized boxes with extension cover for the particular device they will receive.

1. Use plaster extension not less than ½" deep for boxes installed in plastered walls or cast in concrete.
2. Use 1-1/2" deep square corner tile wall extension for boxes installed in tiles, exposed brick or exposed block masonry walls.

C. Where conduit is exposed: switch outlet boxes, plug outlet boxes and fixture outlet boxes shall be acceptable equivalent to Crouse-Hinds "Type FD", with covers to fit devices use.

D. Low Voltage Device Boxes: refer to Section 260525.

E. Flush floor boxes shall be by Walker Systems, Inc. (A Wiremold Company) or acceptable equivalent and shall have the following features:

1. Boxes shall provide flush or recessed device outlets that will not obstruct the floor area.
2. Floor boxes shall be approved for use in concrete floor construction. Boxes shall be approved for above grade (stamped steel) and on grade (cast iron) applications. Floor boxes shall have been examined and tested by Underwriters Laboratories Inc. To meet UL 514A and Canadian Standard C22.2 and shall bear the appropriate label. Floor boxes shall conform to the standard set in the National Electrical Code. Multi-compartment box shall have been evaluated by UL to meet the applicable U.S. and Canadian safety standards for scrub water exclusion when used on tile, terrazzo, wood and carpet covered floors.
3. Boxes shall be available in one, two or three-gang configurations or a single unit with four independent wiring compartments. Boxes shall provide pre and post-pour adjustments. Multiple gang boxes shall also provide a removable barrier between the individual compartments for greater capacity when required.
4. Cast-Iron Boxes: Box interior and exterior shall be painted.

   a. Covers and Flanges: Floor box options shall accept both brass and non-metallic cover plates and flanges. Flanges for both brass and non-metallic cover plates shall be available in one, two and three-gang applications. Each flange shall provide ½" of adjustment to accommodate various floor coverings and concrete depths.
   b. Flanges shall accommodate connectivity outlets and modular inserts.

c. Modular inserts shall snap directly into each flange through the use of a mounting bezel.

5. Stamped Steel Boxes: Boxes shall be manufactured from stamped steel and formed.

a. Covers and Flanges: Floor box options shall accept both brass and non-metallic cover plates and flanges. Flanges for both brass and non-metallic cover plates shall be available in one, two and three-gang applications and install on the previous mentioned boxes. Each flange shall provide ½" of adjustment to accommodate various floor coverings and concrete depths.
b. Flanges shall accommodate connectivity outlets and modular inserts. Where indicated, provide connectivity outlets and modular inserts by Otronics or approved equal.
c. Modular inserts shall snap directly into each flange through the use of a mounting bezel.

6. Multi-Compartment Boxes: box shall have four independent wiring compartments that allow up to 4 duplex receptacles and/or communication services:

a. Boxes shall permit a tunneling feature that will allow internal wiring to various compartments. The box shall provide various size conduit openings.
b. Boxes shall provide a series of device mounting plates that will accept both duplex power devices, as well as plates that will accommodate connectivity outlets and modular inserts. Where indicated, provide connectivity outlets and modular inserts by Ortronics or approved equal.
c. Activation covers shall be die-cast aluminum. Cover finish shall be one of the following, as selected:

1) textured aluminum finish
2) powder coat finish, color shall be black
3) powder coat finish, color shall be brass

d. Activation covers shall be available in flanged or flangeless versions as selected. Covers shall be available with options for tile or carpet inserts, blank covers or covers with one or two 1" liquid tight openings for furniture feed applications as applicable

7. Each box shall contain 4 locations to attach the box to the slab or concrete form or accommodate leveling for pre-pour adjustment.
8. Stamped steel floor boxes shall be as follows:

a. Floor Box: Walker #RFB4 with Walker #RFB-DR internal duplex bracket(s) and RFBN series communication brackets to be coordinated with appropriate communications terminations.

9. Cast Iron Floor Boxes shall be as follows:

a. Floor Box: Walker #RFB4-CI with Walker #RFB-DR internal duplex bracket(s) and RFB series communication brackets to be coordinated with appropriate communications terminations.

F. Boxes shall be securely fastened to structure. Recessed outlet boxes and extension covers shall be set flush with face of finished wall, but in no case greater than 1/4" behind finished face of wall.

2.04 POKE-THROUGH ASSEMBLIES

A. General: poke-thru device shall have been examined and tested by Underwriters Laboratories, Inc. to comply with UL514A and/or UL514C, as applicable and tested to Canadian Standard C22.2 and bear the "UL" mark. The poke-thru shall conform to the standards set in the National Electrical Code, Section 300.21.

1. Poke-thru device shall be for use in 1, 1-1/2 or 2-hour rated, unprotected reinforced concrete floors and 1, 1-1/2 or 2-hour rated floors employing unprotected steel floor units and concrete toppings (D900 series designs) or concrete floors with suspended ceilings. Fire resistive designs with suspended ceilings shall have provisions for accessibility in the ceiling below the poke-thru device fittings.
2. Poke-thru device shall have been evaluated by UL to meet the applicable U.S. and Canadian safety standards for scrub water exclusion when used on tile, terrazzo, wood, and carpet covered floors.
3. Poke-thru device shall be suitable for use in air handling spaces in accordance with Section 300.22C of the National Electrical Code.

B. Fire-rated poke-through assemblies for single- or multiple-service, for use with power or communications floor-mounted service fittings shall be Walker Systems, inc. #RC4 Series or acceptable equivalent as manufactured by Raceway Components (RCI) or Hubbell.

C. Floor-mounted service fittings shall be assembled units suitable for carpet and tile floors.

D. Color shall be as noted or as selected by the Architect.

E. Receptacles used with poke-through assembly shall be as under Paragraph 2.10, RECEPTACLES; provided as part of work of DIVISION 16, ELECTRICAL WORK, not as part of poke-through assembly.

F. Verify type of communications jack required with Owner and Telecommunications Installer.

2.05 BACKBOARDS & EQUIPMENT CABINETS

A. Backboards shall be ¾" plywood painted on all sides before installation. Paint shall be one coat primer and two coats latex fire-retardant gray paint acceptable equivalent to Benjamin-Moore "Retardo 220". Backboards shall be used for mounting grouped switches, starters and other equipment where shown on Contract Drawings.

B. Low Voltage Backboards: refer to Section 260525.

2.06 CONDUIT HANGERS AND SUPPORTS

A. Hangers, clips and accessories supporting conduit shall be UL listed.

B. Individual large conduits shall be supported by means of adjustable, malleable hangers of acceptable design placed on maximum 8'-0" centers. Individual small conduits may be held in place by one hole malleable clips.

C. MC cable shall be supported by hangers of acceptable design placed on maximum 4'-0" centers. MC cable shall be supported within 12" of each fitting. MC cable shall be used only for whips to connect light fixtures from a local junction box above a suspended ceiling and shall have stranded conductors.

2.07 WIRES AND CABLES

A. Secondary conductors shall be new copper with 600 V code gauge insulation, conforming to NEC requirements, and shall be Type THWN or THHN, #8 and smaller except as follows:

1. Type XF or SFF 150°C shall be used for fixture wiring.
2. Ground wires shall be as specified under SECTION 16450, ELECTRICAL GROUNDING, and in accordance with NEC.
3. Type THWN, THHN, or XHHW shall be used for conductors #8 AWG and larger.
4. Type TFE shall be used for high temperature applications.
5. Type XHHW-2 shall be used for underground branch circuits and feeders in conduit.

B. When wire sizes are not shown on Contract Drawings, sizes shall be in accordance with NEC but no smaller than following:

1. Light and power wiring: #12 AWG.
2. Control wiring: #14 AWG.
3. Wiring and cable for alarm and signal systems: as recommended by equipment manufacturer.

C. All multi-purpose feeders and circuits shall include a full size neutral and separate insulated ground conductor.

1. All 277/120 VAC circuits shall include separate full sized neutral and insulated ground conductors. Shared neutrals or ground conductors are not permitted.

2.08 SPLICES

A. Splices for #10 or smaller wires shall be made with UL approved solderless connectors: spring type acceptable equivalent to Minnesota Mining and Manufacturing Company "Scotchlock".

B. Splices, cable taps and terminals for #8 and larger shall be made with UL approved compression connectors: compression taps acceptable equivalent to Thomas & Betts "Colored Keyed" "C" taps applied with special tools according to manufacturer's recommendations; or bolted pressure connectors, bronze or copper construction, by Thomas & Betts, Burndy or acceptable equivalent.

2.09 LIGHT SWITCHES

A. Switches shall be ivory, unless noted otherwise, 20 A, UL labeled and rated for 120/277 V operation; with ground screw or self-grounding clip.

B. Light switches shall be acceptable equivalent to manufacturer's industrial-institutional heavy-duty specification grade switches listed below. Acceptable manufacturers are Arrow-Hart, Bryant, Hubbell, Leviton and P&S.

1. Single pole switches: Hubbell #1221-I.
2. Three-way switches: Hubbell #1223-I.
3. Four-way switches: Hubbell #1224-I.
4. Switches with pilot lights: as specified above, with Arrow-Hart #1720 (120 V).
5. Weatherproof switches: As specified above; with Crouse-Hinds "Type DS-185" cover plate on FS box or FD box, OR with Hubbell #7420 cover plate, fiber shield on FS box or FD box.

2.10 RECEPTACLES

A. Receptacles shall be ivory unless noted otherwise. Receptacles wired to emergency circuits shall be red.

B. Receptacles shall be acceptable equivalent to manufacturer's specification grade listed below and shall include grounding screw terminal. Acceptable manufacturers are Arrow-Hart, Bryant, Hubbell, Leviton and P&S.

1. Receptacles for general use (120 V): 20 A, duplex-grounding type, Hubbell #CR5362-I.
2. Receptacles for exterior locations: weatherproof Crouse-Hinds FS box with Hubbell "Rayntite" (rain tight while in use) aluminum padlockable enclosure and with duplex receptacles as specified for general use.
3. Isolated ground receptacles: 20 A, orange, duplex grounding type; Hubbell #IG5362.
4. Surge suppression/isolated ground receptacles: 20 A, duplex grounding type; Hubbell #IG5352IS.

   a. Surge suppression/isolated ground receptacles: 20 A, hospital grade, duplex grounding type; Hubbell #IG8300HIS.

5. Special two- and three-pole, 250 V receptacles and other receptacles required for special equipment: as required to suit equipment; in general, based on Hubbell "9300 Series", with appropriate line caps.
6. Duplex floor receptacles: as specified for general use, for use in floor boxes and in poke-through fittings.

C. Ground Fault Circuit Interrupter branch breakers shall be 20 A single-pole molded case circuit breakers with neutral pigtail; shall sense current unbalance between branch circuit and its neutral and shall trip upon unbalance; shall be Class "A", 5 mA sensitivity; and shall be by same manufacturer as panelboards.

D. Ground Fault Circuit Interrupter (GFI) receptacles shall be NEMA 5-20R, Class "A", 5 mA sensitivity; Arrow-Hart #GF5342-I, Hubbell #GF362-I, or acceptable equivalent.

2.11 WALL PLATES

A. Wall plates for switches, receptacles and clock outlets where wiring is concealed shall be high impact resistant thermoplastic, specification grade, with blank plates on unused flush boxes: Arrow-Hart "P*I Series" ivory plates.

1. Plates for devices on emergency circuits shall be red with "EMERGENCY" hot-stamped in ¼" letters.

B. Plates on exposed conduit boxes shall be galvanized zinc-coated with rounded edges.

C. Plates for special receptacles, other than 120 V, shall be engraved to indicate the voltage. Cover on three phase switches shall read "3 PHASE".

D. Wherever switches are grouped, they shall be ganged and provided with one-piece gang plates to suit installation.

E. Provide blank plates for unused telephone and data outlet boxes.

2.12 LIGHT DIMMERS

A. Wall type light dimmers shall be wall mounted, calibrated linear slide control with square law dimming feature.

B. Dimmers shall be acceptable equivalent to manufacturer's specification grade switches listed below. Acceptable manufacturers are Lutron, Lightolier, Prescolite or Hubbell.

1. Up to 1000 watts: Lutron #N-1000.
2. 1000 to 2000 watts: Lutron #N-2000.
3. 3-way dimmer switches: Lutron #N-3P-S.

2.13 WALL OCCUPANCY SENSORS

A. The wall occupancy sensor shall be Watt Stopper #WI-200 or approved equal manufactured by Sensor Switch.

B. The sensor shall be a low profile single gang wall mounted 180-degree coverage PIR type with a desktop activity rating of 500 square feet.

C. Sensors shall be rated for 120/277 Volt operation and capable of operating both incandescent and fluorescent, including electronic and PL lamp, ballast loads.

D. Sensors shall have user adjustable time delay feature from 15 seconds to 30 minutes, normal setting shall be 20 minutes. Unit sensitivity shall be adjustable. Normal setting shall be maximum sensitivity.

E. Wall sensors shall have individual manual override switches and a LED type activity indicator. Sensor color shall match other devices.

2.14 CEILING OCCUPANCY SENSORS

A. The Passive Infra Red (PIR) type ceiling occupancy sensor shall be Watt Stopper #CI-200-I with integral isolated relay and light level sensor turned off or approved equal manufactured by Sensor Switch. The sensors shall be a low profile ceiling mounted 360 degree coverage low voltage PIR type sensor unit with a remote power/relay pack and a desktop activity rating of 300 square feet.

B. The dual technology ceiling occupancy sensor shall be a Watt Stopper #DT-200 with integral isolated relay and light level turned off or approved equal manufactured by Sensor Switch. The sensor shall be a low profile surface mount unit with swivel mounting bracket for ceiling or high wall mounting. The sensor shall utilize both high frequency sound (minimum 40 kHz) and PIR technology to trigger on. Activation of either technology will keep the sensor on. The unit shall also be field selectable to operate with either technology only. Sensor coverage shall be dense wide angle type with a desktop activity rating of 1000 square feet.

C. The dual technology ceiling occupancy sensor shall be a Watt Stopper CX-100 with integral isolated relay and light level turned off or approved equal manufactured by Sensor Switch. The sensor shall be a low profile surface mount unit with swivel mounting bracket for ceiling or high wall mounting. The sensor shall utilize both high frequency sound (minimum 40 kHz) and PIR technology to trigger on. Activation of either technology will keep the sensor on. The unit shall also be field selectable to operate with either technology only. Sensor coverage shall be dense wide angle type with a desktop activity rating of 1000 square feel.

D. Power/relay packs shall be rated for 120/277 Volt operation and capable of operating both incandescent and fluorescent ballasts, including electronic and PL lamps, loads and multiple sensor units. Power/Relay packs shall be watt stopper BZ-100 or equal by Sensor Switch.

E. PIR Sensors shall have user adjustable time delay feature from 15 seconds to 30 minutes: normal setting shall be 20 minutes. Sensors shall have user adjustable sensitivity: normal setting shall be maximum sensitivity.

F. Dual Technology Sensors shall have user adjustable time delay feature from 5 seconds to 30 minutes: normal setting shall be 20 minutes. Sensors shall have user adjustable sensitivity: normal setting shall be maximum sensitivity.

G. Sensors shall be white in color and have individual manual override switches and a LED type activity indicator.

H. The remote power/relay pack or sensor shall contain an isolated Form C contact rated .5 Amp at 120 VAC minimum for external system interfaces, watt stopper S120/277/347E-P or equal by Sensor Switch.

I. Sensor for restroom shall be watt stopper W1000A or equal by Sensor Switch.

J. Factory Commissioning:

1. It shall be the manufacturer's responsibility to verify all proper adjustments and train Owner's personnel to ensure Owner's satisfaction with the occupancy system.

2.15 LIGHTING CONTROL SYSTEM

A. System Description

1. Install a lighting control system consisting of bus supply modules, control switches, occupancy sensors, daylight sensors, and other controlling devices. The devices are connected by low voltage and line voltage wiring. The general operation of lighting and controlled loads shall include:

   a. Scheduled on/off Loads: Time on, time off by automatic time schedule with after hour override capability and shutoff.
   b. Exterior Lighting: Photocell or astronomic on/time off, time on/photocell or astronomic off.

B. Quality Assurance

1. Manufacturers: Firms regularly engaged in the manufacture of lighting control equipment and ancillary equipment, of types and capacities, whose products have been in satisfactory use in similar service for not less than 5 years.
2. NEC Compliance: Comply with NEC as applicable to electrical wiring work.
3. NEMA Compliance: Comply with applicable portions of NEMA standards pertaining to types of electrical equipment and enclosures.
4. UL Approvals: UL listed under UL 916 Energy Management Equipment.
5. FCC Emissions: Compliance with FCC emissions Standards specified in Part 15 Subpart J for Class A application.

C. Manufacturers

1. Basis of design product: Lutron EcoSystem or subject to compliance and prior approval with specified requirements of this section.

2.16 LECTURE HALL LIGHTING CONTROL SYSTEM

A. System Description

1. Install a lighting control system consisting of dimming modules, power interfaces, wall station, low voltage control interfaces, sensors, and other controlling devices. The devices are to be connected by low voltage and line voltage wiring.

B. Quality Assurance

1. Manufacturers: Firms regularly engaged in the manufacture of lighting control equipment and ancillary equipment, of types and capacities, whose products have been in satisfactory use in similar service for not less than 5 years.
2. NEC Compliance: Comply with NEC as applicable to electrical wiring work.
3. NEMA Compliance: Comply with applicable portions of NEMA standards pertaining to types of electrical equipment and enclosures.
4. UL Approvals: UL listed under UL 1472 Solid-State Dimming Controls.

C. Manufacturers

1. Basis of design product: Lutron GRAFIK Eye 3000.

2.17 LIGHTING CONTROL RELAYS AND SWITCHES

A. Relays shall have contacts rated for 20 A, 480 V, with poles as noted on Drawings. Relays shall be in NEMA 1 enclosure and shall have 120 V operating coils. Relay shall be mechanically held, heavy duty type, UL listed for electrical discharge lighting: acceptable equivalent to Asco "917 Series". Relays are available in combinations up to 12 poles; Drawings show the active pole requirements only.

B. Control switches shall consist of individual toggle SPDT momentary contact-center-off type operators as specified under Paragraph 2.9, LIGHT SWITCHES.

C. Normal lighting circuit monitoring control modules shall be equal to LVS/HI-LITES Model Number "EPC". Unit shall be UL listed and shall energize emergency lights in the event of loss of normal power or failure of the monitoring control module. Voltage shall match the lighting load.

D. Lighting circuit transfer control module shall be equal to LVS/HI-LITES Model Number "EPC-D". Unit shall be UL listed and shall transfer source from normal circuit to emergency circuit upon loss of normal power or failure of transfer control module. Voltage shall match the lighting load.

2.18 SOLID STATE, DIGITAL TIME SWITCHES

A. Provide automatic solid-state digital 24-hour time switch capable of providing single channel, pre-programmed automatic startup and shutdown control of two loads: Tork #DG180 or acceptable equivalent by Paragon or Intermatic; with following features:

1. LCD display indicating time-of-day (AM/PM or 24-hour format), day-of-week, and on-off status.
2. User-selectable daylight savings time or standard time
3. Automatic leap year compensation.
4. Manual on-off override
5. Clock input power voltage, as noted on Drawings
6. Indoor/outdoor NEMA 3R enclosure.
7. Automatic battery backup, minimum 175 hours, from 9 V lithium or alkaline battery. Battery shall be accessible from front of switch.

B. Provide automatic solid-state digital 7-day time switch capable of providing two-channel, preprogrammed automatic startup and shutdown control of multiple loads: Tork "DZS200 Series" or acceptable equivalent by Paragon or Intermatic; with following features:

1. LCD display indicating time-of-day (am/pm or 24-hour format), day-of-week, and on-off status.
2. User-selectable daylight savings time or standard time
3. Automatic leap year compensation, with astronomic selectability.
4. Block holiday scheduling.
5. Manual on-off override.

6. Clock input power voltage, as noted on Drawings.
7. Indoor/outdoor NEMA 3R enclosure.
8. Automatic battery backup, minimum 72 hours, from rechargeable 9 V nicad battery. Battery shall be accessible from front of switch.

2.19 SAFETY SWITCHES AND FUSES

A. Work of this Division shall include:

1. Furnishing and installing an appropriate fusible safety switch for each motor, unless otherwise noted.
2. Installation of safety switches furnished under DIVISION 15, MECHANICAL WORK.
3. Fuses for safety switches.
4. Power wiring to and from safety switches.

B. Disconnect Switches for Motor Starters

1. Provide disconnect switch ahead of each magnetic motor starter. The disconnect switch shall be located in sight of the controller location and not more than 50' apart.
2. Where more than one motor is connected to single branch feeder, provide fused disconnect switch for each motor, even if within sight of feeder branch breaker.
3. Motors requiring disconnecting means remote from the starter shall have a fused switch as close as possible to motor.

C. Safety switches shall have rejection clips for RK fuses and NEMA 1 enclosure, unless otherwise noted. Safety switches shall be NEMA Type HD (heavy-duty), manufacturer's specification grade switches by Square D, General Electric, or Westinghouse, acceptable equivalent to following:

1. Switches for use on 120/208 V system: rated for 240 V.
2. Switches for use on 480V system: Rated for 600V.
3. Fused disconnect 2-pole and 3-pole: Square D "Type H".
4. Switches that are used in conjunction with variable frequency drives (VFDs) and elevators shall have auxiliary contacts that open before switch blades to interrupt control circuits. Auxiliary contacts shall be 120 VAC; 5 Ampere rated.
5. Switches for use with 6 lead motors: 600 VAC, NEMA 4X enclosure.

    a. Fused: Square "D" Type H

D. Fuses for safety switches shall be non-renewable dual element cartridge type, Class RK5, UL listed. Fuses shall be Bussmann #FRN for 208 V usage and Bussmann #FRS for 460V usage, or acceptable equivalent by Shawmut or Littelfuse. Install fuse so that size is readily visible. Special types and classes are indicated on Contract Drawings.

E. Provide one spare set of fuses for each type and size used with switches and other equipment.

F. Pedestals for roof mount disconnect switches shall be listed for use in wet locations with an integrally welded deck flange. Pedestals shall extend 36" above roof line and 12" below roof line and shall include pedestal mounted NEMA 3R safety switch and GFCI receptacle. Pedestals shall be equal to MAPA #MPD-30.

2.20 MOTOR STARTERS

A. Unless otherwise noted, provide an appropriate motor starter for each motor. Installation of, and power wiring to and from, the starters furnished under DIVISION 23, MECHANICAL WORK, shall be done as part of the work of this Division. Unless otherwise noted, control wiring shall be provided as specified under SECTION "CONTROL TRADE WORK".

B. Motor starters shall meet NEC, NEMA, UL, CSA and ANSI and shall be suitable for required load, duty, voltage, phase, frequency, service and location.

C. Starters shall be by Allen-Bradley, Cutler-Hammer/Westinghouse, Square D, or General Electric, acceptable equivalent to following:

1. Manual motor starters for 115 V or 200 V, single-phase motors less than 1/2 HP: Square D "Class 2510" #FG-1P or #FG-2P.
2. Manual motor starters for three-phase motors: Square D "Class 2510".
3. Magnetic across-the-line starters, for single-phase motors 1/2 HP and larger and for three-phase motors: Square D "Class 8536".
4. Combination motor starters, with fused disconnect switch (fuse class RK-5): Square D "Class 8538".
5. Combination motor starters, with thermal-magnetic circuit breaker (with interrupting rating as specified elsewhere): Square D "Class 8539".
6. Magnetic starters for two-speed, single winding, consequent pole motors: Square D "Class 8810".
7. Combination motor starters with fused disconnect switch (fuse class RK-5) or with thermal-magnetic circuit breakers; for two-speed, two winding motors: Square D "Class 8810".
8. Reduced voltage starters, solid state: Square D "Class 8660".

D. Provide compelling and decelerating relays for two-speed motors driving cooling tower fans and other high inertia loads.

E. For 208V systems, provide 120 V control power by tapping one power phase leg with single-pole fuse in fuse clip and running one #12 AWG neutral to starter.

F. For 277/480 VAC systems, provide integral 120 VAC fused control power transformer in each starter, unless otherwise noted.

G. Unless otherwise noted, motor starter shall have NEMA 1 enclosure.

H. Magnetic starters shall have the following features:

1. Two extra N.O. and two extra N.C. auxiliary contacts, for each speed.
2. "HAND-OFF-AUTOMATIC" switch mounted in cover.
3. Red "ON" pilot light equipped with neon lamp and mounted in starter cover.
4. Red and yellow "ON" pilot lights for high and low speeds, on two-speed motors.
5. Terminal strip for field wiring connections to control circuits.
6. Cover-mounted reset button.
7. Three thermal overload relays, with appropriate heaters to provide protection on all motor phase legs. Relays shall be bimetallic or melting alloy type.

8. High-Low selector switch which is functional only in "HAND" position on two-speed motors.
9. Reverse phase and phase failure relay, for motors 100 HP and larger.
10. Other features specified in motor starter schedule.

I. For control of HVAC starters, refer to DIVISION 15, MECHANICAL WORK.

2.21 EMERGENCY FAN SHUTDOWN SYSTEM

A. Provide following system to shut down fans upon signal from Fire Alarm System or upon the actuation of a manual fan shutdown switch.

1. Provide relay within three feet of each temperature control panel. Relay shall have 120 V, 60 Hz coil and shall have one N.O. and one N.C. contact for use with controls under SECTION "CONTROL TRADE WORK", to shut down fans upon deactivation of relay.
2. Dry contacts in shutdown switches and Fire Alarm System shall be connected in series to energize all relays under normal conditions. Any alarm shall cause relays to de-energize.

B. Relays shall be acceptable equivalent to Square D "Type X" control relay with one N.O. and one N.C. 10 A contact and continuous duty rated coil. Provide NEMA 1 enclosure, acceptable equivalent to Square D "Class 9991 Type UE7".

C. Wiring shall be #12 AWG in 1/2" EMT.

D. Provide 120 V control power from 20 A, single pole circuit breaker provided with handle lock. (Where available, this shall be an emergency circuit.)

2.22 TERMINAL STRIPS

A. Terminal strips shall be Buchanan or acceptable equivalent, with a numbering strip for identification of individual punchings.

PART 3 - EXECUTION

3.01 SUPERVISION

A. Furnish services of experienced electrical Superintendent who shall be constantly in charge of electrical work, together with skilled laborers required to unload, transfer, erect, connect, adjust, start, operate and test each system.

B. Particular emphasis is placed on timely installation of major apparatus and furnishing of other trades and Contractor with relevant information.

3.02 MOTOR AND CONTROL CIRCUIT WIRING

A. Provide wiring required for electrical equipment furnished under other Divisions of this Specification. Provide disconnects, starting switches and motor protection ahead of each piece of equipment, unless specified otherwise.

B. Check all protective and control equipment furnished or installed under this Division. Ensure that such equipment is properly sized for motor or other electrical equipment that it serves. Replace any material or equipment damaged due to improperly-sized protective control mechanisms.

C. Electrical controls and starters integral with or specialized for mechanical equipment are specified with equipment in DIVISION 15, MECHANICAL WORK. Disconnects and other controls and starters are specified in this Division.

D. Output power wiring from variable frequency drive (VFD) to motor shall be run in metallic conduit; other wiring shall NOT be run in this conduit. VFD shall have separate equipment conductor back to ground bus of source panel or switchboard and shall NOT depend on metallic conduit for grounding. Power shall NOT be applied to VFD until VFD manufacturer has checked and approved VFD installation.

E. Control cable to VFD speed input shall be shielded and shall be installed without excess cable so that electrical noise shall be minimized.

3.03 IDENTIFICATION

A. Provide nameplates and general identification as required under SECTION 260010, GENERAL REQUIREMENTS FOR ELECTRICAL WORK, and under DIVISION 1, and as follows:

1. Nameplates on panelboards, distribution panels and service switches: minimum of 1-1/2" by 2-1/2" size with letters not less than 3/8" high.
2. Nameplates on starters and other switches and devices: minimum of 3/4" by 2-1/2" size with letters not less than 1/4" high.
3. Receptacles shall have branch circuit identification marked on faceplate with clear tape with black lettering including circuit number and panel designation.

B. Wall plates provided for flush-mounted control switches in finished areas shall be engraved, stainless steel with black-filled letters.

C. Conductors size #6 and smaller shall have solid color insulation for identification.

D. Conductors size #4 and larger shall have color identification, six inches minimum length near termination and in splice boxes, junction boxes, panels and manholes. Identification shall be by solid color insulation, tape or paint.

E. Phase rotation shall be indicated by following color code:

Phase	*208Y/120V*	*480Y/277V*
A	Black	Brown
B	Red	Orange
C	Blue	Yellow
Neutral	White	White with purple stripe or natural gray
Ground	Green	Green

F. Conduits containing emergency feeders* shall be identified by attaching orange adhesive tape with black letters stating "EMERGENCY POWER" at three foot maximum intervals.

G. Provide red lamicoid label on cover of motor starter enclosure, adjacent to H-O-A switch, to read:

WARNING- In hand position, all control interlocks are bypassed USE FOR CAUTIOUS TESTING ONLY

H. Where wall plates are provided for control switches flush mounted in finished areas, plates shall be engraved, stainless steel with black-filled letters.

3.04 ACCESSIBILITY, ACCESS PANELS AND ACCESS DOORS

A. Locate equipment which must be serviced, including motor starters, switches, panels and junction boxes, in accessible locations if at all possible. For other locations, furnish access panels as described under DIVISION 1.

B. Access doors shall be located to conveniently serve intended purpose and shall be installed so that adjacent piping, equipment and structures do NOT render doors unusable.

C. Access doors are not required in removable panel ceilings if suitable identifying markers are provided to indicate access locations.

D. During project closeout, Contractor shall perform walk-through identifying and demonstrating access to equipment for service and/or replacement. Walk-through shall be arranged at times convenient for Engineer and Owner to attend.

1. Equipment with insufficient access shall be relocated or provided with additional access panels at no additional cost to Owner.
2. Trade responsible for access problem shall be responsible for costs of access modifications. In general, this shall be understood to be the trade installing the equipment. If access problem was caused by architectural layout changes which occurred subsequent to equipment installation, cost of access modifications shall be borne by trade responsible for architectural changes.

3.05 WATERPROOFING

A. Where work pierces waterproofing, including waterproof concrete and floor of a wet area, submit method of installation for review by the Architect before work is done.

B. Provide necessary sleeves, caulking and flashing required to make openings waterproof. See DIVISION 7 on WATERPROOFING.

3.06 INSTALLATION OF CONDUIT, BOXES AND FITTINGS

A. Ends of conduits shall be reamed before assembly, and bushings and locknuts shall be provided where conduits connect to boxes.

B. Boxes shall be set plumb and square with building lines. Exposed conduit shall run parallel to building lines, unless noted otherwise, and shall NOT block ceiling inserts.

C. Maintain conduit and outlet boxes in position during construction of concrete floors, masonry walls, etc.

D. Wiring device boxes shall NOT be installed back-to-back in walls.

E. Conduit shall run to avoid low pockets which might collect water, and, during installation, open ends shall be capped.

F. RMC or IMC buried in grade or in ductbanks shall have couplings made up tight. Thread to coupling joint shall be coated heavily with bitumastic paint, ensuring watertightness.

G. Parallel groups of conduit shall be supported from below, either by horizontal angle irons or channel systems such as "Unistrut", with vertical hanger rods at appropriate intervals.

H. Supports for conduit on concrete walls shall be attached to wall either with all metal expansion shields or explosive-type inserts, as permitted.

I. Conduits in slabs or in grade shall be swabbed internally prior to pulling wire or cable.

J. Final connections to motors, control devices mounted on equipment, vibrating equipment and vibration isolated equipment shall be made through liquid-tight flexible metal conduit.

K. Use standard radius bends on concealed conduit; on exposed work, use either standard bends or "L" type fittings acceptable equivalent to Crouse-Hinds.

L. Wherever MC cable is used, leave sufficient slack for future removal or withdrawal of boxes or fixtures from finished ceiling or partitions.

M. Exposed wiring shall be kept as close as possible to underside of roof and floor slabs or bottom of beams, unless noted otherwise. Space above hung ceilings is extremely critical and coordination with mechanical trades is essential.

N. Conduit and wiring shall NOT be run in roof fill and shall NOT pierce roof deck, unless specifically noted to on Contract Drawings.

O. Galvanized electrical conduit of 1/2" nominal diameter may be embedded within 4-1/2" overall thickness suspended concrete slabs over permanent metal floor forms; galvanized electrical conduit of 1" nominal diameter may be embedded within slabs of 6" thickness overall.

P. Conduits concealed in or beneath slab on grade: Conduits larger than 3/4" nominal diameter shall be completely buried below vapor barrier within the porous fill layer, such that surface of vapor barrier is smooth and level within ±1/4" tolerance. Conduits 3/4" and smaller may be:

1. Completely buried below the vapor barrier within the porous fill, or
2. Placed above the vapor barrier, within the slab, at mid-height of slab, or
3. If within the slab, spaced minimum of 3 diameters away from parallel conduits.

Q. Additional Requirements for Low Voltage Systems: refer to Section 260525.

R. Field cut IMC and RGS conduits shall be field threaded. Field threads to be cold galvanized by brush or spray. Cold galvanize to be minimum 95% zinc and shall cure before attaching to threaded fitting. Set screw and compression fittings shall not be acceptable.

S. Conduit shall not be run directly above generator set exhaust system including piping, silencer, emission control equipment, heat recovery exchangers or any other equipment that contains hot exhaust gases.

T. Where PVC conduit, whether direct buried or in ductbank, terminates within a building or utility structure, the PVC conduit shall transition to rigid metal conduit prior to entering building or utility structure. Additionally, sweeps up through slabs on grade shall be RMC.

U. Seal all conduits at the last structure prior to conduits entering a building and where conduits enter a building with Carlon "MAT" or "MAQ" series duct plug for conduits with wires and Carlon "MAE" series for spare conduits or equal. All spare conduits shall have nylon pull string and footage tape.

V. Adjacent poke-thru devices shall not be located closer then 24 inches on center.

W. No more than one poke-thru device shall be provided per 65 square feet of floor area in each span per UL Fire Resistance Directory.

3.07 INSTALLATION OF CABLES

A. Parallel groups of cables shall be supported from below, either by horizontal angle irons or channel systems such as "Unistrut", with vertical hanger rods at maximum of three-foot intervals.

B. Supports for cables on concrete walls shall be attached to wall either with all metal expansion shields or explosive-type inserts, as permitted.

3.08 INSTALLATION OF LIGHT SWITCHES

A. Light switches shall be wall-mounted on the strike side of door jambs. Coordinate with Architectural, Electrical and Mechanical Contract Drawings for elevations, locations and mounting heights of switches. Verify all final locations of devices and door swings with Architect prior to installation.

3.09 INSTALLATION OF RECEPTACLES

A. Receptacles shall be installed vertical with the U-ground up above the floor and below ceiling. Coordinate with Architectural, Electrical and Mechanical Contract Drawings for elevations and mounting heights of receptacles and surface raceway. Verify all final locations of devices with Architect prior to installation.

B. If receptacles are located within six feet of sink, faucet or water source; GFCI/GFI receptacles shall be used.

C. Where GFI circuit breakers are used, all receptacles on the circuit shall be labeled GFCI/GFI with the circuit number.

3.10 MOTOR CONTROL

A. Mount grouped switches, starters and other equipment on backboards. See Paragraph 2.05, BACKBOARDS & EQUIPMENT CABINETS.

3.11 SURFACE RACEWAY

A. Surface raceway shall be installed with all appropriate fittings in accordance with the manufacturer's installation instructions and in compliance with all appropriate codes. Raceway is to be plumb, square, level and in alignment with casework or furniture as required.

3.12 INSTALLATION OF LIGHTING CONTROL SYSTEMS

A. Install equipment in accordance with manufacturer's installation instructions.

B. Provide complete installation of system in accordance with Contract Documents.

C. Provide equipment at locations and in quantities indicated on Drawings. Provide any additional equipment required to provide control intent.

3.13 SLEEVES, INSERTS AND ANCHOR BOLTS

A. Furnish, set in place, coordinate and be responsible for location of sleeves, inserts and anchor bolts required for work of this Division. If work is not completed in coordination with work of other trades, trade involved shall do cutting and patching required or have same done, at no additional cost to Owner.

B. Conduits passing through floors, walls or partitions shall be provided with sleeves which have internal diameter one inch larger than outside diameter of conduit and insulation, if any.

C. Sleeves through fire-rated concrete floors or interior masonry walls shall be Schedule 40 steel pipe; sleeves through concrete floors or interior masonry walls which are not fire-rated shall be Schedule 40 PVC. Sleeves shall be flush with finished wall, flush with finished ceiling, and extended two inches above finished floor.

D. Sleeves through interior partitions shall be Schedule 40 PVC, set flush with finished surfaces of partitions.

E. Inserts shall be of pressed steel construction, with accommodation for removable nuts and threaded rods up to 3/4" diameter, permitting lateral adjustment. Inserts shall be by Carpenter and Patterson, Grinnell or acceptable equivalent.

1. Individual inserts shall open at top, permitting reinforcing rods up to 1/2" diameter to pass through insert body.
2. Strip inserts shall have attached rods with hooked ends.

3.14 BASES AND SUPPORTS

A. Unless noted otherwise, provide necessary supports, rails, framing, bases and piers required for equipment furnished or installed under this Division.

B. Unless otherwise indicated: floor-mounted equipment shall be mounted on concrete pads. Concrete and associated reinforcing materials shall be as specified in DIVISION 3, CONCRETE.

1. Pads shall be three-inch thick minimum. Pads for seismically supported equipment shall extend at least 6 inches beyond equipment footprint. Coordinate final extension requirements with approved seismic shop drawing calculations and details. All other pads shall NOT extend more than one inch beyond equipment footprint. Top edge of pads shall be chamfered.
2. Furnish dimensional and load information so that shop drawings for pads may be submitted and reviewed prior to pad installation.
3. Equipment shall be firmly grouted into concrete pads and anchor bolted.

C. Where mounted on the floor: Foundations, supports, pads, bases and piers shall be of the same finish quality as the adjacent flooring material.

D. Equipment supports shall be designed and constructed so that equipment will be capable of resisting both vertical and horizontal movement. Refer to SECTION 260548, SEISMIC RESTRAINT & VIBRATION ISOLATION FOR ELECTRICAL SYSTEMS.

3.15 PAINTING

A. Unless otherwise specified, materials furnished under this Division shall have prime coat and standard manufacturer's finish.

B. Finish painting of exposed work and equipment is covered under DIVISION 9.

C. Paint electrical equipment and appurtenances in concealed and unfinished areas with one coat of rust-inhibiting paint or with an appropriate bitumastic protective product designed for the intended application. Asphalt paint is NOT acceptable. Items to be painted shall include, but not be limited to: non-insulated hangers, supports, piping, conduit, tanks and other ferrous metal work, which are concealed or inaccessible but not galvanized.

D. Special care shall be taken to avoid painting or spattering equipment nameplates.

E. Cooperate in identifying systems for painters. Refer to Paragraph 3.3, 3.4, IDENTIFICATION.

3.16 GENERAL WIRING TESTS

A. Prior to final inspection and tests: Wiring and connections shall be completed, devices and equipment shall be properly operating, power and lighting circuit and control wiring shall be clearly identified with acceptable tags, and lighting fixtures shall be installed, ready for acceptance.

B. Before devices are installed, test each wiring system for following:

1. System shall be free from short circuits.
2. System shall be free from grounds.
3. Systems at or below 600 V shall have minimum insulation resistance of 100 megohms when tested with 1000 VDC potential between conductors and between conductors and ground, for minimum of one minute, at 70°F ambient temperature and reasonably dry atmosphere.

C. Upon completion, demonstrate that systems are properly phase balanced.

3.17 OPERATIONAL TESTS

A. Each piece of electrical equipment, including lighting fixtures, motors and controls shall be operated continuously for minimum test period of one hour.

B. Demonstrate by operating equipment that circuits and devices are in good operating condition. Each item of control equipment shall be operated minimum of five times. Demonstration shall be performed after wiring tests.

3.18 MECHANICAL SYSTEM ADJUSTMENT AND TESTING

A. Be present during adjustment period and final testing of mechanical systems. Take readings necessary to ensure that electrical systems are operating properly. Tests for mechanical work are detailed under DIVISION 15, MECHANICAL WORK.

B. Take ampere readings at each electrical component, such as motor and heating coil, to determine proper operation.

C. Record readings and submit them in triplicate to Engineer for review.

END OF SECTION 260500

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SECTION 260525 – LOW VOLTAGE RACEWAY DISTRIBUTION

SECTION 260525 - LOW VOLTAGE RACEWAY DISTRIBUTION

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

A. This Section covers the specification of raceway systems to support telephone, video, data wiring and security systems.

B. Installation shall be in accordance with applicable Codes and ANSI/TIA/EIA 569 Commercial Building Standards for Telecommunications Pathways and Spaces.

C. Refer to Section 260010, Section 260500, and GENERAL CONDITIONS, SUPPLEMENTARY CONDITIONS and applicable parts of DIVISION 1 for other general requirements.

1.02 SCOPE

A. Provide labor, materials, equipment and services equipment and transportation necessary for complete and operational raceway system including but not limited to the following:

1. Raceways
2. Outlet, pull and junction boxes
3. Sleeves
4. Backboards
5. Cable tray
6. Grounding
7. System Commissioning

B. Provide a telecommunications raceway system including all interior raceways, boxes, plywood backboards, outlets, fittings and all other appurtenances required, leaving the entire installation ready for installation of equipment and cables.

C. Refer to Drawings for additional requirements.

1.03 SUBMITTALS

A. Submit for review shop drawings for the following:

1. Raceways
2. Boxes

PART 2 - PRODUCTS

A. Refer to Specification Sections 260500 and 260526.

PART 3 - EXECUTION

3.01 GENERAL

A. In general, the telecommunications system raceways, outlets and terminal backboard locations shall be as indicated on the Drawings.

B. All work and the entire installation of same shall be coordinated with the Owner, the Telephone System, Video System and Data System Installers before the start of the construction and shall be in full conformance with their requirements and recommendations.

C. Verify service point with Owner, and provide service raceways to meet requirements and as indicated on the Drawings and Specifications.

D. At telecommunications rooms/closets provide 3/4-inch thick MDO plywood backboards with smooth finish for the mounting of equipment and cable terminations. The backboards shall be painted matte white with two coats of non-conductive fire resistive paint. Exact dimensions of the backboards shall be as indicated on the Drawings. Minimum size shall be 4 feet by 8 feet mounted 12 inches above the floor and 8 feet high and 6 inches off the wall.

E. Provide a double duplex surge suppression outlet on an individual 20A/1P, 120V circuit at each backboard.

3.02 TELECOMMUNICATIONS AND EMPTY RACEWAYS

A. Empty Raceways and Raceways installed for Telecommunications Systems including telephone, data, security, alarm, CATV, sound, video, low voltage conductors, etc. shall be installed as required by the Electrical Code, as required for raceways specified in this Section and as indicated herein.

B. Provide 1 inch conduit for all voice, data and video, unless otherwise indicated, from outlets indicated on the Drawings into the nearest partition, extended a minimum of 6 inches above an accessible ceiling or to the backboard if there is no nearby accessible ceiling. Provide 90 degree bend at top of wall.

C. Terminate conduits with insulated throat fittings. Provide grounding bushings for backbone and riser conduits and for conduits entering equipment rooms or wiring closets. Ground conduits, cable trays and raceways to the local Telecommunications ground bus using braided hollow copper conductor equal to Belden #8669 (60A ampacity).

D. Provide pull boxes each time raceway installation exceeds a 100-foot (30M) section or a total of 180 degrees in bends and offsets between pull boxes. Do not install a pull box in lieu of a conduit bend. Align the corresponding conduits on opposite sides of pull box with each other.

E. Minimum conduit size for security, alarm, sound and other low voltage systems shall be 3/4".

F. Pull boxes shall be sized according to the following table:

Maximum Trade Size in Conduit Inches	*Size of Box*			*For each additional Conduit increase Width*
	Width	*Depth*	*Length*	
21 mm (0.75 in.)	102 mm (4 in.)	305 mm (12 in.)	76 mm (3 in.)	51 mm (2 in.)
27 mm (1.0 in)	102 mm (4 in.)	406 mm (16 in.)	76 mm (3 in.)	51 mm (2 in.)
35 mm (1.25 in.)	152 mm (6 in.)	508 mm (20 in.)	76 mm (3 in.)	76 mm (3 in.)
41 mm (1.5 in.)	203 mm (8 in.)	686 mm (27 in.)	102 mm (4 in.)	102 mm (4 in.)
53 mm (2.0 in.)	203 mm (8 in.)	914 mm (36 in.)	102 mm (4 in.)	127 mm (5 in.)
63 mm (2.5 in.)	254 mm (10 in.)	1067 mm (42 in.)	127 mm (5 in.)	152 mm (6 in.)
78 mm (3.0 in.)	305 mm (12 in.)	1219 mm (48 in.)	127 mm (5 in.)	152 mm (6 in.)
91 mm (3.5 in.)	305 mm (12 in.)	1372 mm (54 in.)	152 mm (6 in.)	152 mm (6 in.)
103 mm (4.0 in.)	381 mm (15 in.)	1524 mm (60 in.)	203 mm (8 in.)	203 mm (8 in.)

NOTE: Width is measured perpendicular to conduit orientation. Length is measured parallel to conduit orientation.

G. Pull boxes with covers over 20 inches shall have piano hinged covers with pad locking capability. Covers over 20 inches wide shall be split bulkhead type with piano hinges located on the long sides. Provide doors where one door is able to be secured to the pull box while the other is able to swing free.

H. Locate pull box so it is accessible and covers can be opened at least to 90 degrees. Where above ceiling or behind access door center pull box in access door or ceiling tile opening.

I. Pull boxes shall be securely mounted to building structure.

J. Grounding continuity shall be assured throughout raceway and pull box installation equal to electrical power raceway installation.

K. Bends shall be large radius, not exceeding 90 degrees and minimum size radius as follows:

1. 2 inch trade size and less - 6 times conduit diameter.
2. 2-1/2 inch trade size and larger - 10 times conduit diameter.
3. Conduits for fiber optics cabling - 10 times conduit diameter.
4. Surface raceways - 2 inch radius bends.

L. Raceways and outlets shall be separated from sources of EMI and RFI such as transformers, ballasts and power lines. Do not install raceways parallel to power raceways unless a four-foot distance is maintained. Cross other raceways at 90 degrees. Maintain minimum 24 inch clearance in all directions from lighting fixtures and power wiring rated over 20 A. Maintain a minimum 6-inch clearance elsewhere from raceways and outlets. Maintain 48-inch clearance from transformers. Clearances are measured all around raceway and outlets including through walls and floors.

M. Provide sleeves for raceways and cable trays penetrating full height walls or floors. Install approved fire stop between sleeve and rated wall or floor. Install approved watertight seal between sleeve and wall or floor for penetrations to the exterior or underground. Sleeves shall extend two inches above the floor and shall be watertight.

N. Provide sleeves for telecommunications cabling and at full height walls in path of cabling from outlet location to termination point in closet minimum size two inch except four 4-inch sleeves into telecommunications closets or rooms, computer class rooms, media center and equipment head end rooms.

O. Provide four-inch conduit sleeves between stacked Telecommunication closets or rooms. Provide a minimum of four sleeves per closet, provide more if indicated.

P. Provide one multi-duct conduit in underground ductbanks and between Telcom room or closets where raceways are installed for non-stacked areas. Provide additional mutli-duct conduits where indicated.

Q. Align sleeves and conduits on opposite walls of rooms, closets or manholes so there is a straight line between corresponding openings, parallel or perpendicular to structure. Provide 4-inch conduits between telecommunications rooms, closets and backboards. As a minimum provide one conduit for telephone cables, one multiple duct conduit with three 1-1/2 inch inner ducts for data and one spare conduit for future use.

R. Provide a 200 lb test pull line in each raceway. Leave 12 inches of exposed slack at each end. Secure pull line at each end to prevent it from slipping back into raceway.

S. Non-metallic raceways or boxes are not allowed in interiors of buildings.

T. Provide insulated bushings at all cable or pull string penetrations through steel studs.

U. No cabling to an outlet is to be installed exposed. Provide conduit to outlet where cabling would have to be installed exposed.

V. Provide direct raceway from outlet boxes to an accessible location above the finished corridor ceiling, or in area with non-accessible ceilings directly to the plywood termination backboard in the nearest telecommunications closet/room on the same floor or as indicated on the Drawings.

3.03 OUTLETS

A. Provide blank device outlet cover plates for all outlets without device plates installed at time of Substantial Completion. All outlet cover plates shall be of the same finish material and by the manufacturer furnishing all other device and switch plates installed throughout the buildings.

Provide blank plate or outlet plate as coordinated with the Telephone, Video and Data System Installer.

B. Provide 4-11/16 inch square by 2-1/8 inch deep box with single gang plaster ring for each outlet, unless otherwise indicated.

C. Outlet shall be spaced 6 inches minimum from an electrical outlet.

END OF SECTION 260525

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SECTION 260526 – ELECTRICAL GROUNDING

SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 REFERENCES

A. This Section covers the specification of grounding for electrical equipment and systems. Refer to SECTION 260010, SECTION 260500, GENERAL CONDITIONS, SUPPLEMENTARY CONDITIONS and applicable parts of DIVISION 1 for other general requirements.

1.02 SCOPE

A. Provide labor, materials, services, equipment and transportation necessary for complete and operational grounding systems as indicated on Contract Drawings and specified herein, including but not limited to following:

1. Service ground
2. Equipment grounds
3. Ground fault protection
4. Building and piping ground system
5. Telecommunications Systems in compliance with ANSI/TIA/EIA 607 - Commercial Building Grounding and Bonding Requirements for Telecommunications
6. Systems Commissioning

1.03 SHOP DRAWING SUBMITTALS

A. Submit for review shop drawings for the following:

1. Ground rods
2. Bus
3. Bushings and pressure lugs
4. Pipe clamps
5. Circuit breakers
6. Grounding conductors
7. Receptacles
8. Plug-in tester unit

PART 2 - PRODUCTS

2.01 SERVICE GROUND

A. Provide one green insulated copper grounding electrode conductor in 3/4" conduit from the service entrance switchboard ground bus to the grounding electrode system. Grounding electrode conductor shall be installed in one continuous length, without splice or joint, per NEC Article 250.64(C). Grounding electrode conductor shall be #4/0 AWG unless otherwise noted on contract drawings.

B. Provide grounding electrode system in accordance with NEC Articles 250.50 and 250.52. System shall consist of water service piping, concrete-encased electrode and three ground rods in delta configuration. Concrete-encased electrode shall be at least 20 feet of bare #4 AWG copper encased in concrete, unless otherwise noted on contract drawings. Grounding electrode conductor shall be connected to water service piping using acceptable pipe clamp by OZ/Gedney or acceptable equivalent.

C. Provide main bonding jumper per NEC Article 250.28. Jumper shall bond together equipment ground bus, switchgear enclosure and grounded service conductor (neutral) and shall be 500 kcmil unless otherwise indicated on contract drawings. Where main switchgear bus work meets the bonding requirements indicated, additional bonding conductors are not required.

D. Provide transformer grounding counterpoise for service transformers. Refer to Contract Drawings.

2.02 EQUIPMENT GROUNDS

A. Provide green THW insulated copper equipment grounding conductor between the ground bus of the source distribution panel or switchboard and each load being served. Conductor shall be sized according to NEC Table 250.122. Provide separate grounding conductor for each branch circuit, unless otherwise indicated on Contract Drawings.

2.03 GROUND FAULT PROTECTION

A. If excessive ground current flows in feeders to 480 V main switchboard, main breakers and/or circuit breakers with ground fault sensing shall trip to protect switchboard against arcing ground faults.

B. Provide ground fault circuit interrupter protection for receptacles as required and indicated.

2.04 TELECOMMUNICATIONS SYSTEM GROUND BUSSES

A. Provide grounding busses as follows:

1. Telecommunications Building Entrance Facility: Provide a Telecommunications Main Grounding Busbar (TMGB) pre-drilled with Standard NEMA two-bolt hole sizing and spacing, 1/4" thick by 4" wide by 36" long. Provide electrotin plated copper busbar.
2. Telecommunications Closets or Rooms: provide a Telecommunications Grounding Busbar (TGB) pre-drilled for Standard NEMA two-bolt hole sizing and spacing, 1/4" thick x 2" wide x 24" long. Provide electrotin plated copper busbar.

B. Bonding and Grounding Jumper Cable

1. Provide products meeting the requirements of the Drawings and Specifications from one of the following manufacturers:

   a. Belden (No. 8669) or equivalent.

2. Jumper cable shall be hollow braided, 60 Amp capacity, copper.
3. Provide equal conductor as described in "B" above for aluminum equipment.
4. Jumpers shall have compression or exothermic type terminals on both ends of cables. Terminals shall be compatible with jumper cable material and equipment material in order to not have any degenerative reaction.

2.05 MATERIALS

A. Ground rods shall be 3/4" x 10'-0" copper-clad steel, by Carolina or acceptable equivalent.

B. Below-grade and concealed connections shall be Thermweld, Cadweld or acceptable equivalent. Above-grade and exposed connections shall be Burndy or acceptable equivalent.

C. Wire shall be stranded bare copper or insulated copper, as indicated on Contract Drawings.

D. Bus shall be copper bar.

E. Bushings and Pressure Lugs shall be by T&B, O.Z./Gedney or acceptable equivalent.

F. Pipe Clamps shall be by O.Z./Gedney or acceptable equivalent.

PART 3 - EXECUTION

3.01 INSTALLATION - GENERAL

A. Refer to SECTION 260500, BASIC MATERIALS & METHODS - ELECTRICAL.

B. Grounding shall be installed and tested in accordance with NEC (NFPA 70) and to satisfaction of local electrical inspector and Architect.

C. If outlet is located within six feet of sink of faucet, outlet shall use GFI receptacles.

3.02 EQUIPMENT GROUNDS

A. Equipment grounds shall be continuous from ground bus to electrical equipment and devices.

B. Provide equipment grounds for electrical equipment furnished or installed as part of this Contract.

C. Grounded service conductor (neutral) of 480Y/277 V distribution system shall be grounded at only one point: neutral connection to the ground bus. Under no circumstances shall system neutral be grounded at any other point. As part of final inspection procedures, demonstrate purity of system neutral.

D. Regardless of rating or length, circuits run in FMC shall carry grounding conductor for that portion of circuit in FMC; bond conductor at each end.

E. Current return conductors (neutrals), which are grounded at the source, shall NOT be used for equipment grounding. Provide separate conductors for equipment grounding; refer to SECTION 260500, paragraph on IDENTIFICATION, for color requirements.

F. Grounding conductor shall be secured to equipment enclosure at power source (usually to a ground bus) and at apparatus being served by AC supply. Grounding conductors shall be insulated and shall be large enough to carry ground fault current safely.

G. Provide following for panelboards: neutral bus insulated from enclosure; and grounding bus bonded to enclosure. Grounding bus shall have means for termination of grounding conductors to panelboard cabinet.

H. Maintain electrical continuity of raceways by the following means:

1. Threaded fittings with joints made up wrench-tight where threaded rigid conduit is used.
2. Threadless fittings made up tight.
3. Metal bushing inside and locknut outside of metal boxes and cabinets when threaded conduit is used. If outside locknut is inaccessible for tightening after installation, provide additional locknut inside. If bushing is composed entirely of insulating material, use locknuts inside and outside.
4. Bonding jumper across joints of wireways, cable trays, expansion or deflection fittings, etc.
5. Devices listed for the purpose by UL.

I. NOTE: Addition of equipment grounding conductor to AC circuits run in metallic enclosures does NOT lessen the requirement for conductor enclosure continuity, since part of total ground fault current will flow through the raceway and enclosure system. Therefore, the continuity of this system shall be maintained.

3.03 IDENTIFICATION

A. Engrave nameplates of receptacles wired to GFI breakers to read "GFI" adjacent to or above receptacle opening.

3.04 TELECOMMUNICATIONS GROUNDING

A. Raceways including wireways, conduits, cable trays, etc. installed for low voltage or fiber optic cabling shall be made electrically continuous for grounding purposes. Provide hollow braided copper jumpers equal to Belden No. 8669 (60A Ampacity). Provide equal impedance conductor for aluminum raceway. Provide connections from each item to the ground bus or if bonded in series provide two separate connections to the ground bus so as to form a loop.

B. Bond raceways to the ground bus located in the telecommunications closets/rooms. Bond raceways in each room they terminate in.

C. Provide a ground bus mounted on insulators 2 inch off wall in each Telecommunication Closet or Room, near location of backbone cabling, at plywood backboard when not in a dedicated Telecommunications Room, and at building entrances of Telecommunication cabling. Bond bus to building steel, raceways, racks and cabinets with a hollow braided conductor equal to Belden No. 8669 (60 A Ampacity). Bond to the room power source equipment ground bus with a No. 4 AWG copper insulated conductor in a 3/4" C. Bond to conduit at each end.

D. Bond Telecommunications ground busses together with a No. 2/0 AWG copper insulated Telecommunications Bonding Backbone (TBB). Provide compression connectors with NEMA two-hole bolted connections to ground bus. Bond TBB to TMGB at Telecommunications Service Entrance. Bond TMGB to Building Service Main Electrical Ground Bus (MEGB) at Main Electric Service Room.

E. Where two or more vertical Telecommunications Bonding Backbones (TBB) are used in a multi-story building, bond with an equal size TBB at the top floor, bottom floor and every other floor.

F. Install TBB in conduit; bond TBB to conduit and ground bus at each end.

G. Grounding or bonding conductors installed for Telecommunications Systems shall be labeled near their termination points. Labels shall be non-metallic and include the following:

1. "WARNING if this connector or cable is loose or must be removed, please call the Building Telecommunications Manager."
2. Labels and installation shall meet the requirements of ANSI/TIA/EIA 606 and 607.

3.05 TESTS

A. Test and inspect the main grounding electrode system in accordance with Section 7.13 of the NETA Handbook for Electrical Testing Procedures. Perform a resistance to ground test and insure that resistance is no greater than 5 (five) ohms. Investigate and supplement grounding system where resistance exceeds recommended values and re-test as required.

B. Ground Fault Circuit Interruption shall be tested after installation by random connection of plug-in tester to various protected receptacles, as directed by Architect.

C. The main service disconnect switch's ground fault protection equipment shall be performance tested when first installed on site per manufacturer's instructions and NETA Acceptance Testing Specifications Inspection and Test Procedures for Ground-Fault Protection Systems. Tests shall include, but not be limited to, resistance measurements through all bolted connections, insulation resistance test on all control wiring and pick up tests using primary injection.

END OF SECTION 260526

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SECTION 260548 – VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

SECTION 260548 - VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 REFERENCES

A. This Section covers the specification of seismic restraint for electrical systems. Refer to SECTION 260010, SECTION 260500, GENERAL CONDITIONS, SUPPLEMENTARY CONDITIONS and applicable parts of DIVISION 1 for other general requirements.

1.02 SCOPE

A. Provide labor, materials, equipment, services and transportation for seismic restraint systems for electrical equipment, conduit, busway, and other wiring systems as indicated on Contract Drawings and specified herein, including but not limited to following:

1. Seismic restraint systems, including equipment bolts and welding.
2. Flexible connections.
3. Equipment bases.

B. Refer to SECTION 265100, "LUMINAIRES", for further requirements regarding seismic restraint of lighting fixtures.

C. Seismic devices shall be by manufacturer with 5 years experience in designing and manufacturing seismic devices.

1.03 SHOP DRAWINGS AND OTHER SUBMITTALS

A. Submit for review shop drawings on every product and material furnished under this Section.

B. Shop drawings shall include:

1. Itemized list detailing electrical systems and components to be seismically restrained, associated seismic restraint system to be used, device loading and reference to specific drawings showing base and construction where applicable. List shall include number and location of seismic restraints and anchors for each piece of equipment.
2. Itemized list detailing electrical systems and components which are to be neither isolated nor seismically restrained.
3. Seismic restraint calculations.
4. Structural Engineer's seal verifying design and calculations for seismic restraining systems. Certification shall be by a professional structural engineer with P.E. registration in the state in which the project is located.
5. Detail drawings on equipment bases including dimensions, structural member sizes, support point locations, maximum loading at each location, and concrete and steel details such as anchor bolt locations.
6. All seismic restraining devices shall have a pre-approved number from California OSHPD or other recognized government agency showing maximum restraint ratings.

7. Detail drawings on seismic restraint systems for conduit, busway, cable tray and other wiring systems, including methods of suspension, support guides, and maximum loading at each location.

C. In addition to other requirements for approval of substitutions:

1. Contractor must prove substitute systems meet the deflection and structural design of systems specified.
2. Requests for substitution of "internally isolated" electrical equipment in lieu of specified restraint systems must include certification by equipment manufacturer that equipment supports meet specified seismic restraint criteria. Certification must be sealed by Structural Engineer.

D. Shop drawing for equipment shall include bolt points and diameter of inserts, certified by civil or structural engineer.

E. Submit seven copies of manufacturer's installation instructions and drawings.

F. Submit seven copies of final inspection report which includes:

1. Manufacturer's report(s) indicating restraint devices as properly installed or requiring correction. Correction measures shall be detailed.
2. Contractor's report detailing steps taken to properly complete the isolation work.

1.04 GUARANTEE

A. Manufacturer of seismic control equipment shall guarantee performance of the seismic restraint systems including specified system deflection.

PART 2 - PRODUCTS

2.01 SEISMIC RESTRAINT SYSTEMS - GENERAL

A. Systems shall comply with the 2003 International Building Code and with all Federal, State and local requirements.

B. System for seismic restraint of normal equipment shall be capable of safely accepting 0.5 “G” external force in any direction, without failure and without permanent displacement of system being restrained.

C. Systems for seismic restraint of life safety equipment (e.g., emergency distribution) shall be capable of safely accepting 1.0 “G” external force in any direction, without failure and without permanent displacement of system being restrained.

D. Systems shall maintain electrical equipment, conduit, and other wiring systems in a captive position.

2.02 SEISMIC RESTRAINT PRODUCTS

A. Refer to Paragraph 2.1 above for general requirements. Products shall be manufactured by Mason Industries (M.I), Vibrations Mountings and Controls or Grinnell.

B. Certified seismic anchor bolt: M.I. Type SAB

C. Certified seismic anchor stud: M.I. Type SAS

D. Bolt isolation washer bushing: M.I. Type HG

E. Panelboard mount: M.I. Type PB

F. Seismic cable brace anchor and assembly: M.I. Type SLB

G. Seismic cable brace hook anchor assembly: M.I. Type SCBH

H. Seismic solid brace swivel anchor assembly: M/I. Type SSB

I. Seismic restrained spring mount assembly: M.I. Type SLR.

2.03 EQUIPMENT STRUCTURES, BASES AND RAILS

A. General

1. Units shall meet seismic restraint criteria specified in Paragraph 2.1, SEISMIC RESTRAINT SYSTEMS - GENERAL. Units shall form a rigid support structure which will not twist, rack, deform or deflect so as to negatively affect operation of supported equipment or performance of vibration isolation.
2. Units shall support basic equipment units and motors, pipe and conduit, electrical control elements and other components requiring attachment to, and support from, the building structure.

PART 3 - EXECUTION

3.01 GENERAL INSTALLATION REQUIREMENTS

A. Furnish services of manufacturer for field supervision of installation of seismic restraint units, associated hangers and bases. Obtain copy of manufacturer's installation instructions and drawings, for Contractor's use during installation.

B. Install devices in accordance with manufacturer's written instructions. Seismic restraint equipment shall NOT cause any change of position of equipment or wiring resulting in wiring stresses or misalignment.

C. Piping, ductwork and conduit shall NOT be suspended from one another and shall NOT physically contact one another, under any circumstances.

D. Install equipment with flexibility in wiring connection.

E. For overhead suspended non-isolated systems, install seismic restraint system taut. For isolated systems, install seismic restraint system slack with 1/2" cable deflection.

3.02 INSTALLATION OF EQUIPMENT BASES AND SUPPORTS

A. With concrete base, provide supports for conduit bends connections. Where concrete base is non-rectangular, "T" shaped, or "L" shaped, locate mountings under projections and main body of concrete base, to eliminate cantilevering of projections.

B. If equipment is mounted on housekeeping pads, pads shall be properly doweled or expansion shielded to structural deck to meet seismic restraint criteria.

C. Where base anchoring is insufficient to resist seismic forces, supplementary restraints shall be installed. Restraints shall be attached to equipment at point(s) above the equipment's center of gravity, as required. Equipment with high center of gravity may require this additional restraint.

D. Ensure that overhead supported equipment does NOT over-stress the building structure. This might be accomplished by bracing from:

1. Flanges of structural beams.
2. Upper or lower truss chords in bar joist construction at the panel points.
3. Cast-in-place inserts or drilled and shielded inserts in concrete structures.
4. Where needed by specific equipment OR device requirements, verify that seismic restraint systems permit equipment motion in all directions. Adjust or provide additional resilient restraints to flexibly limit start-up equipment lateral motion to 1/4".

E. Prior to start-up, remove foreign matter between bases and equipment.

3.03 SEISMIC RESTRAINT SCHEDULE

A. Seismic restraint shall be provided on wiring systems where the system is supported by hangers longer than 12", as measured from top of wiring system to bottom of supporting structure. Restraint type shall be as follows:

Wiring System	*Size*	*Seismic Restraint Type*
Conduit	Larger than 2-1/2"	SCB/SSB
Racked Multiple Conduits	Any Size	SCB/SSB
Other electrical systems (i.e., cable tray or busway)	Any Size	SCB/SSB

B. Seismic restraint shall be provided on electrical equipment. Device types shall be as follows:

Equipment	*Seismic Restraint Type (Mason Ind.)*
Panelboard	PB/Approved wall mounting system
Transformer/Switchboards	HG/SAS/SAB
Floor/roof-mounted non-isolated equipment, if not specified elsewhere	HG/SAS/SAB
Wall-mounted non-isolated equipment, if not specified elsewhere	PB/Approved wall mounting system
Non-isolated equipment suspended from structure, if not specified elsewhere	SCB/SSB
Floor mounted isolated equipment (i.e., generators) if not specified elsewhere	SLR/SAB/Welded

C. Refer to Section 263213, "Engine Generators" for additional requirements.

3.04 INSPECTION

A. Furnish services of structural engineer with P.E. registration in the state in which the project is located, to review the system, to inspect the completed system and to verify that there are no isolation short circuits in equipment mounting/bases, isolators or seismic restraints. Engineer shall furnish written certification on installation; refer to Paragraph 1.3.F.

END OF SECTION 260548

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SECTION 260560 – ELECTRICAL TESTING

SECTION 260560 - ELECTRICAL TESTING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. This Section includes general requirements for electrical field testing and inspecting. Detailed requirements are specified in each Section containing components that require testing. General requirements include the following:

1. Qualifications of testing agencies and their personnel.
2. Suitability of test equipment.
3. Calibration of test instruments.
4. Coordination requirements for testing and inspecting.
5. Reporting requirements for testing and inspecting.

B. Allowances: Electrical tests and inspections specified in various Division 26 Sections are covered by a testing and inspecting allowance specified in Division 1 Section "Allowances." See Division 1 Section "Allowances" for what is included in allowance amount, the amount of the allowance, payment procedures for allowances, changes to allowance amounts, and disposition of unused portions of allowance.

1.03 QUALITY ASSURANCE

A. Testing Agency Qualifications: As specified in each Section containing electrical testing requirements.

PART 2 - NOT USED

PART 3 - EXECUTION

3.01 GENERAL TESTS AND INSPECTIONS

A. If a group of tests are specified to be performed by an independent testing agency, prepare systems, equipment, and components for tests and inspections, and perform preliminary tests to ensure that systems, equipment, and components are ready for independent agency testing. Include the following minimum preparations as appropriate:

1. Perform insulation-resistance tests.
2. Perform continuity tests.
3. Perform rotation test (for motors to be tested).
4. Provide a stable source of single-phase, 208/120-V electrical power for test instrumentation at each test location.

B. General Wiring Tests

1. Prior to final inspection and tests: wiring and connections shall be completed, devices and equipment shall be properly operating, power and lighting circuit and control wiring shall be clearly identified with acceptable tags, and lighting fixtures shall be installed, ready for acceptance.

C. Operational Tests

1. Each piece of electrical equipment, including lighting fixtures, motors and controls shall be operated continuously for minimum test period of one hour.
2. Demonstrate by operating equipment that circuits and devices are in good operating condition. Each item of control equipment shall be operated minimum of five times. Demonstration shall be performed after wiring tests.

D. Mechanical System Adjustment and Testing

1. Be present during adjustment period and final testing of mechanical systems. Take readings necessary to ensure that electrical systems are operating properly. Tests for mechanical work are detailed under DIVISION 15, MECHANICAL WORK.
2. Take ampere readings at each electrical component, such as motor and heating coil, to determine proper operation.
3. Record readings and submit them in triplicate to Engineer for review.

E. Test and Inspection Reports: In addition to requirements specified elsewhere, report the following:

1. Manufacturer's written testing and inspecting instructions.
2. Calibration and adjustment settings of adjustable and interchangeable devices involved in tests.
3. Tabulation of expected measurement results made before measurements.
4. Tabulation of "as-found" and "as-left" measurement and observation results.

END OF SECTION 260560

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SECTION 260573 – OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

SECTION 260573 - OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes computer-based, fault-current and overcurrent protective device coordination studies, and the setting of these devices.

1. Prepare a fault-current and coordination study for all existing electrical overcurrent devices and for all new electrical overcurrent devices to be installed under this project to assure proper equipment and personnel protection.

2. The study shall present an organized time-current analysis of each protective device in series from the individual device back to the utility and the on-site generator sources. The study shall reflect the operation of each device during normal and abnormal current conditions.

3. Provide study reports with Professional Engineer's seal verifying calculations. Certification shall be by a Professional Electrical Engineer with P.E. registration in the state in which the project is located. One copy is to have live seal. The remaining copies may have photocopies of the Engineer's seal.

1.3 SUBMITTALS

A. Product Data: For computer software program to be used for studies.

B. Product Certificates: For coordination-study and fault-current-study computer software programs, certifying compliance with IEEE 399.

C. Qualification Data: For coordination-study specialist.

D. Other Action Submittals:

1. Coordination-study input data, including completed computer program input data sheets.
2. Fault-current and coordination-study report.
3. Equipment evaluation report.
4. Setting report.

1.4 QUALITY ASSURANCE

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are not acceptable.

B. Coordination-Study Specialist Qualifications: An organization experienced in the application of computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.

C. Testing Agency Qualifications: Member company of the InterNational Electrical Testing Association.

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association to supervise testing specified in Part 3.

D. Comply with IEEE 399 for general study procedures.

E. Comply with IEEE 242 for short-circuit currents and coordination time intervals.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

A. Available Computer Software Developers: Subject to compliance with requirements, companies offering computer software programs that may be used in the Work include, but are not limited to, the following:

B. Computer Software Developers: Subject to compliance with requirements, provide computer software programs developed by one of the following:

1. EDSA Micro Corporation.
2. SKM Systems Analysis, Inc.

2.2 COMPUTER SOFTWARE PROGRAM REQUIREMENTS

A. Comply with IEEE 399.

B. Analytical features of fault-current-study computer software program shall include "mandatory," "very desirable," and "desirable" features as listed in IEEE 399, Table 7-4.

C. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices.

1. Optional Features:

a. Arcing faults.
b. Simultaneous faults.
c. Explicit negative sequence.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Devices to be coordinated are indicated on Drawings.

B. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices not submitted for approval with coordination study may not be used in study.

3.2 FAULT-CURRENT STUDY

A. Source Impedance: Utility company's fault-current contribution as indicated.

B. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project and use approved computer software program to calculate values. Include studies of system-switching configurations and alternate operations that could result in maximum fault conditions.

C. Calculate momentary and interrupting duties on the basis of maximum available fault current.

D. Calculations to verify interrupting ratings of overcurrent protective devices shall comply with the following:

1. Low-Voltage Circuit Breakers: IEEE 1015 and IEEE C37.50.
2. Low-Voltage Fuses: IEEE C37.46.
3. Circuit Breakers: IEEE C37.13.

E. Study Report: Enter calculated X/R ratios and interrupting (5-cycle) fault currents on electrical distribution system one-line diagram of the report. List other output values from computer analysis, including momentary (1/2-cycle), interrupting (5-cycle), and 30-cycle fault-current values for 3-phase, 2-phase, and phase-to-ground faults.

F. Equipment Evaluation Report: Prepare a report on the adequacy of overcurrent protective devices and conductors by comparing fault-current ratings of these devices with calculated fault-current momentary and interrupting duties.

3.3 COORDINATION STUDY

A. Gather and tabulate the following input data to support coordination study:

1. Product Data for overcurrent protective devices specified in other Division 26 Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Impedance of utility service entrance.

3. Electrical distribution system one-line diagram showing the following:

    a. Load current that is the basis for sizing continuous ratings of circuits for cables and equipment.
    b. Circuit-breaker and fuse-current ratings and types.
    c. Relays and associated power and current transformer ratings and ratios.
    d. Transformer kilovolt amperes, primary and secondary voltages, connection type, impedance, and X/R ratios.
    e. Generator kilovolt amperes, size, voltage, and source impedance.
    f. Cables. Indicate conduit material, sizes of conductors, conductor insulation, and length.
    g. Busway ampacity and impedance.
    h. Motor horsepower and code letter designation according to NEMA MG 1.

4. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram:

    a. Special load considerations, including starting inrush currents and frequent starting and stopping.
    b. Magnetic inrush current overload capabilities of transformers.
    c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
    d. Ratings, types, and settings of utility company's overcurrent protective devices.
    e. Special overcurrent protective device settings or types stipulated by utility company.
    f. Time-current-characteristic curves of devices indicated to be coordinated.
    g. Manufacturer, frame size, interrupting rating in amperes RMS symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
    h. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
    i. Panelboards, switchboards, motor-control center ampacity, and interrupting rating in amperes RMS symmetrical.

B. Perform coordination study and prepare a written report using the results of fault-current study and approved computer software program. Comply with IEEE 399.

C. Comply with NFPA 70 for overcurrent protection of circuit elements and devices.

D. Comply with IEEE 242 recommendations for fault currents and time intervals.

E. Transformer Primary Overcurrent Protective Devices:

1. Device shall not operate in response to the following:

    a. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
    b. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.

2. Device shall protect transformer according to IEEE C57.12.00, for fault currents.

F. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and conductor melting curves in IEEE 242. Verify adequacy of phase conductors at maximum three-phase bolted fault currents, equipment grounding conductors, and grounding electrode conductors at maximum ground-fault currents.

G. Coordination-Study Report: Prepare a written report indicating the following results of coordination study:

1. Tabular Format of Settings Selected for Overcurrent Protective Devices:

a. Device tag.
b. Relay-current transformer ratios; and tap, time-dial, and instantaneous-pickup values.
c. Circuit-breaker sensor rating; and long-time, short-time, and instantaneous settings.
d. Fuse-current rating and type.
e. Ground-fault relay-pickup and time-delay settings.

2. Coordination Curves: Prepared to determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between series devices, including power utility company's upstream devices. Show the following specific information:

a. Device tag.
b. Voltage and current ratio for curves.
c. Three-phase and single-phase damage points for each transformer.
d. No damage, melting, and clearing curves for fuses.
e. Cable damage curves.
f. Transformer inrush points.
g. Maximum fault-current cutoff point.

3. Completed data sheets for setting of overcurrent protective devices.

3.4 OVERCURRENT PROTECTIVE DEVICE SETTING

A. Manufacturer's Field Service: Engage a factory-authorized service representative, of electrical distribution equipment being set and adjusted, to assist in setting of overcurrent protective devices within equipment.

B. Testing: Owner will engage a qualified testing agency to perform device setting.

C. Testing: Engage a qualified testing agency to perform the following device setting and to prepare test reports.

D. Testing: Perform the following device setting and prepare reports:

1. After installing overcurrent protective devices and during energizing process of electrical distribution system, perform the following:

    a. Verify that overcurrent protective devices meet parameters used in studies.
    b. Adjust devices to values listed in study results.

2. Adjust devices according to recommendations in Chapter 7, "Inspection and Test Procedures," and Tables 10.7 and 10.8 in NETA ATS.

END OF SECTION 260573

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SECTION 260590 – HEAT TRACING

SECTION 260590 - HEAT TRACING

PART 1 - GENERAL

1.1 REFERENCES

A. This Section covers the specification of heat tracing for use on piping systems. Refer to SECTION 260010, SECTION 260500, GENERAL CONDITIONS, SUPPLEMENTARY CONDITIONS and applicable parts of DIVISION 1 for other general requirements.

1.2 SCOPE

A. Provide labor, materials, services, equipment and transportation necessary for complete and operational heat tracing systems as shown on Contract Drawings and specified herein, including, but not limited to, the following:

1. Cable
2. Controls
3. Connectors and Mounting
4. Systems Commissioning

1.3 SHOP DRAWING SUBMITTALS

A. Submit for review shop drawings on heat tracing systems.

B. Submittals shall include:

1. Copy of UL file indicating the heating cable is specifically listed for heat tracing applications.
2. Manufacturer's catalog cuts showing materials and performance data.

PART 2 - PRODUCTS

2.1 ELECTRICAL HEAT TRACING FOR PIPING

A. Self-regulating heater shall consist of two 16 AWG tinned-cooper bus wires embedded in parallel, in self-regulating polymer core; with radiation cross-lined modified polyolefin dielectric jacket, outer braid of tinned copper, and outer jacket of polyolefin dielectric. Heater shall be Raychem "XL-Trace" or equal by Thermon or Brisk-Heat.

B. Heater shall vary its power output to respond to temperature along its length, allowing heater to cross over itself without overheating. Heater shall be capable of being used directly on plastic pipe and of being cut to length in field.

C. Heater shall have self-regulating factor of 90 percent minimum. Self-regulating factor is the percentage reduction, without thermostatic control, of the heater output going from 40°F pipe temperature operation to 150°F pipe temperature operation.

D. Heat tracing shall be UL listed with thermal ratings as follows. Refer to Drawings for specific applications.

1. Raychem "XL-Trace" #5XL1-CR: 5 Watts per linear foot at 50°F operating at 120 Volt, single phase.
2. Raychem "XL-Trace" #5XL2-CR: 5 Watts per linear foot at 50°F operating at 208/277 Volt, single phase.
3. Raychem "XL-Trace" #8XL1-CR: 8 Watts per linear foot at 50°F operating at 120 Volt, single phase.
4. Raychem "XL-Trace" #8XL2-CR: 8 Watts per liner foot at 50°F operating at 208/277 Volt, single phase.

E. Each run of heat trace cable shall have Raychem "RAYCLIC-PC" power connection: Raychem "Rayclic-T" Tee: Raychem "RAYCLIC-S" splice; Raychem "RAYCLIC-E" end seal kit; Raychem #ETL "ELECTRIC TRACED" pipe labels; Raychem #GT-66 glass cloth adhesive tape for metal piping; and Raychem #AT-180 aluminum tape for plastic piping.

F. Heating cable shall operate at rated line voltage without use of transformers.

G. System shall be controlled by ambient sensing thermostat: Raychem #AMC-1A. Sensing shall be set at 40°F, located on outside of pipe insulation.

H. Contactor shall be Raychem "E Series" 120 Volt coil with poles as noted on Drawings; contacts rated at 40 A per pole; NEMA 4X enclosure.

I. Heating cable circuit shall be protected by 30 mA ground fault sensing circuit breaker for equipment and personnel protection. Ground fault sensing receptacles shall not be used.

J. Maximum circuit lengths of heater cable shall be as follows:

1. 5XL1-CR: 250 feet
2. 5XL2-CR: 450 feet
3. 8XL1-CR: 190 feet
4. 8XL2-CR: 350 feet

K. Exact lengths of heater cable required for each run shall be coordinated between Electrical Contractor and Mechanical/Plumbing Contractors based on coordination drawings submitted.

2.2 GROUND FAULT PROTECTIVE DEVICES – INDIVIDUAL

A. Each circuit of self-regulating heating cable shall be sourced by a 30ma ground fault circuit breaker. Standard 5ma trip GFI breakers shall not be permitted.

1. Ground fault circuit breakers shall match in manufacture, the panelboards that are used on the project. Ground fault circuit breakers used for heat trace systems shall be capable of being mounted in panelboard without any modifications to panelboard being furnished. Single pole GFI circuit breakers will require two poles for mounting.

2. For 120V circuits between 15 amp and 30 amp rating, circuit breakers shall be as follows:

   a. Square D: Type "QOB-EPD", 1 pole bolt-in
   b. General Electric: Type "THQB-GFEP", 1 pole bolt-in
   c. Cutler Hammer: Type "QE", 1 pole plug-in
   d. Siemens: Type: "BLE" 1 pole bolt-in

3. For 208V circuits between 15 amp and 50 amp rating, circuit breakers shall be as follows:

   a. Square D: Type "QOB-EPD", 2 pole bolt-in
   b. General Electric: Type THQB-GFEP" 2 pole bolt-in (up to 40Amp only)
   c. Cutler Hammer: Type " QE", 2 pole plug-in
   d. Siemens: Type: "BLE", 2 pole bolt/plug-in

4. For 277V circuits between 15 amp and 50 amp rating, circuit breakers shall be as follows:

   a. Square D: Raychem "TraceGard 277" GFEPD, 1 pole bolt-in
   b. General Electric: Not Available
   c. Cutler Hammer: Type "GHBGFEP", 1 pole bolt-in (up to 60Amp)
   d. Siemens: Type: "ED", 1 pole bolt-in

B. 120/208V ground fault circuit breakers are limited to 10 KAIC interrupting rating.

C. 277V ground fault circuit breakers are limited to 14 KAIC interrupting rating.

2.3 POWER DISTRIBUTION MONITORING PANEL

A. Provide a dedicated power distribution, control, ground fault protection, monitoring and alarm panel for heat trace/temperature maintenance/snow melting/roof and gutter de-icing applications where shown on drawings or specified elsewhere. Panel shall be Tracer "HTPG" by Tyco Thermal Controls.

B. Panel shall include main breaker, 3 pole contactor, Hand-Off-Auto switch and 30ma ground fault trip branch breakers mounted in NEMA 12 indoor enclosure.

C. Panel shall operate at 120/208V or 277/480V using Square D Type "QOB-EPD" or Type "EHB-EPD" 30ma trip ground fault branch breakers. 120V branch breakers shall be available in 15A, 20A, and 30A trip ratings. 208/277V branch breakers shall be available in 15A, 20A, 30A, 40A and 50A trip ratings.

PART 3 - EXECUTION

3.1 INSPECTION

A. Examine work prepared by others to receive work of this Section and report defects affecting execution to Contractor for correction. Commencement of work will be construed as complete acceptance of preparatory work by others.

3.2 INSTALLATION OF HEAT TRACING

A. Apply heat tracing linearly on piping after it has been successfully pressure tested and before mechanical insulation is installed under DIVISION 23, MECHANICAL WORK.

B. Apply single run of heat tracing linearly on piping 6" and smaller; install double run of heat tracing on piping 8" and larger, unless indicated otherwise.

1. Secure heat tracing to piping with fiberglass tape. Wrap valves and flanges according to manufacturer's requirements.
2. At pipe expansion coupling, apply aluminum tape. Heat tracing shall be looped over coupling length to permit expansion and contraction.

C. For heat tracing cooling tower piping, apply two runs of heat tracing linearly on all piping. Runs shall be installed at the 225° and 315° position of pipe in cross sections.

1. Secure heat tracing to piping with fiberglass tape. Wrap valves and flanges according to manufacturer's requirements.
2. At pipe expansion coupling, apply aluminum tape. Heat tracing shall be looped over coupling length to permit expansion and contraction.

D. Apply "ELECTRIC TRACED" labels to outside of thermal insulation, one sign every five feet.

E. Perform megger testing of heat trace system, using 2500 VDC megger at following times. Minimum insulation resistance shall be 20 megohms regardless of length.

1. After installation of heat trace system and before installation of mechanical insulation.
2. After installation of mechanical insulation.

END OF SECTION 260590

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SECTION 262400 - SERVICE AND DISTRIBUTION

SECTION 262400 - SERVICE AND DISTRIBUTION

PART 1 - GENERAL

1.1 REFERENCES

A. This Section covers the specification of secondary electrical service and distribution systems. Refer to SECTION 260010, SECTION 260500, GENERAL CONDITIONS, SUPPLEMENTARY CONDITIONS and applicable parts of DIVISION 1 for other general requirements.

1.2 SCOPE

A. Provide labor, materials, services, equipment and transportation necessary for complete and operational secondary electrical service and distribution systems as indicated on Contract Drawings and specified herein, including but not limited to following:

1. Switchboard
2. Interior dry type distribution transformers
3. Lighting and power panelboards
4. New motor control sections in Chiller Plant
5. Fuses and circuit breakers
6. Systems Commissioning

B. For related work, refer to SECTION 260548, VIBRATION AND SEISMIC CONTROL FOR ELECTRICAL SYSTEMS.

1.3 SHOP DRAWING SUBMITTALS

A. Submit for review shop drawings on following:

1. Switchboard
2. Panelboard
3. Transformer
4. Motor control center sections
5. Circuit breakers
6. Fuses

B. Submit coordination curves for breakers and fuses with shop drawing submittals for review. Acceptance of system components will be contingent upon achievement of reasonable coordination of system. Final sizing of fuses and selection of trip settings shown on Contract Drawings are subject to this coordination review by Architect and manufacturer's representative.

C. Submit five copies of test report, for review by Engineer.

1.4 STANDARDS

A. Work of this Division shall conform to following standards, as applicable:

1. NEMA Instructions for Safe Installation, Operation, and Maintenance of Panelboards Rated 600 Volts or less.
2. NEMA Instructions for Safe Handling, Installation, Operation and Maintenance of Busway and Associated Fittings.

PART 2 - PRODUCTS

2.1 SWITCHBOARD

A. Switchboard shall be front connected, front accessible with fixed, individually mounted main devices, group mounted feeder devices and sections rear aligned.

B. Switchboard shall have UL label and shall meet UL enclosure requirements. Provide NEMA 1 enclosure for switchboard. Switchboard shall be Square D Power-Style QED or acceptable equivalent by General Electric, Cutler Hammer or Siemens.

C. Switchboard main device shall have ground fault protection, shunt trip and auxiliary switches for all applications rated at 1000 Amperes or above with a solidly grounded system above 150 Volts to ground per NEC.

1. Provide ground fault protection on switchboard feeder breakers rated at 225 Amperes and above where the main device is equipped with ground fault protection.
2. This allows for selective coordination between the feeders and the main for low level ground faults that would not otherwise be detected by the feeder breakers.

D. Switchboard, as a complete unit, shall have single short circuit current rating of 100,000 Amps RMS symmetrical, established by actual tests which meet UL specifications and were made on switchboard of similar construction. Series ratings are not acceptable.

E. Switchboard shall be dead-front with steel channel supports bolted to rigidly welded framework of code gauge steel, supporting cover plates, bussing and components. Paint finish shall be ANSI #49 medium light gray. Switchboard construction shall be rated for Seismic Zone 2 applications per BOCA.

F. Each switchboard section shall have open bottom and individual removable top plate, for installation and termination of conduit. Wireway front covers shall be hinged, permitting easy access to branch circuit breaker load-side terminals.

G. Switchboard bussing shall be of sufficient cross-sectional area to meet UL #891 on temperature rise.

H. Through bus shall be plated copper with ampacity as noted on drawings. Through bus supports, connections and joints shall be bolted with hex head bolts and Belleville washers. Through bus shall have provisions for addition of future sections.

I. Unless otherwise noted, vertical distributing bus shall be full capacity, matching through bus.

J. Main disconnect device shall be molded case circuit breaker, totally front accessible and front connectable for applications rated 800 Amperes and below. Main and tie devices shall be individually mounted insulated case circuit breakers with solid-state trip units for all applications rated above 800 Amperes.

K. Branch circuit breakers shall be group mounted molded case circuit breakers, totally front accessible, mounted to permit maintenance and testing without reaching over any line-side bussing. Circuit breakers shall be removable by disconnection of only load-side cable terminations; line- and load-side connections shall be individual to each circuit breaker. Each circuit breaker shall have "push-to-trip" button.

L. Owner's Power Monitoring System

1. All breaker positions shall be metered by a Microprocessor-based unit suitable for three- or four-wire systems, listed and labeled by an NRTL. The system shall be Powerlogic Circuit Monitor Model CM3250.

a. Switch-selectable digital display with the following features:

1) Phase Currents, Each Phase: Plus or minus 1 percent.
2) Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
3) Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
4) Three-Phase Real Power: Plus or minus 2 percent.
5) Three-Phase Reactive Power: Plus or minus 2 percent.
6) Power Factor: Plus or minus 2 percent.
7) Frequency: Plus or minus 0.5 percent.
8) Integrated Demand, with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2 percent.
9) Accumulated energy, in megawatt hours (joules), plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.

b. Mounting: Display and control unit that is flush or semiflush mounted in instrument compartment door.

c. The monitor shall be UL listed per UL 508, CSA recognized under C22.2, CE compliant, and tested for EMC in accordance with the IEC 1000-2, 1000-4, 1000-5 series of electrical tests (level 4), FCC compliant per FCC Part 15, Class A, and vibration and temperature tested. The monitor module shall be rated for an operating temperature range of 0 °C to 60 °C.

d. The metering inputs shall utilize current transformers for the current inputs. It shall be rated 5A nominal and 10A full scale. In addition, it shall be industrially and utility hardened to have an overload withstand rating of 15A continuous and 500A for 1 second.

e. Each monitor shall have built-in RS-485 data communications to allow multipoint communication to multiple computer workstations, programmable controllers, and other host devices, up to a data rate of 19,200 baud.

f. The display shall scale readings automatically, without the need for multipliers.

g. All setup information and reset commands shall be password protected.

h. A KYZ pulse initiator for communication of KWh, kVARh, or kVAh information to third-party energy management systems shall be provided.
i. The monitor shall provide diagnostics to trouble shoot miswired installations.

M. Provide Main Service Protector mounted in main service switchboard.

1. Protector shall be a hybrid high-energy power conditioning filter that incorporates transient voltage surge suppression (TVSS) and high frequency electrical line noise filtering. Protector shall be approved under UL 1449 for use as a transient voltage surge suppressor. Protector shall be Current Technology SEL 200 or equivalent by Liebert or United Power.
2. Protector shall be the open-frame type designed for mounting integral to the switchboard or switchgear.
3. Internal wiring and bussing shall be copper. Protector shall include:

   a. Filed connection mechanical lugs for each phrase, neutral and ground; as applicable. Lugs shall accommodate up to #2 AWG copper conductor.
   b. Integral disconnect switch.
   c. Unit status indicator.
   d. Integral diagnostic test point.
   e. Open-Frame type.
   f. Form C dry contacts for connection to the Building Management System that shall monitor on-line status of unit.
   g. Disturbance counters: Two solid-state, six digit LCD indicators that discriminate between and exhibit both common-mode (L-G) and normal mode (L-N or L-L) disturbances. Counters shall use self-contained lithium batteries, with nominal 10 year life. Reset function shall be secure, remotely located.

4. Coordinate system voltage, poles and wiring configuration with each application.

2.2 DISTRIBUTION TRANSFORMERS

A. Transformers shall be 3-phase 2-winding dry type transformers. Transformers shall have 480 V delta primary with two 2-1/2% ANFC and four 2-1/2% BNFC taps to 208Y/120 V secondary.

B. Transformers shall be totally enclosed and ventilated, Square D, Type EE Energy Efficient transformers or acceptable equivalent by Cutler Hammer/Westinghouse or General Electric. Transformers shall comply with NEMA standard TP-1 for optimum efficiency at 35% load and shall be labeled for EPA Energy Star Program.

C. Transformer enclosure shall be heavy gauge, sheet steel, ventilated, NEMA 1 enclosure. Maximum temperature of enclosure top shall NOT exceed 50□C rise above 40□C ambient. Core of transformer shall be visibly grounded to enclosure, by flexible grounding conductor sized per NEMA, IEEE and ANSI standards.

D. Transformers shall be bottom wired to avoid heat transfer to conduit and shall meet NEMA standards for sound level.

E. Transformer final connections to both primary and secondary shall be run in flexible metal conduit to minimize sound transmission. Combination vibration isolation/seismic restraint mounting pads shall be factory installed between the core and coil assembly and the enclosure. The assembly shall comply with BOCA Seismic Zone 2 requirements.

F. Cores shall be high grade non-aging silicon steel with high magnetic permeability and low hysteresis and eddy current losses. Magnetic flux densities shall be kept well below saturation point.

2.3 DISTRIBUTION TRANSFORMERS (Harmonic Mitigating)

A. Transformers shall be 3-phase, 2-winding dry type, copper, shielded, 115° rise transformer. Transformers shall have 480 V delta primary with two 2-1/2% ANFC and two 2-1/2% BNFC taps to 208Y/120 V secondary. Unit shall include passive harmonic mitigation device and integral transient voltage surge suppression. Units shall be Energy Star TP1 rated. Mounting shall comply with seismic zone 2 requirements per Connecticut Basic Building Code Supplement.

B. Transformer enclosure shall be heavy gauge, sheet steel, ventilated, NEMA 1 enclosure. Maximum temperature of enclosure top shall NOT exceed 50°C rise above 40°C ambient. Core of transformer shall be visibly grounded to enclosure, by flexible grounding conductor sized per NEMA, IEEE and ANSI standards.

C. Transformers shall be bottom wired to avoid heat transfer to conduit and shall meet NEMA standards for sound level.

D. Transformer final connections to both primary and secondary shall be run in flexible metal conduit to minimize sound transmission. Combination vibration isolation/seismic restraint mounting pads shall be furnished and installed by the Contractor between the enclosure and the structure. The assembly shall comply with BOCA seismic zone 2 requirements.

E. Cores shall be high grade non-aging silicon steel with high magnetic permeability and low hysteresis and eddy current losses. Magnetic flux densities shall be kept well below saturation point.

F. Transformers shall be low inrush design.

G. Transformer shall be Harmonics Limited, TransMax Plus.

2.4 PANELBOARDS FOR GENERAL USE

A. Panelboards shall be by Square D, General Electric, or Cutler Hammer. Refer to Contract Drawings for requirements on special ratings and auxiliary devices such as relays, contactors and time switches. Panelboards shall be UL listed and circuit breaker-equipped. Design shall be such that individual breakers can be removed without disturbing adjacent units or without loosening or removing supplemental insulation supplied as means of obtaining clearances as required by UL. Where "space only" is indicated, make provisions for future installation of breaker sized as indicated.

B. Panelboards shall conform to standards of NEMA PB-1. Panelboards shall have distributed phase bussing throughout. Support bus bars on bases independent of circuit breakers. Main buses and back pans shall be designed so that breakers may be changed without machining, drilling, or tapping. Provide isolated neutral bus in each panel for connection of circuit neutral conductors. Provide separate ground bus identified as equipment grounding bus for connecting grounding conductors; bond to steel cabinet. In addition to equipment grounding bus, provide second "isolated" ground bus, where indicated.

C. Panelboards shall have copper bussing.

D. Multiple section panelboards shall have same height boxes.

E. Each cabinet shall have hinged locking metal door and card holder for directory. All locks shall be fitted to same key. Panelboard card directories shall be completely filled out (typewritten) upon completion of project and shall include source of service. Cover trims for panelboards shall be hinged to box with full height, semi-concealed piano hinges, fastened to box lip with screws, not trim clamps. Door shall be hinged. Trims shall be UL labeled.

F. Provide oversize gutters for gutter taps where wiring runs through to floor above. Through-feed lugs will NOT be accepted.

G. 208Y/120 V Panelboards: Panelboard shall have main, lugs, branches, and circuit breakers as scheduled. Panelboards shall have a minimum rating of 22,000 A RMS symmetrical interrupting capacity unless scheduled otherwise. Series ratings are NOT acceptable.

1. Lighting and small power panelboards shall be Square D #NQOD with bolt-on breakers or acceptable equivalent.
2. Power panelboards shall be Square D "I-Line" or acceptable equivalent.

H. 480Y/277 V WYE and 480 V DELTA panelboards: Panelboards shall have main, lugs, branches and circuit breakers as scheduled. Panelboards shall have a minimum rating of 42,000 A symmetrical interrupting capacity unless scheduled otherwise. Series ratings are NOT acceptable.

1. Lighting panelboards fed from a 480Y/277 V WYE source shall be Square D, Type NF with bolt-on breakers or acceptable equivalent.
2. Lighting or power panelboards fed from a 480 V DELTA source shall be Square D "I-Line" or acceptable equivalent.

I. Provide bolt-on thermal magnetic-type circuit breakers with interrupting capacity to match panelboard rating. Breaker terminals shall be UL listed as suitable for the type of conductor provided. Multiple circuit breaker shall be a common trip-type with single operating handle. Breaker design shall be such that overload in one pole automatically causes all poles to open. Maintain phase sequence throughout each panel so that any three adjacent breaker poles are connected to Phase A, B, C, respectively.

2.5 MOTOR CONTROL CENTER

A. Existing Motor Control Center (MCC) is Siemens "System/89". MCC sections shall be in accordance with NEMA Standards for Control Centers, Industrial Control and UL Standard #845.

B. Structures shall be totally enclosed dead-front, freestanding assemblies, 90" high and not more than 20" deep. Each structure shall contain following:

1. Main horizontal bus rated at minimum of 600 A or as shown.
2. Vertical bus, in each compartment: rated at one-half the value of the main horizontal bus; installed full height in the compartment
3. Both vertical and horizontal buses shall be held rigid within structure. Bus assemblies shall be braced to withstand bolted fault conditions of not less than 42,000 A RMS symmetrical.
4. MCC construction shall be rated for Seismic Zone 2 application per BOCA.

C. Mount operating mechanism on primary disconnect. Mechanism shall be mechanically interlocked with unit door to prevent access unless disconnect is in "OFF" position. Provide defeater to prevent inadvertent closing of disconnect. Provide padlocking facilities for three padlocks so as to positively lock disconnect in either "ON" or "OFF" position with one, two or three padlocks, with door open or closed.

D. Fuses shall have interrupting capacity of not less than 100,000 A RMS symmetrical at 480 V. Motor starters are specified under SECTION 260500, BASIC MATERIALS & METHODS - ELECTRICAL. Drawout units shall have tin-plated stab assembly for connection to vertical bus. No wiring to these stabs shall extend into bus compartment. Terminal blocks for NEMA Type B assemblies shall be mounted within drawout unit and shall be factory wired. Disconnection of power wiring only shall be necessary for starter withdrawal.

E. MCC shall be Class I, NEMA B with terminal blocks in individual units. Service voltage shall be 480 V, 3-phase, 3-wire; incoming lines shall be at top, unless otherwise noted. Provide branch feeder switches and combination fusible single-speed and two-speed single winding, across-the-line starters with listed accessories. Each starter unit shall be arranged for 120 V control with unit CPTs. Fuse clips shall be rejection type to accommodate UL Class "R" fuses.

F. Variable frequency drives (VFD's)

1. VFD's in Chiller Plant shall be furnished and installed under this Section.
2. VFD shall be UL or ETL listed, adjustable frequency motor drive, for use powering NEMA Design B alternating current induction motor; by Siemens. Vendor shall have factory-trained service organization within 100 miles of jobsite
3. VFD shall have digital control logic and the following features and accessories:
    a. Input power factor: minimum 0.95 at all speeds and loads.
    b. Input efficiency: minimum 97% at full speed, full load.
    c. Output: from 0 VAC to rated input voltage; three-phase, unless otherwise specified; from 6 Hz to 60 Hz frequency.
    d. 115 VAC power supply to operate the control components.
    e. Ambient temperature requirements: 0 to 40°C operating conditions, -20 to 60°C storage.
    f. Ambient humidity requirements: 0 to 95% RH, non-condensing.
    g. Short circuit protection including instantaneous over-current protection, ground fault protection and current limiting input fuses. J Protection devices shall be selected to safely interrupt the available fault current of the VFD input feeder.
    h. Over-voltage and under-voltage protection, within 15% of rated input voltage.
    i. Over-temperature protection.

j. Output over-current protection, to 110% of rated current.
k. Automatic restart, after a trip condition; with shutdown after five failed attempts at restart. Automatic restart shall be capable of being activated or deactivated by building operating personnel.
l. Current limit: automatic speed control to limit VFD output from 60% to 110% of rated current.
m. Field-adjustable parameters:
    1) Volts per hertz, and volts per hertz squared: +/-10%.
    2) Acceleration rate: 1 to 200 seconds.
    3) Deceleration rate: 1 to 200 seconds.
    4) Maximum speed: 100% to 0%.
    5) Minimum speed: 0% to 80%.
    6) Gain, offset and inversion for input signal. Gain shall be adjustable from 1:1 to 10:1.
    7) Carrier frequency for VFD using pulse width modulations.
n. Electronic l-squared-t overload protection.
o. Spinning load pickup (including backwheeling conditions).
p. Speed command signal source: 4-20 ma DC, isolated; or 0-10 VDC, capable of being grounded.
q. Proportional integral derivative setpoint controller, within VFD, allowing a pressure drop of flow signal to be connected to the VFD, using the VFD for the closed loop control.
r. Pre-wired Hand-Off-Auto switch, speed potentiometer and manual disconnect, fused switch or circuit breaker.
s. Diagnostic panel, indicating: power on, zero speed, enabled, over-current, over-voltage, under-voltage, current limit, over-temperature, output frequency (in percent), and current draw (in amperes).
t. Safe shutdown, in the event of momentary or sustained power loss. Interruption of input or output power shall NOT damage VFD.
u. Output contacts to indicate "VFD running".
v. Output contacts to indicate "Fault trip".
w. Auxiliary contacts rated at 120 VAC, normally closed, to open and close when motor is energized.
x. Start-stop by external dry contact, external 120 VAC signal and switching on-off of line voltage.
y. For VFDs for cooling towers only: reversing switch with protection, for reversing high-mass gear-drive propeller fan.

PART 3 - EXECUTION

3.1 SPECIAL CLEANING

A. Perform vacuum cleaning and wiping down of bus bars, bus bracing and supports in panelboards, internal enclosure base in motor control centers, and electrical equipment enclosures. (Refer to cleaning requirements specified under DIVISION 1.)

B. Check bus connections and tighten bolts in panels within work areas, in accordance with manufacturer's torque requirements.

3.2 IDENTIFICATION

A. Provide nameplates and general identification as required under SECTION 260010, GENERAL REQUIREMENTS FOR ELECTRICAL WORK, SECTION 260500, BASIC MATERIALS & METHODS - ELECTRICAL, and under DIVISION 1, and as follows.

B. Panelboard nameplate shall include following information:

1. Panelboard reference number.
2. Source panel reference, including circuit breaker supplying panelboard.
3. Location of source panel by building, floor level and room number.

3.3 STARTUP AND ADJUSTMENT OF VFD's

A. Startup of equipment shall be performed according to manufacturer's recommendations. Startup and adjustment shall include services required to check out, test and balance devices to ensure proper sequencing of operation, prior to instruction of the Owner's maintenance personnel.

B. Prior to startup, equipment shall be checked for physical damage, loose connections, loose parts, leaks and other defects and defects shall be corrected.

C. VFD adjustments shall be done after work of SECTION 230501, BASIC MATERIALS – TESTING, ADJUSTING AND BALANCING. VFD shall be set at 60 Hz during balancing.

3.4 TESTING

A. Testing procedures shall be as described in INETA "Acceptance Testing Specifications".

B. Obtain circuit breaker and relay characteristic curves from manufacturer, prior to testing, and furnish copies to Architect.

C. Testing firm shall notify switchgear manufacturer in advance of dates on which acceptance tests will be performed so that manufacturer's representative may be present.

D. Testing firm shall immediately notify Contractor and Engineer, of any deficiencies requiring correction before switchboard is placed in service and shall confirm information in writing within five days.

E. Discrepancies found shall be corrected by firm which installed switchboard. However, testing firm shall make minor field adjustments that may be found necessary.

F. Test report shall include typewritten test results on firm's standard test forms. Refer to paragraph.

3.5 CIRCUIT BREAKER SETTINGS

A. Verify final trip settings for adjustable circuit breaker elements. Instantaneous magnetic settings shall be minimum, unless otherwise noted.

END OF SECTION 262400

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SECTION 263213 - ENGINE GENERATORS

SECTION 263213 - GENERATORS

PART 1 - GENERAL

1.1 REFERENCES

A. This Section covers the specification of Engine Generators. Refer to SECTION 260010, SECTION 260500, GENERAL CONDITIONS, SUPPLEMENTARY CONDITIONS and applicable parts of DIVISION 1 for other General Requirements..

1.2 SCOPE

A. Provide labor, materials, services, equipment and transportation necessary for complete and operational electrical generation systems as indicated on Contract Drawings and specified herein, including, but not limited to the following:

1. Battery charger.
2. Sub-base fuel tank.
3. Engine-generator set.
4. Muffler.
5. Outdoor enclosure.
6. Remote annunciator.
7. Remote stop switch.
8. Starting battery.
9. System Commissioning

B. Related Sections include the following:

1. Section 263600 "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine-generator sets.

1.3 DEFINITIONS

A. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.

B. Steady-State Voltage Modulation: The uniform cyclical variation of voltage within the operational bandwidth, expressed in Hertz or cycles per second.

1.4 SUBMITTALS

A. Product Data: Include the following:

1. Data on features, components, accessories ratings, and performance.
2. Thermal damage curve for generator.
3. Time-current characteristic curves for generator protective device.
4. Certified generator set fuel consumption curve.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Dimensioned outline plan and elevation drawings of engine-generator set and other components specified.
2. Design Calculations: Signed and sealed by a qualified professional engineer. Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
3. Vibration Isolation Base Details: Signed and sealed by a qualified professional engineer. Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include base weights.
4. Wiring Diagrams: Power, signal, and control wiring.

C. Welding certificates.

D. Manufacturer Seismic Qualification Certification: Submit certification that engine-generator set, batteries, battery racks, accessories, and components will withstand seismic forces defined in Section 260548 "Vibration and Seismic Controls for Electrical Systems." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

   a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Submit Qualification Data for testing agency; including a sample of a representative Field Quality Control Test Report.

F. Certified summary of prototype-unit test report.

G. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.

H. Certified Summary of Performance Tests: Demonstrate compliance with specified requirement to meet performance criteria for sensitive loads.

I. Test Reports:

1. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.
2. Report of sound generation.

3. Report of exhaust emissions showing compliance with applicable regulations.
4. Field quality-control test reports.

J. Certification of Torsional Vibration Compatibility: Comply with NFPA 110.

K. Operation and Maintenance Data: For packaged engine generators to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 and Division 26 , include the following:

1. List of tools and replacement items recommended to be stored at the Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.

L. Warranty: Special warranty specified in this Section.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.

1. Maintenance Proximity: Not more than four hours' normal travel time from Installer's place of business to Project site.
2. Engineering Responsibility: Preparation of data for vibration isolators and seismic restraints of engine skid mounts, including Shop Drawings, based on testing and engineering analysis of manufacturer's standard units in assemblies similar to those indicated for this Project.

B. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 50 miles of Project site, a service center capable of providing training, parts, and emergency maintenance repairs.

C. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

D. Source Limitations: Obtain packaged generator sets and auxiliary components through one source from a single manufacturer.

E. Product Options: Drawings indicate size, profiles, and dimensional requirements of packaged generator sets and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."

F. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX for welding exhaust system piping.

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

H. Comply with NFPA 37.

I. Comply with NFPA 70.

J. Comply with NFPA 110 requirements for Level 1 emergency power supply system.

K. Engine Exhaust Emissions: Comply with applicable state and local government requirements.

L. Noise Emission: Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by generator set including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

1.6 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

1.7 DELIVERY, STORAGE AND HANDLING

A. Deliver engine generator set and system components to their final locations in protective wrappings, containers and other protection that will exclude dirt and moisture and prevent damage from construction operations. Remove protection only after equipment is safe from such hazards.

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

1.9 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, provide 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include quarterly exercising to check for proper starting, load transfer, and running under load. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Maintenance agreements shall include parts and supplies as used in manufacture and installation of original equipment.

1.10 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: One for every 10 of each type and rating, but not less than one of each.
2. Indicator Lamps: Two for every six of each type used, but not less than two of each.
3. Filters: One set each of lubricating oil, fuel, and combustion-air filters.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

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

1. Caterpillar; Engine Div.
2. Kohler Co; Generator Division.
3. Cummins Power Generation; Industrial Business Group.

2.2 ENGINE-GENERATOR SET

A. Packaged engine-generator set shall be a coordinated assembly of compatible components.

B. Power Output Ratings: Nominal ratings as indicated, with capacity as required to operate as a unit as evidenced by records of prototype testing.

C. Output Connections: Three phase, four wire.

D. Safety Standard: Comply with ASME B15.1.

E. Nameplates: Each major system component shall be equipped with a nameplate to identify manufacturer's name and address, and model and serial number of component.

F. Fabricate engine-generator-set mounting frame and attachment of components to resist generator-set movement during a seismic event when generator-set mounting frame is anchored to building structure.

G. Mounting Frame: Adequate strength and rigidity to maintain alignment of mounted components without depending on concrete foundation. Mounting frame shall be free from sharp edges and corners and shall have lifting attachments arranged for lifting with slings without damaging components.

1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and generator-set center of gravity.

2.3 GENERATOR-SET PERFORMANCE

A. Oversizing generator compared with the rated power output of the engine is permissible to meet specified performance.

1. Nameplate Data for Oversized Generator: Show ratings required by the Contract Documents rather than ratings that would normally be applied to generator size installed.

B. Steady-State Voltage Operational Bandwidth: 2 percent of rated output voltage from no load to full load.

C. Steady-State Voltage Modulation Frequency: Less than 1 Hz.

D. Transient Voltage Performance: Not more than 10 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within 0.5 second.

E. Steady-State Frequency Operational Bandwidth: Plus or minus 0.25 percent of rated frequency from no load to full load.

F. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.

G. Transient Frequency Performance: Less than 2-Hz variation for a 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within three seconds.

H. Output Waveform: At no load, harmonic content measured line to neutral shall not exceed 2 percent total with no slot ripple. The telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.

I. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at system output terminals, the system shall supply a minimum of 300 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to winding insulation or other generator system components.

J. Excitation System: Performance shall be unaffected by voltage distortion caused by nonlinear load.

K. Start Time: Comply with NFPA 110, Type 10, system requirements.

2.4 SERVICE CONDITIONS

A. Environmental Conditions: Engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:

1. Ambient Temperature: Minus 15 to plus 40 deg C.
2. Relative Humidity: 0 to 95 percent.
3. Altitude: Sea level to 1000 feet (300 m).

2.5 ENGINE

A. Fuel: Diesel

B. Rated Engine Speed: 1800 rpm.

C. Maximum Piston Speed for Four-Cycle Engines: 2250 fpm (11.4 m/s).

D. Lubrication System: The following items are mounted on engine or skid:

1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.

E. Engine Fuel System:

1. Main Fuel Pump: Mounted on engine. Pump ensures adequate primary fuel flow under starting and load conditions.
2. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.

F. Coolant Jacket Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity: minimum 1500 Watt.

G. Governor: Adjustable isochronous, with speed sensing.

H. Pipe crankcase ventilation fumes directly into engine intake to burn them and reduce unwanted emissions.

2.6 ENGINE COOLING SYSTEM

A. Description: Closed loop, liquid cooled, with radiator factory mounted on engine-generator-set mounting frame and integral engine-driven coolant pump.

B. Radiator: Rated for specified coolant.

C. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.

D. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.

E. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.

F. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, ultraviolet-, and abrasion-resistant fabric.

1. Rating: 50-psig (345-kPa) maximum working pressure with coolant at 180 deg F (82 deg C), and non-collapsible under vacuum.
2. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.

2.7 FUEL SUPPLY SYSTEM

A. Comply with NFPA 30.

B. Base-Mounted Fuel Oil Tank: Factory installed and piped, complying with UL 142 fuel oil tank. Features include the following:

1. Tank level indicator.
2. Capacity: Fuel for eight hours' continuous operation at 100 percent rated power output.
3. Vandal-resistant fill cap.
4. Containment Provisions: Comply with requirements of authorities having jurisdiction.

2.8 ENGINE EXHAUST SYSTEM

A. Muffler: Critical type, sized as recommended by engine manufacturer; sound level measured at a distance of 10 feet (3 m) from exhaust discharge shall be 85 dBA or less.

1. Provide muffler with drain outlet through a petcock.

B. Connection from Engine to Exhaust System: Flexible section of corrugated stainless-steel pipe, minimum 18” length from exhaust outlet to muffler with flanged pipe connections.

C. Connection from Exhaust Pipe to Muffler: Stainless-steel expansion joint with liner.

D. Exhaust Piping External to Engine: ASTM A 53/A 53M, Schedule 40, welded, black steel, with welded joints and fittings.

2.9 COMBUSTION-AIR INTAKE

A. Description: Heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

2.10 STARTING SYSTEM

A. Description: 24-V electric, with negative ground and including the following items:

1. Components: Sized so they will not be damaged during a full engine-cranking cycle with ambient temperature at maximum specified in "Environmental Conditions" Paragraph in "Service Conditions" Article.
2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
3. Cranking Cycle: 60 seconds.
4. Battery: Adequate capacity within ambient temperature range specified in "Environmental Conditions" Paragraph in "Service Conditions" Article to provide specified cranking cycle at least three times without recharging.
5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 10 deg C regardless of external ambient temperature within range specified in "Environmental Conditions" Paragraph in "Service Conditions" Article. Include accessories required to support and fasten batteries in place.
7. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
8. Battery Charger: Current-limiting, automatic-equalizing and float-charging type. Unit shall comply with UL 1236 and include the following features:

   a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
   b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 deg C to plus 60 deg C to prevent overcharging at high temperatures and undercharging at low temperatures.
   c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
   d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
   e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
   f. Enclosure and Mounting: NEMA 250, Type 1 wall-mounted cabinet.

2.11 CONTROL AND MONITORING

A. Functional Description: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of the generator set. When mode-selector switch is switched to the on position, the generator set starts. The off position of the same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down the generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down the generator set.

B. Functional Description: Switching on-off switch on the generator control panel to the on position starts the generator set. The off position of the same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down the generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down the generator set.

C. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the generator set. Mounting method shall isolate the control panel from generator-set vibration.

D. Indicating and protective devices and controls shall include those required by NFPA 110 for a Level 1 system, and the following:

E. Indicating and Protective Devices and Controls:

1. AC voltmeter: dual scale, 0-600V, 2% accuracy, 2-1/2" diameter.
2. AC ammeter: dual scale, 2% accuracy, 2-1/1" diameter.
3. AC frequency meter: dial type.
4. DC voltmeter (alternator battery charging).
5. Engine-coolant temperature gage.
6. Engine lubricating-oil pressure gage.
7. Engine lube oil temperature.
8. Running-time meter.
9. Ammeter-voltmeter, phase-selector switch(es).
10. Generator-voltage adjusting rheostat.
11. Upper and lower meter scale indicator lights.
12. Start-stop switch.
13. Overspeed shutdown device.
14. Coolant high-temperature shutdown device.
15. Coolant low-level shutdown device.
16. Oil low-pressure shutdown device.
17. Auto/Off/Test switch. Test mode shall automatically start unit without interrupting normal electrical supply.
18. Overspeed shutdown device with LED status indicator which lights when overspeed condition has occurred as cause of shutdown.
19. Coolant high-temperature shutdown device with LED status indicator which lights when pre-alarm operating temperature has been reached and stays lit when shutdown occurs.
20. Coolant low-level shutdown device with LED status indicator which lights when low coolant level causes shutdown.

21. Oil low-pressure shutdown device with LED status indicator which lights when pre-alarm oil pressure condition has been reached and stays lit when shutdown occurs.
22. Overcrank shutdown device with LED status indicator which indicates engine has failed to start after 60 second cranking period.
23. Lamp test switch and audible alarm with silencer switch.
24. Low coolant temperature alarm with LED status indicator which indicates failure of block heater.
25. LED status indicator for "switch off", which indicates when control switch has been placed in "off" position.
26. LED status indicator for "system ready", indicating no malfunctions detected.
27. Fuel tank derangement alarm.
28. Fuel tank high-level shutdown of fuel supply alarm.
29. Generator overload.

F. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator, unless otherwise indicated.

G. Connection to Data Link: A separate terminal block, factory wired to Form C dry contacts, for each alarm and status indication is reserved for connections for data-link transmission of indications to remote data terminals.

H. 12 Volt remote annunciator panel: with lights, audible alarm, alarm switch and lamp test switch, in accordance with NFPA 110, Level 1, to monitor the following conditions:

1. Line power.
2. Generator power.
3. System ready (in auto position).
4. Alarm switch off.
5. Generator switch off.
6. Emergency stop.
7. Engine high-temperature shutdown.
8. Lube-oil low-pressure shutdown.
9. Overspeed shutdown.
10. Remote emergency-stop shutdown.
11. Engine high-temperature prealarm.
12. Lube-oil low-pressure prealarm.
13. Fuel tank, low-fuel level.
14. Low coolant level.
15. Overcrank shutdown.
16. Coolant low-temperature alarm.
17. Control switch not in auto position.
18. Battery-charger malfunction alarm.
19. Battery low-voltage alarm.
20. Battery high voltage alarm.

I. Remote Emergency-Stop Switch: Flush; wall mounted, unless otherwise indicated; and labeled. Push button shall be protected from accidental operation.

2.12 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Generator Circuit Breaker: Molded-case, thermal-magnetic type; 100 percent rated; complying with NEMA AB 1 and UL 489.

1. Tripping Characteristic: Designed specifically for generator protection.
2. Trip Rating: Matched to generator rating.
3. Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices.
4. Mounting: Adjacent to or integrated with control and monitoring panel.

B. Ground-Fault Indication: Comply with NFPA 70, Article 700.7(D). Integrate ground-fault alarm indication with other generator-set alarm indications.

C. Provide generator output breaker with one N.C. and one N.O. contact indicating breaker status. This status indication shall signal an alarm to the remote annunciator panel to indicate a "Generator Output Breaker Open" alarm. The remote annunciator panel shall be equipped with a single summary alarm wired to the building BMS system indicating a "Generator Trouble" alarm.

2.13 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

A. Comply with NEMA MG 1 and specified performance requirements.

B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.

C. Electrical Insulation: Class H or Class F.

D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required.

E. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.

F. Excitation shall use no slip or collector rings, or brushes, and shall be arranged to sustain generator output under short-circuit conditions as specified.

G. Enclosure: Drip proof.

H. Instrument Transformers: Mounted within generator enclosure.

I. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified.

1. Adjusting rheostat on control and monitoring panel shall provide plus or minus 5 percent adjustment of output-voltage operating band.
2. Provide with under-frequency protection and moisture-resistive protection.
3. Regulation shall be within +/-1% of rated voltage from no load to full load.

4. On application of rated load at rated power factor, instantaneous voltage dip shall NOT exceed 20%, with recovery within one second and for application of Fire Pump it shall not exceed 15% at the Fire Pump Control Cabinet.

J. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.

K. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.

L. Subtransient Reactance: 12 percent, maximum.

M. Provide Permanent Magnet Generator (PMG) system.

N. Alternator shall be self-ventilated, one-piece cast aluminum alloy, uni-directional internal fan shall provide high volume, low noise air delivery with broad range, 12-load reconnectable, four pole rotating field unit.

O. Temperature rise shall be within NEMA MG1-22.40, IEEE and ANSI Standards for standby duty at rated output.

P. Provide front-end mounted junction box for load connections. Junction box shall have space to mount regulator and voltage adjust rheostat inside box and to relocate same to opposite side without unit modification.

2.14 OUTDOOR GENERATOR-SET ENCLOSURE

A. Description: Vandal-resistant, weatherproof steel housing, wind resistant up to 100 mph (160 km/h). Multiple panels shall be lockable and provide adequate access to components requiring maintenance including rear-hinged control panel door. Panels shall be removable by one person without tools. Instruments and control shall be mounted within enclosure.

1. Provide locking hasps (keyed alike) on engine side panels and control door.

B. Engine Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 110 percent of rated load for 2 hours with ambient temperature at top of range specified in system service conditions.

1. Louvers: Fixed-engine cooling-air inlet and discharge. Storm-proof and drainable louvers prevent entry of rain and snow.
2. Automatic Dampers: At engine cooling-air inlet and discharge. Dampers shall be closed to reduce enclosure heat loss in cold weather when unit is not operating.

2.15 FINISHES

A. Outdoor Enclosure and Components: Manufacturer's standard enamel over corrosion-resistant pretreatment and compatible standard primer.

2.16 SOURCE QUALITY CONTROL

A. Prototype Testing: Factory test engine-generator set using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.

1. Tests: Comply with NFPA 110, Level 1 energy converters in Paragraphs 3.2.1, 3.2.1.1, and 3.2.1.2.
2. Generator Tests: Comply with IEEE 115.
3. Components and Accessories: Items furnished with installed unit that are not identical to those on tested prototype shall have been factory tested to demonstrate compatibility and reliability.

B. Project-Specific Equipment Tests: Before shipment, factory test engine-generator set and other system components and accessories manufactured specifically for this Project. Perform tests at rated load and power factor. Include the following tests:

1. Full load run.
2. Maximum power.
3. Voltage regulation.
4. Transient and steady-state governing.
5. Single-step load pickup.
6. Safety shutdown.
7. Observation of Factory Tests: Provide 14 days' advance notice of tests and opportunity for observation of tests by Owner's representative.

C. Report factory test results within 10 days of completion of test.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine-generator performance.

B. Examine roughing-in of piping systems and electrical connections. Verify actual locations of connections before packaged engine-generator installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 CONCRETE BASES

A. Coordinate size and location of concrete bases. Verify structural requirements with structural engineer.

B. Concrete materials and installation requirements are specified in Division 3.

3.3 INSTALLATION

A. Comply with packaged engine-generator manufacturers' written installation and alignment instructions and with NFPA 110.

B. Install packaged engine generators level on concrete base.

1. Seismic Restraint: Mount packaged engine generator on restrained spring isolators to provide seismic restraint and vibration isolation. Seismic restraint and vibration isolation requirements are specified in Section 260548 "Vibration and Seismic Controls for Electrical Systems". Seismic installation shall provide "withstand" requirement specified in Paragraph 1.04.

C. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.

D. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

1. Verify that electrical wiring is installed according to manufacturer's submittal and installation requirements in Division 26 Sections. Proceed with equipment start up only after wiring installation is satisfactory.
2. Provide interconnecting wiring between generator and automatic transfer switch(es).
3. Provide interconnecting wiring between generator and remote annunciator panel.

3.4 CONNECTIONS

A. Piping installation requirements are specified in Division 23 Sections. Drawings indicate general arrangement of piping and specialties. The following are specific connection requirements:

1. Install fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow service and maintenance.
2. Connect cooling-system water supply and drain piping to diesel engine heat exchangers. Install flexible connectors at connections to engine generator and remote radiator.
3. Connect fuel piping to engines with a gate valve and union.

    a. Diesel storage tanks, tank accessories, piping, valves, and specialties for fuel systems outside the building are specified in Division 2 Section "Fuel Oil Distribution."
    b. Diesel fuel piping, valves, and specialties inside the building are specified in Division 23 Section "Fuel Oil Piping."

4. Connect exhaust-system piping to engines.

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Connect wiring according to Section 260500 "Basic Materials & Methods – Electrical."

D. 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 UL 486B.

3.5 IDENTIFICATION

A. Identify system components according to Division 23 Section "Mechanical Identification" and Section 260500 "Basic Materials & Methods - Electrical."

3.6 FIELD QUALITY CONTROL

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

B. Perform the following field tests and inspections and prepare test reports: Furnish required materials, equipment and services to perform on-site tests, in presence of Architect and Owner, to demonstrate system operation. Correct defects and re-test system until proper operation is guaranteed. Materials and equipment shall include: temporary power and wiring; temporary cooling; infinitely variable, outdoor load bank and operator; monitoring devices; etc.

1. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Sections 7.15.2.1 and 7.22.1 (except for vibration baseline test). Certify compliance with test parameters. Tests shall be conducted by applying load (via load bank) to load side of automatic transfer switch or to other load point acceptable to Engineer.
2. Perform tests recommended by manufacturer.
3. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here including, but not limited to, the following:

   a. Single-step full-load pickup test.

4. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.

   a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
   b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
   c. Verify acceptance of charge for each element of the battery after discharge.
   d. Verify that measurements are within manufacturer's specifications.

5. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
6. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine-generator system before and during system operation. Check for air, exhaust, and fluid leaks.
7. Exhaust-System Back-Pressure Test: Use a manometer with a scale exceeding 40-inch wg (120 kPa). Connect to exhaust line close to engine exhaust manifold. Verify that

back pressure at full-rated load is within manufacturer's written allowable limits for the engine.

8. Exhaust Emissions Test: Comply with applicable government test criteria.
9. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.
10. Harmonic-Content Tests: Measure harmonic content of output voltage under 25 percent and at 100 percent of rated linear load. Verify that harmonic content is within specified limits.
11. Noise Level Tests: Measure A-weighted level of noise emanating from generator-set installation, including engine exhaust and cooling-air intake and discharge, at four locations on the property line and compare measured levels with required values.

C. Coordinate tests with tests for transfer switches and run them concurrently.

D. Test instruments shall have been calibrated within the last 12 months, traceable to standards of the National Institute for Standards and Technology, and adequate for making positive observation of test results. Make calibration records available for examination on request.

E. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

F. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

G. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

H. Remove and replace malfunctioning units and retest as specified above.

I. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.

J. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

3.7 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.

C. Complete installation and startup checks according to manufacturer's written instructions.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators. Refer to Division 1.

1. Coordinate this training with that for transfer switches.

END OF SECTION 263213

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SECTION 263600 – TRANSFER SWITCHES

SECTION 263600 - TRANSFER SWITCHES

PART 1 - GENERAL

1.01 REFERENCES

A. This Section covers the specification of Transfer Switches. Refer to Section 260010, Section 260500, General Conditions, Supplementary Conditions and applicable parts of Division 1 for other General Requirements.

1.02 SCOPE

A. Provide labor, materials, services, equipment and transportation necessary for complete and operational electrical systems as indicated on Contract Drawings and specified herein, including, but not limited to, the following:

1. Automatic transfer switches.
2. Remote annunciation system.
3. Systems Commissioning.

1.03 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: Dimensioned plans, sections, and elevations showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.

1. Wiring Diagrams: Single-line diagram. Show connections between transfer switch, power sources, and load.

C. Manufacturer Seismic Qualification Certification: Submit certification that transfer switches, accessories, and components will withstand seismic forces defined in Division 16 Section "Seismic Controls for Electrical Work." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

   a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Submit Qualification Data for testing agency; including a sample of a representative Field Quality Control Test

E. Field quality-control test reports.

F. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 Section "Closeout Procedures and/or Operation and Maintenance Data," include the following:

1. Features and operating sequences, both automatic and manual.
2. List of all factory settings of relays; provide relay-setting and calibration instructions, including software, where applicable.

1.04 QUALITY ASSURANCE

A. Manufacturer Qualifications: Maintain a service center capable of providing training, parts, and emergency maintenance repairs within a response period of less than eight hours from time of notification.

B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

C. Source Limitations: Obtain automatic transfer switches and remote annunciator and control panels through one source from a single manufacturer.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, for emergency service under UL 1008, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. Comply with NEMA ICS 1.

F. Comply with NFPA 70.

G. Comply with NFPA 110.

H. Comply with UL 1008 unless requirements of these Specifications are stricter.

I. Manufacturer Testing

1. During withstand tests, there shall be NO contact welding or damage. Tests shall be performed on identical samples without the use of current limiting fuses. Oscillograph traces across the main contact shall verify that contact separation has NOT occurred. Test procedures shall meet UL 1008. Testing shall be certified by UL or acceptable nationally recognized independent testing laboratory.

2. When conducting temperature rise tests to Paragraph 17.3 of UL 1008, manufacturer shall include post-endurance temperature rise tests to verify ability of transfer switch to carry full-rated current after completing overload and endurance tests.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

1. Contactor Transfer Switches:

a. Caterpillar; Engine Division.
b. Emerson; ASCO Power Technologies, LP.
c. Kohler Co.; Generator Division.
d. Cummins Power Generation; Industrial Business.

2.02 GENERAL TRANSFER-SWITCH PRODUCT REQUIREMENTS

A. Tested Fault-Current Closing and Withstand Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.

B. Annunciation, Control, and Programming Interface Components: Devices at transfer switches for communicating with remote programming devices, annunciators, or annunciator and control panels have communication capability matched with remote device.

C. Solid-State Controls: Repetitive accuracy of all settings is plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.

D. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.

E. Neutral Terminal: Solid and fully rated or switched neutral where four-pole switches are shown.

F. Enclosures: General-purpose NEMA 250, Type 1, complying with NEMA ICS 6 and UL 508, unless otherwise indicated.

G. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, either by color code or by numbered or lettered wire and cable tape markers at terminations.

1. Designated Terminals: Pressure type suitable for types and sizes of field wiring indicated.
2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.

H. Electrical Operation: Accomplish by a non-fused, momentarily energized solenoid or electric-motor-operated mechanism, mechanically and electrically interlocked in both directions.

I. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.

2.03 AUTOMATIC TRANSFER SWITCHES

A. Comply with Level 1 equipment according to NFPA 110.

B. Switching Arrangement: Double-throw type, incapable of pauses or intermediate position stops during normal functioning, unless otherwise indicated.

C. Manual Switch Operation: Unloaded. Control circuit automatically disconnects from electrical operator during manual operation. Manual switch operation shall provide same contact-to-contact transfer speed as the electrical operator and prevent injury to operating personnel.

D. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval is adjustable from 1 to 30 seconds.

E. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.

F. Motor Disconnect and Timing Relay: Controls designated starters so they disconnect motors before transfer and reconnect them selectively at an adjustable time interval after transfer. Control connection to motor starters is through wiring external to automatic transfer switch. Time delay for reconnecting individual motor loads is adjustable between 1 and 60 seconds, and settings are as indicated. Relay contacts handling motor-control circuit inrush and seal currents are rated for actual currents to be encountered.

G. Programmed Neutral Switch Position: Switch operator has a programmed neutral position arranged to provide a midpoint between the two working switch positions, with an intentional, time-controlled pause at midpoint during transfer. Pause is adjustable from 0.5 to 30 seconds minimum and factory set for 0.5 second, unless otherwise indicated. Time delay occurs for both transfer directions. Pause is disabled unless both sources are live.

2.04 AUTOMATIC TRANSFER-SWITCH FEATURES

A. Undervoltage Sensing for Each Phase of Normal Source: Senses low phase-to-ground voltage on each phase. Pickup voltage is adjustable from 85 to 100 percent of nominal, and dropout voltage is adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.

B. Time delay for override of normal-source voltage sensing delays transfer and engine start signals. Adjustable from zero to six seconds, and factory set for one second.

C. Voltage/Frequency Lockout Relay: Prevents premature transfer to generator. Pickup voltage is adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency is adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.

D. Time Delay for Retransfer to Normal Source: Adjustable from 0 to 30 minutes, and factory set for 10 minutes. Provides automatic defeat of delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.

E. After transfer to normal, engine generator shall operate at no load for 5 minutes.

F. Test Switch: Simulates normal-source failure.

G. Switch-Position Pilot Lights: Indicate source to which load is connected.

H. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.

1. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
2. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."

I. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.

J. Transfer Override Switch: Overrides automatic retransfer control so automatic transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.

K. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.

L. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.

M. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods are adjustable from 10 to 30 minutes. Factory settings are for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:

1. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
2. Push-button programming control with digital display of settings.
3. Integral battery operation of time switch when normal control power is not available.

2.05 REMOTE ANNUNCIATOR SYSTEM

A. Functional Description: Remote annunciator panel annunciates conditions for indicated transfer switches. Annunciation includes the following:

1. Sources available, as defined by actual pickup and dropout settings of transfer-switch controls.

2. Switch position.
3. Switch in test mode.
4. Failure of communication link.

B. Annunciator Panel: LED-lamp type with audible signal and silencing switch.

1. Indicating Lights: Grouped for each transfer switch monitored.
2. Label each group, indicating transfer switch it monitors, location of switch, and identity of load it serves.
3. Mounting: Flush, modular, steel cabinet, unless otherwise indicated.
4. Lamp Test: Push-to-test or lamp-test switch on front panel.

2.06 FINISHES

A. Enclosures: Manufacturer's standard enamel over corrosion-resistant pretreatment and primer.

2.07 SOURCE QUALITY CONTROL

A. Factory test and inspect components, assembled switches, and associated equipment. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

PART 3 - EXECUTION

3.01 APPLICATION

A. Four-Pole Switches: Where four-pole switches are indicated, install neutral switching.

3.02 INSTALLATION

A. Comply with mounting and anchoring requirements specified in Section 260548 "Vibration and Seismic Controls for Electrical Systems."

1. Concrete Bases: 4 inches high, reinforced, with chamfered edges. Extend base no more than 2 inches in all directions beyond the maximum dimensions of switch, unless otherwise indicated. Cast anchor-bolt inserts into bases. Comply with Division 3 Section "Cast-in-Place Concrete."

B. Annunciator Panel Mounting: Flush in wall, unless otherwise indicated.

C. Identify components according to Section 260500 "Basic Electrical Materials & Methods - Electrical."

3.03 WIRING TO REMOTE COMPONENTS

A. Provide type and number of cables and conductors to match control and communication requirements of transfer switches as recommended by manufacturer.

B. Provide signal wiring from closed transition transfer switch external timer to shunt trip upstream normal power feeder breaker.

C. Provide required interconnecting wiring between generator and transfer switches including fire pump transfer switches for engine starting, load shed, monitoring and other communication requirements.

D. All wiring shall be in EMT raceway, minimum 3/4" unless noted otherwise. Increase raceway sizes at no additional cost to Owner if necessary to accommodate required wiring.

3.04 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Section 260500 "Basic Materials & Methods - Electrical."

C. 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 UL 486B.

3.05 FIELD QUALITY CONTROL

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

B. Testing Agency: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:

1. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
2. Perform each electrical test and visual and mechanical inspection stated in NETA Acceptance Testing Specification, Section 7.22.3. Certify compliance with test parameters.
3. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.

   a. Check for electrical continuity of circuits and for short circuits.
   b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
   c. Verify that manual transfer warnings are properly placed.
   d. Perform manual transfer operation.

4. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.

   a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.

b. Simulate loss of phase-to-ground voltage for each phase of normal source.
c. Verify time-delay settings.
d. Verify pickup and dropout voltages by data readout or inspection of control settings.
e. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.
f. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.

5. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.

a. Verify grounding connections and locations and ratings of sensors.
b. Observe reaction of circuit-interrupting devices when simulated fault current is applied at sensors.

6. Perform all tests and documentation as required for system acceptance as specified in NFPA-110.

C. Coordinate tests with tests of generator and run them concurrently.

D. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.

E. Remove and replace malfunctioning units and retest as specified above.

3.06 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment as specified below. Refer to Division 1 Section "Closeout Procedures and/or Demonstration and Training."

1. Coordinate this training with that for generator equipment.

END OF SECTION 263600

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SECTION 264113 – LIGHTNING PROTECTION SYSTEM

SECTION 264113 - LIGHTNING PROTECTION SYSTEM

PART 1 - GENERAL

1.01 REFERENCES

A. This Section covers the specification of lightning protection systems. Refer to SECTION 260010, SECTION 260500, SECTION 260526, GENERAL CONDITIONS, SUPPLEMENTARY CONDITIONS and applicable parts of DIVISION 1 for other general requirements.

1.02 STANDARDS

A. The following specifications and standards of the latest issue form a part of this specification:

1. Underwriters Laboratories, Inc. (UL) UL 96A – Installation Requirements for Lightning Protection Systems, current edition.
2. Underwriters Laboratories, Inc., UL 96 – Standard for Safety for Lightning Protection Components, - current edition.
3. NFPA 780 – Standard for the Installation of Lightning Protection Systems – current edition.
4. NFPA 77 - Recommended Practice on Static Electricity – current edition.
5. Work of this Section shall be performed by Firm with minimum ten years experience, which is listed in UL's Electrical Construction Materials Directory (or Supplement) under Lightning Protection Installation (OWAY).
6. Materials used for work of this Section shall be furnished by manufacturer with minimum ten years experience in fabrication of lightning protection equipment, who is listed in UL's Electrical Construction Materials Directory (or Supplement) under Lightning Protection (OVGR) – Lightning Conductor, Air Terminals and Fittings (OVTZ).

1.03 SCOPE

A. Provide labor, materials, services, equipment and transportation necessary for complete, functional, unobtrusive and operational lightning protection system which is either Class I below 75 feet and/or Class II above 75 feet, as shown on Contract Drawings and specified herein, including, but not limited to, the following:

1. Air terminals on roofs and parapets
2. Bonding of roof-mounted mechanical equipment and stacks
3. Bonding of grade mounted mechanical equipment and generators
4. Bonding of structure and other metal parts
5. Ground conductors and rods
6. Connectors, fasteners, etc.
7. Electrode testing of existing lightning protection system
8. Reconditioning and/or replacement of existing lightning protection system as required so that electrode test measurements are under 25 ohms.

B. The lightning protection system shall be designed by a Lightning Protection Certified Master Designer and the drawing shall bear the seal. The seal shall be current at the time of submission and shall be signed by the Master Designer. This shall be accepted in lieu of a state certified Engineer's stamp on the lightning protection drawings.

C. If any departure from the contract drawings or submittal drawings covered below are deemed necessary by the Contractor, details of such departures and reasons therefore shall be submitted as soon as practical to the Architect and Engineer for acceptance.

1.04 SUBMITTALS

A. Submit for review shop drawings on lightning protection system. Shop drawings shall include:

1. Reproducible drawing of complete design and installation work, showing type, size and locations of all grounding, down conductors, through roof/through wall assemblies, roof conductors and air terminals, including bonding connections to structure and other metal objects.
2. Terminal, electrode and conductor sizes
3. Connection and termination details
4. Manufacturer's information, dimensions and materials of each component
5. Documentation of listing in accordance with UL 96 and UL 96A

B. Submit for review test results on existing lightning protection system. Identify the additional grounding locations required.

1.05 PROJECT RECORD DOCUMENTS

A. Keep record drawings as specified in SECTION 260010, GENERAL REQUIREMENTS FOR ELECTRICAL WORK, paragraph on "RECORD DRAWINGS".

B. Special items to be indicated include: actual locations of air terminals, grounding electrodes, and bonding connections; and routing of system conductors.

C. Submit for review, test results on existing lightning protection system. Identify the additional grounding locations required.

PART 2 - PRODUCTS

2.01 GENERAL

A. The system to be furnished under this specification shall be the standard product of a manufacturer regularly engaged in the production of lightning protection equipment and shall be the manufacturer's latest approved design. The equipment shall be UL listed and properly UL labeled. All equipment shall be new and of a design and construction to suit the application where it is used in accordance with accepted industry standards and UL and NFPA requirements.

2.02 AIR TERMINALS

A. Air terminal shall be aluminum. Include proper base for material and location being installed.

2.03 CONDUCTORS

A. Conductors shall be aluminum soft drawn cable.

2.04 FITTINGS AND MISCELLANEOUS

A. Bolted connectors shall be used for connecting two cables together at all locations.

B. Clips for securing conductors to building and equipment throughout shall be spaced maximum 36" on center.

C. Fasteners and bases shall be compatible with material to which fasteners and bases are being secured.

D. Through-roof Assembly

1. Pitch pockets shall not be used.
2. Through-structure assemblies for 1-1/2" PVC shall be used.
3. Structural member C-clamp and bonding plate shall be used to secure grounding to building steel.

2.05 GROUND RODS

A. Ground rods shall be minimum 10'-0" long x ¾" diameter copper clad steel. If rods cannot be used, use 18" x 18" x .032" minimum copper grounding plates.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify that surfaces are ready to receive work. Verify that field measurements are as shown on Drawings.

B. Beginning of work without special written notification to Architect of adverse conditions shall indicate acceptance by the lightning protection system installer of adverse field conditions.

3.02 PROTECTION OF SURROUNDING ELEMENTS

A. Protect property surrounding work of this Section from damage and disfiguration.

3.03 COORDINATION

A. The lightning protection system installer shall work with other trades to ensure a correct, neat and unobtrusive installation.

B. The lightning protection system installer shall coordinate the work of this Section with roofing, exterior and interior finish installations.

3.04 WORK BY OTHERS

A. The Roofing Contractor shall be responsible for sealing and flashing all lightning protection roof penetrations as per the roof manufacturer's recommendations.

3.05 INSTALLATION

A. The installation shall be accomplished by an experienced installation company that is listed with Underwriters Laboratories for lightning protection installation. The installation company shall utilize Lightning Protection Institute Certified Master Installers. All equipment shall be installed in a neat, workmanlike manner. The system shall consist of a complete conductor network at the roof and include air terminals, connectors, splices, bonds, down leads and proper ground terminals.

B. Ferrous fasteners (except stainless steel) and ferrous holding devices shall NOT be used as permanent fasteners.

C. Each anchor bolt shall have a minimum pull-out resistance of 100 pounds as determined by actual test.

D. System shall be installed so as to be inconspicuous. Conductors shall be coursed on the back side of architectural construction so as to conceal lightning protection equipment as much as possible.

E. Air terminals shall have their points aligned vertically and their bases shall be bolted or welded to the building. Adhesive attachments shall not be used.

F. Conductors

1. Conductors shall be connected to building steel at their down points. Conductors shall be bonded to roof structural steel and to reinforcement bars in structure near respective extremities.
2. Conductor connections shall have sufficient slack for expansion and contraction. Steel surfaces shall be clean and bright before applying connector plates or cadwelding. Conductor bends shall NOT have angles over 90 degrees. Bends shall have a minimum radius of 8 inches. When fixed to conductors, connectors shall be capable of withstanding a pull of 200 pounds.
3. Bonding conductors shall be connected to bonding clamps, with sufficient slack for expansion and contraction.
4. Metal facia and metallic roof-mounted equipment shall be grounded. This shall include, but not be limited to: stacks, parapets, skylights, vents, cooling towers, ventilators and air handling equipment.

G. Ground Installation

1. Ground terminals shall be installed as indicated and at such other points as necessary to properly ground the system.
2. Grounding loop conductor shall be placed around the building so that systems have access to a common ground. Building service, communications and lightning protection systems shall be connected to the loop.

3.06 INSPECTION AND CERTIFICATION

A. Upon completion of the installation, the Contractor shall furnish the Master Label issued by Underwriters Laboratories, Inc. for this system.

END OF SECTION 264113

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SECTION 265100 – LUMINAIRES

SECTION 265100 - LUMINAIRES

PART 1 - GENERAL

1.01 REFERENCES

A. This Section covers the specification of lighting systems, including lighting fixtures, lamps and ballasts. Refer to SECTION 260010, SECTION 260500, GENERAL CONDITIONS, SUPPLEMENTARY CONDITIONS and applicable parts of DIVISION 1 for other general requirements.

B. The following industry standards shall be applicable to this Section:

1. ANSI 62.41
2. ANSI C78.379 - American National Standard for Electric Lamps -- Reflector Lamps - Classification of Beam Patterns; Current Edition.
3. ANSI C82.1 - American National Standard Specifications for Fluorescent Lamp Ballasts; Current Edition.
4. ANSI C82.4 - American National Standard for Ballasts for High-Intensity-Discharge and Low Pressure Sodium Lamps (Multiple-Supply Type); Current Edition.
5. NFPA 70 - National Electrical Code; National Fire Protection Association; Current Accepted Edition.

1.02 SCOPE

A. Provide labor, materials, services, equipment and transportation necessary for complete and operational lighting systems as shown on Contract Drawings and specified herein, including but not limited to, the following:

1. Interior luminaires and accessories.
2. Ballasts.
3. Fluorescent dimming ballasts and controls.
4. Fluorescent lamp emergency power supply.
5. Lamps.
6. Luminaire accessories.
7. Systems Commissioning

1.03 SUBMITTALS

A. See Section 260010 and Division 1 for requirements for shop drawings, product data, operation & maintenance manuals, coordination drawings, record drawings, other general submittals, and manufacturer's instructions.

B. Shop Drawings / Product Data: Include following information:

1. Information on each fixture which indicates lamp(s), ballast(s), and performance data.
2. Certified test report by recognized independent testing laboratory, on electronic ballasts.

C. Contractor's request for approval of unnamed substitute lighting fixture shall include the following (at no additional cost to the Contract), if requested by Architect:

1. Sample lighting fixture, prelamped, with suitable cord and plug; to demonstrate quality of construction and performance.
2. Point-by-point footcandle printouts for the spaces where used.

1.04 QUALITY ASSURANCE

A. Performance: Fluorescent ballasts and HID ballasts shall have protective circuiting that will sense the end-of-lamp-life characteristic and will prevent the lamp from overheating.

B. Products: Listed and classified by Underwriters Laboratories, Inc. as suitable for the purpose specified and indicated.

PART 2 - PRODUCTS

2.01 LUMINAIRES

A. Furnish products as indicated in Lighting Fixture Schedule on drawings.

1. "Type" letter designation is shown on Contract Drawings to indicate what fixture is to be provided in each location; it does not indicate quantity.
2. Fixtures named in Schedule are indicative of type, performance, appearance, and quality desired. Appearance, features and accessories inherent in the named fixture are mandatory.

B. Special Protection for Luminaires with Exposed Reflector Assemblies: Factory-supplied protective wrap which prevents contact, staining and damage.

2.02 BALLASTS AND CONTROL UNITS

A. Fluorescent Ballasts - General

1. Approved Manufacturers: Advance, GE, Osram/Sylvania, Universal, Chloride and Bodine.
2. Units: Meeting Federal, State and local energy codes; eligible for local utility company's rebate program; appropriate for the lamps indicated. Ballasts shall produce normal rated life from indicated lamps.

   a. Unless otherwise noted: ETL/CBM approved, Class P, leakproof, high power factor type, minimum Class A sound rating, electronic, full output.
   b. Minimum start temperature, interior unit for occupied spaces: 50 degrees F (10 degrees C).
   c. Minimum start temperature, interior unit for other spaces: 32 degrees F (0 degrees C).
   d. Minimum start temperature, exterior unit: 0 degrees F (minus 18 degrees C).

3. Ballasts for Double-Ended Lamps: In indoor, non-hazardous spaces, a disconnecting means that disconnects all conductors to the ballast shall be provided in luminaries that are not wired to an emergency power source and that do not have an emergency ballast battery pack

4. Accessories: Protective circuiting that will sense the end-of-lamp-life characteristic and will prevent the lamp from overheating.

B. Fluorescent Electronic Ballasts: ANSI C82.1; ANSI C62.41, Category A; FCC Part 10 and Part 18 (RFI and EMI); high power factor; suitable for lamps specified.

1. Voltage: Match luminaire voltage.
2. Ballast Factor: 0.87 minimums.
3. Power Factor: 0.95 minimums.
4. Crest Factor: 1.7 maximum.
5. Total Harmonic Distortion (THD): less than 10 percent.
6. Third Harmonic: less than 10 percent.

C. Fluorescent Electromagnetic Ballasts: ANSI C82.1, high power factor type electromagnetic ballast, suitable for lamps specified.

1. Voltage: Match luminaire voltage.

D. High Intensity Discharge (HID) Ballasts: ANSI C82.4, High reactance/high power factor type or constant wattage auto transformer/high power factor type; minimum Class B sound rating; meeting Federal, State and local energy codes; eligible for local utility company's rebate program; appropriate for the lamps indicated. Ballasts shall produce normal rated life from indicated lamps.

1. Voltage: Match luminaire voltage.
2. Minimum starting temperature, exterior unit: minus 20 degrees F (minus 29 degrees C).
3. Minimum start temperature, interior unit: 32 degrees F (0 degrees C).
4. Ballasts for Recessed Ceiling Fixtures: With individual overcurrent protection, integral thermal protection.

E. Fluorescent Ballasts for Dimming Applications: Electronic integrated circuit, high efficiency; which dim continuously between 12 percent and 100 percent of light output.

1. Voltage: Match luminaire voltage.
2. Product: Advance Model "Mark VII Controllable Integrated Circuit"; Lutron Model "ECO-10".

F. Fluorescent Ballasts for Dimming Applications: Electronic integrated circuit, high efficiency; which dim continuously between 1 percent and 100 percent of light output.

1. Voltage: match luminaire voltage.
2. Product: Lutron Model "Hi Lume".

G. Fluorescent Lamp Emergency Power Supply: Emergency battery power supply suitable for installation in ballast compartment of fluorescent luminaire.

1. Lamp Ratings: dual lamp, 1100 lumens minimum output for 90 minutes.
2. Battery: Sealed lead calcium or nickel cadmium type, rated for 5 year life.
3. Include TEST switch and AC ON indicator light, installed to be operable and visible from the outside of an assembled luminaire.
4. Product: Bodine B-50.

2.03 LAMPS

A. Approved Manufacturers: Osram/Sylvania, General Electric, Philips.

1. Fluorescent lamps of same color temperature shall be by same manufacturer.
2. HID lamps of same color temperature shall be by same manufacturer.

B. Incandescent Lamps: unless otherwise noted: Style A, medium base, inside frosted, 120-130 volt.

C. Linear Fluorescent Lamps: unless otherwise noted: T8 or T5, rapid start, medium bi-pin, 3500 K color, minimum 85 CRI, low-mercury.

D. Compact Fluorescent Lamps: Unless otherwise noted: 3500 K color, minimum 82 CRI, 4-Pin, low-mercury.

E. Metal Halide Lamps: Unless otherwise noted: universal burn; phosphor coated or clear, as suited to fixture design. Coated lamps shall be 3200 K color, unless otherwise noted.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine wall and ceiling layout and construction defined on Architectural Contract Drawings, and coordinate locations and mounting heights of fixtures. Provide mounting accessories for particular construction in which fixtures will be installed.

3.02 INSTALLATION

A. Fixtures shall be securely attached to the building structure by mechanical means and by safety wire. Provide box-mounted studs and additional structural supports as required. Provide two safety wires per fixture. Each safety wire shall be capable of supporting four times the weight of the fixture. Safety wire shall be adjusted to be in slack tension.

B. Chain Hung Fixtures: Permitted in mechanical rooms and storage areas and where specifically shown on Drawings. Run safety wire through chain links.

C. Pendant Fixtures: Install suspended luminaires and exit signs using pendants supported from swivel hangers. Provide pendant length required to suspend luminaire at indicated height.

D. Pendant-mounted fixtures shall be stud-mounted to boxes which are securely attached to building structure. Run safety wire inside of each fixture pendant. Fixtures over 50 lbs (22.7 kg) shall be mounted direct from building structure independent of the box.

E. Support luminaires larger than 2 x 4 foot (600 x 1200 mm) size independent of ceiling framing.

F. Locate recessed ceiling luminaires as indicated on reflected ceiling plan.

G. Install surface mounted luminaires and exit signs plumb and adjust to align with building lines and with each other. Secure to prevent movement.

H. Exposed Grid Ceilings: Support surface-mounted luminaires in grid ceiling directly from building structure.

I. Install recessed luminaires to permit removal from below.

J. Install recessed luminaires using accessories and fire-stopping materials to meet regulatory requirements for fire rating. Provide fire-rated enclosures or fire-rated fixtures, as needed to match fire rating of the ceiling assembly.

K. Install seismically rated clips to secure recessed grid-supported luminaires in place. Provide four clips per fixture.

L. Install wall mounted luminaires, emergency lighting units, and exit signs at height as indicated on Drawings.

M. Install accessories furnished with each luminaire.

N. Make wiring connections to branch circuit using building wire with insulation suitable for temperature conditions within luminaire.

O. Bond products and metal accessories to branch circuit equipment grounding conductor.

P. Install specified lamps in each emergency lighting unit, exit sign, and luminaire.

Q. Emergency lighting equipment and wiring shall comply with requirements of NFPA 101 and NFPA 70 (NEC) Article 700 "Emergency Systems".

R. Emergency lighting equipment shall have necessary relays and controls which activate the equipment upon failure of normal lighting power serving the area where the equipment is located. Provide "hot" leg to battery units from ahead of control switches.

3.03 FIELD QUALITY CONTROL

A. Operate each luminaire after installation and connection. Inspect for proper connection and operation.

3.04 ADJUSTING

A. Aim and adjust luminaires as directed.

B. Position exit sign directional arrows as indicated.

3.05 CLEANING

A. Clean electrical parts to remove conductive and deleterious materials.

B. Remove dirt and debris from enclosures.

C. Clean photometric control surfaces as recommended by manufacturer.

D. Clean finishes and touch up damage.

E. Remove factory protective wrap from fixture reflector assemblies only after Contract area surface finishes are applied and after cleaning is complete. Replace damaged reflector assemblies as directed.

3.06 PROTECTION

A. Relamp luminaires that have failed lamps at Substantial Completion.

END OF SECTION 265100

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SECTION 266100 – SPECIAL SYSTEMS

SECTION 266100 - SPECIAL SYSTEMS

PART 1 - GENERAL

1.01 REFERENCES

A. This Section covers the specification of special systems and miscellaneous electrical equipment not covered under other Sections. Refer to SECTION 260010, SECTION 260500, GENERAL CONDITIONS, SUPPLEMENTARY CONDITIONS and applicable parts of DIVISION 1 for other general requirements.

1.02 SCOPE

A. Provide labor, materials, equipment, services and transportation necessary for complete and operating systems as shown on Contract Drawings and specified herein, including but not limited to following:

1. Elevator wiring
2. Elevator recall system
3. Emergency disconnect system for elevator main power feeder
4. Systems Commissioning

B. Related Work In Other Divisions:

1. Elevators, including controllers, motors, signal equipment, etc.

1.03 SUBMITTALS

A. Submit for review shop drawings for following:

1. Elevator submittal including all electrical requirements
2. Conduit
3. Pull boxes
4. Outlet boxes
5. Disconnects
6. Elevator lights
7. Duplex receptacles
8. Smoke detectors
9. Heat detectors
10. Elevator recall system

PART 2 - PRODUCTS

2.01 ELEVATOR WIRING

A. Elevators, including controllers, motors and signal equipment, are specified under DIVISION 14.

B. Confirm exact location and electrical requirements of equipment with Elevator Manufacturer. As part of work of this Section, provide disconnects, lighting, power, wiring and conduit necessary, including:

1. Fused disconnect ahead of each controller.
2. Disconnects for signal equipment.
3. Lights and duplex receptacles in elevator shafts, as required by elevator manufacturer.
4. Power and signal connections to controllers.
5. Light and duplex receptacle in each elevator pit, with switches at pit entrances.

2.02 ELEVATOR RECALL SYSTEM

A. Provide elevator recall smoke detection system as part of the fire alarm system. Elevator recall smoke detection system shall comply with the local Elevator Code, ANSI/ASME A17.1 Section 211, and requirements of Elevator Inspector and other authorities having jurisdiction.

B. Any smoke detector, located in the elevator lobbies, shafts or elevator machine rooms, shall cause following upon alarm:

1. Elevator shall drop to designated floor level and shall remain at that level, until system is reset.
2. If alarm initiates from Elevator Machine Room, shaft, or any floor other than the primary designated floor (floor of entry), controller shall return all cars to primary designated floor.
3. If alarm initiates from primary designated floor, controller shall return all cars to an alternative designated floor (e.g., second floor).
4. If alarm initiates from Elevator Machine Room or shaft, the controller shall signal the elevator cab to alert occupants that the elevators are no longer safe to use.

2.03 EMERGENCY DISCONNECT SYSTEM FOR ELEVATOR MAIN POWER FEEDER

A. For elevator main power feeder, provide emergency disconnect system which meets local Elevator Code, ANSI/ASME A17.1, and requirements of Elevator Inspector and other authorities having jurisdiction. System shall be part of the fire alarm system and shall include:

1. Shunt trip operator on elevator main power feeder circuit breaker. Circuit breaker shall have two auxiliary contacts for elevator emergency lowering device(s); contacts shall be normally open, rated 3 A minimum at 120 VAC.
2. One 135°F fixed temperature heat detector located adjacent to each sprinkler head: in each elevator machine room, in each elevator pit, and at top of each elevator shaft.

B. Upon alarm: Heat detector shall signal shunt trip device in elevator main power feeder breakers to activate and shut down the main drive power to the associated elevator. Contacts for elevator emergency lowering device(s) shall open and prevent activation of elevator emergency lowering device(s).

C. Alarm condition at heat detector serving one elevator/hoistway shall NOT cause shutdown of other elevators in different hoistways.

PART 3 - EXECUTION

3.01 INSTALLATION OF ELEVATOR SYSTEM WIRING

A. Wiring shall be type used for electrical light and power, shall be identified at junction points, and shall test free from shorts and grounds.

B. Upon completion, arrange for manufacturer to check devices, connections and wiring for proper system operation.

3.02 INSTALLATION OF ELEVATOR RECALL SYSTEM WIRING

A. Wiring to building fire alarm system shall be as specified for fire alarm system.

B. Wiring to the elevator controllers shall be as specified for electrical light and power wiring.

C. Wiring shall be in rigid metallic conduit.

D. Verify elevator wiring requirements and terminal box terminal jumpering with elevator manufacturer and work of DIVISION 14 prior to beginning any work.

E. Final connections to the elevator controller wiring shall be done under DIVISION 14.

END OF SECTION 266100

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SECTION 283111 - DIGITAL, ADDRESSABLE FIRE ALARM SYSTEM

SECTION 283111 - DIGITAL, ADDRESSABLE FIRE ALARM SYSTEM

PART 1 - GENERAL

1.01 REFERENCES

A. This Section covers the specification of fire detection and alarm systems.

B. Refer to SECTION 260010, SECTION 260500, GENERAL CONDITIONS, SUPPLEMENTARY CONDITIONS and applicable parts of DIVISION 1 for other general requirements.

C. The system and all associated operations shall be in accordance with the following:

1. Guidelines of the following Building Code: 2003 International Building Code
2. NFPA 72; National Fire Alarm Code
3. NFPA 70; National Electrical Code
4. NFPA 101; Life Safety Code
5. NFPA 90A; Standard for the Installation of Air Conditioning and Ventilating Systems
6. Other applicable NFPA standards
7. Local Jurisdiction Adopted Codes and Standards
8. ADA Accessibility Guidelines

1.02 SCOPE

A. Provide labor, materials, equipment, services and transportation necessary for complete and operational fire alarm systems as shown on Contract Drawings and specified herein, including but not limited to following:

B. A new intelligent reporting microprocessor controlled addressable fire alarm and detection system, shall be provided in accordance with the project specifications and drawings, to include, but not be limited to:

1. Heat and smoke detectors.
2. Duct smoke detectors.
3. Speakers/strobes.
4. Horns/strobes.
5. Magnetic door holders.
6. Fire fighter's phones.
7. Sprinkler flow/tamper tie-ins.
8. Manual pull stations.
9. Elevator re-call system tie-in.
10. Elevator main power disconnect tie-in
11. Smoke damper tie-ins.
12. Status command center (annunciator).
13. Main command center and battery cabinet.
14. Addressable interface modules (monitor and control).
15. Device identification.
16. Testing.
17. Warrantee.

18. Manual controls for smoke control.
19. Interface to building HVAC Building Management System (BAS) to initiate mode control functions.
20. Provide monitoring of automatic transfer switches and generator system. Provide programming so that a contact closure will cause a trouble alarm to show up on FACP and secondary reporting location, i.e., security, fire command center, fire department entrance, 24-hour manned location. Locate addressable monitoring modules adjacent to the item monitored.
21. Monitoring of fire pump status
22. Interface with existing fire alarm system.

C. Systems Commissioning

D. Related Work Under Other Divisions

1. Division 8 Section "Door Hardware" for door closers and holders with associated smoke detectors, electric door locks and release devices that interface with the fire alarm system.
2. This Contractor shall coordinate work in this section with all related trades. Work and/or equipment provided in other sections and related to the fire alarm system shall include, but not be limited to:

   a. Duct smoke detectors to be installed by the Mechanical Contractor. See Division 23. They shall be furnished, wired and connected to the fire alarm system by this Contractor.
   b. Air handling system, smoke exhaust fan and smoke damper control circuits and fan status contacts to be provided by the fan systems control equipment. See Division 23. They shall be wired and connected to the fire alarm system by this Contractor.
   c. Stairwell smoke hatch/vent control circuits to be provided by each hatch/vent. They shall be wired and connected to the fire alarm system by this Contractor.
   d. Sprinkler water flow alarm and valve tamper switches to be provided and installed by the Fire Protection Sprinkler Contractor. See Division 23. They shall be wired and connected to the fire alarm system by this Contractor.
   e. Elevator communications circuit wiring (trail cables) and installation of alarm notification devices to be provided by the Elevator Contractor. See Division 14.
   f. Elevator recall control circuits to be provided by the elevator control equipment. See Division 14. They shall be wired and connected to the fire alarm system by this Contractor.
   g. Elevator shaft smoke hatch/vent control circuits to be provided with by hatch/vent. See Division 14. They shall be wired and connected to the fire alarm system by this Contractor.
   h. Coordinate with all other trade contractors for the mounting of and/or interfacing with any and all other fire alarm system related devices.

1.03 DEFINITIONS

A. FACP: Fire alarm control panel.

B. LED: Light-emitting diode.

C. NICET: National Institute for Certification in Engineering Technologies.

D. Definitions in NFPA 72 apply to fire alarm terms used in this Section.

1.04 SUBMITTALS

A. Product Data: For each type of product indicated to include, but not be limited to:

1. Heat and smoke detectors
2. Audio and visual units
3. Fire alarm pull stations
4. Control panels
5. Battery unit
6. Charger
7. Wiring, conduit and accessories
8. Hangers and supports
9. Addressable monitor and control interface modules
10. Door holders
11. Remote LCD annunciator/Voice Command Center for fire alarm system devices
12. Fire Fighter's telephone handset, cabinet and jacks

B. Shop Drawings:

1. Shop Drawings shall be prepared by persons with the following qualifications:
   a. Trained and certified by manufacturer in fire alarm system design.
   b. Fire alarm certified by NICET, minimum Level III.
2. System Operation Description: Detailed description for this Project, including method of operation and supervision of each type of circuit and sequence of operations for manually and automatically initiated system inputs and outputs. Manufacturer's standard descriptions for generic systems are not acceptable.
3. Device Address List: Coordinate with final system programming.
4. System riser diagram in AutoCad compatible format with device addresses, conduit sizes, and cable and wire types and sizes.
5. Wiring Diagrams in AutoCad compatible format: Power, signal, and control wiring. Include diagrams for equipment and for system with all terminals and interconnections identified. Show wiring color code. Indicate final outlet locations on floor plans showing address of each addressable device. Show size and route of cable and conduits.
6. Batteries: Size calculations.
7. Duct Smoke Detectors: Performance parameters and installation details for each detector, verifying that each detector is listed for the complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
8. Voice/Alarm Signaling Service: Equipment rack or console layout, grounding schematic, amplifier power calculation, and single-line connection diagram.
9. Include manufacturer's name(s), model numbers, ratings, power requirements, and device arrangement.
10. Show annunciator layout, configurations and terminations.
11. Submit samples as requested.

C. Qualification Data: For Installer.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For fire alarm system to include in emergency, operation, and maintenance manuals. Comply with NFPA 72, Appendix A, recommendations for Owner's manual. Include abbreviated operating instructions for mounting at the FACP. Manuals shall include the following:

1. Manufacturer's name(s), including technical data sheets.
2. Wiring diagrams that indicate internal wiring for each device and the interconnections between the items of equipment.
3. Clear and concise description of operation that gives, in detail, the information required to properly operate the equipment and system.
4. Manufacturer's roughing-in diagrams and written product specifications and instructions for installation, operation and maintenance, suitable for inclusion in maintenance manuals.
5. Copies of manufacturer's published product warranties. Include standard or typical riser and wiring diagrams.

F. Submittals to Authorities Having Jurisdiction: In addition to distribution requirements for submittals specified in Division1 Section "Submittals," make an identical submittal to authorities having jurisdiction. To facilitate review, include copies of annotated Contract Drawings as needed to depict component locations. Resubmit if required to make clarifications or revisions to obtain approval. On receipt of comments from authorities having jurisdiction, submit them to Architect for review.

G. Documentation:

1. Approval and Acceptance: Provide the "Record of Completion" form according to NFPA 72 to Owner, Architect, and authorities having jurisdiction.

H. Certifications:

1. Together with the shop drawing submittal, submit a certification from the major equipment manufacturer indicating that the proposed supervisor of the installation and the proposed performer of contract maintenance is an authorized representative of the major equipment manufacturer. Include names and addresses in the certification.

I. The Contractor also shall include the following information in the equipment submittal:

1. Power Calculations
2. Voltage drop calculations demonstrating worst case condition.
3. Complete manufacturer's catalog data including technical data, physical dimensions, finish and mounting requirements. Data describing more than one type of item shall be clearly marked to indicate the type the Contractor intends to provide for a given application.
4. Statements shall be included, with copies of required licensing, verifying the qualifications of the installer as specified.

1.05 RECORD DRAWINGS

A. Prior to final inspection and instruction period, deliver the following items in duplicate to the Architect:

1. Certificate by manufacturer of fire alarm system, which states that system has been properly installed, adjusted and tested.
2. Complete operating and maintenance manuals including wiring diagrams, technical data sheets and information for ordering replacement parts.
3. "As-Built" riser diagrams in AutoCad compatible format that indicates each piece of equipment and interconnecting wiring; and complete diagrams of internal wiring for each piece of equipment, including "as-built" revisions. Diagrams shall identify wiring terminals and wiring sequences to facilitate installation, operation and maintenance.

1.06 APPLICABLE STANDARDS AND APPROVALS

A. The specifications and standards listed below form a part of this specification. The system and its components shall fully comply with the latest accepted edition of these standards.

1. National Fire Protection Association (NFPA):

a. NFPA 12 CO_2 Extinguishing System
b. NFPA 13 Fire Prevention Code
c. NFPA 15 Water Spray Systems
d. NFPA 16 Foam/Water Deluge and Spray Systems
e. NFPA 72 National Fire Alarm Code
f. NFPA 101 Life Safety Code

2. Underwriters Laboratories Inc. (UL):

a. UL 268 Smoke Detectors for Fire Protective Signaling Systems
b. UL 864 Control Units for Fire Protective Signaling Systems
c. UL 268A Smoke Detectors for Duct Applications
d. UL 521 Heat Detectors for Fire Protective Signaling Systems
e. UL 464 Audible Signaling Appliances
f. UL 38 Manually Actuated Signaling Boxes
g. UL 346 Waterflow Indicators for Fire Protective Signaling Systems
h. UL 1076 Control Units for Burglar Alarm Proprietary Protective Signaling Systems
i. UL 1971 Visual Notification Appliances

3. Factory Mutual (FM)
4. State and Local Building Codes.
5. All requirements of the Authority Having Jurisdiction (AHJ).
6. Distributor of fire alarm to be approved UUJS certified company.

B. The system shall have proper listing and/or approval from the following nationally recognized agencies:

1. UL – Underwriters Laboratories, Inc.
2. FM – Factory Mutual

1.07 GUARANTEE

A. All work performed and all material and equipment furnished under this contract shall be free from defects and shall remain so for a period of at least one (1) year from the date of acceptance. The full cost of maintenance, labor and materials required to correct any defect during this one year period shall be included in the submittal bid.

1. Control panel shall carry a minimum of a 2-year warranty
2. Initiating devices shall carry a minimum of a 3-year warranty.

1.08 SYSTEM INSTRUCTION AND SERVICE

A. Furnish services of competent, factory-trained engineer to instruct Owner's maintenance personnel in operation and maintenance of system.

B. Furnish one-year contract with equipment manufacturer, for maintenance and inspection service with minimum of two inspections during contract year. Contract shall be effective from date of acceptance testing approval and shall be at no additional cost to the Owner, i.e., included in bid price.

1.09 QUALITY ASSURANCE

A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.

B. Installer Qualifications: Personnel certified by NICET as Fire Alarm Level III.

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

D. System and equipment shall meet NFPA, UL, NEMA and related Code requirements.

E. Complete system shall be furnished by single factory-authorized vendor.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide complete fire alarm system by Simplex Grinnell.

2.02 FIRE ALARM SYSTEM – GENERAL

A. The fire alarm system shall comply with requirements of NFPA Standard 72 for Protected Premises Signaling Systems except as modified and supplemented by this specification. The system shall be electrically supervised and monitor the integrity of all conductors.

B. The system shall be manufactured by an ISO 9001 certified company and meet the requirements of BS EN9001: ANSI/ASQC Q9001.

C. The FACP and peripheral devices shall be manufactured 100% by a single U.S. manufacturer or division thereof.

D. The system and its components shall be Underwriters Laboratories, Inc. listed under the appropriate UL testing standard as listed herein for fire alarm applications and shall be in compliance with the UL listing.

2.03 FIRE ALARM SYSTEM - PERFORMANCE REQUIREMENTS

A. Comply with NFPA 72, current accepted Edition.

B. Fire alarm signal initiation shall be by one or more of the following devices:

1. Manual stations.
2. Heat detectors.
3. Flame detectors.
4. Smoke detectors.
5. Verified automatic alarm operation of smoke detectors.
6. Automatic sprinkler system water flow.
7. Fire extinguishing system operation.

C. Fire alarm signal shall initiate the following actions:

1. Alarm notification appliances shall operate continuously.
2. Identify alarm at the FACP and remote annunciators.
3. De-energize electromagnetic door holders.
4. Transmit an alarm signal to the remote alarm receiving station.
5. Unlock electric door locks in designated egress paths.
6. Release fire and smoke doors held open by magnetic door holders.
7. Activate voice/alarm communication system.
8. Switch heating, ventilating, and air-conditioning equipment controls to fire alarm mode.
9. Close smoke dampers in air ducts of system serving zone where alarm was initiated.
10. Record events in the system memory.
11. Record events by the system printer.

D. Supervisory signal initiation shall be by one or more of the following devices or actions:

1. Operation of a fire-protection system valve tamper.

E. System trouble signal initiation shall be by one or more of the following devices or actions:

1. Open circuits, shorts and grounds of wiring for initiating device, signaling line, and notification-appliance circuits.
2. Opening, tampering, or removal of alarm-initiating and supervisory signal-initiating devices.
3. Loss of primary power at the FACP, remote control panel or remote annunciator panel.
4. Ground or a single break in FACP internal circuits.
5. Abnormal ac voltage at the FACP.
6. A break in standby battery circuitry.
7. Failure of battery charging.
8. Abnormal position of any switch at the FACP or annunciator.

9. Fire-pump power failure, including a dead-phase or phase-reversal condition.
10. Low-air-pressure switch operation on a dry-pipe or preaction sprinkler system.

F. System Trouble and Supervisory Signal Actions: Ring trouble bell and annunciate at the FACP and remote annunciators. Record the event on system printer.

2.04 FIRE ALARM SYSTEM - OPERATION

A. Activation of any manual fire alarm station, heat or smoke detector or waterflow switch shall cause all of the following to occur throughout the building.

1. All system audible alarm devices sound continuously until the alarm condition has been manually acknowledged and reset.
2. All system visual alarm devices to flash until the alarm condition has been acknowledged and reset.
3. All door holdback devices to de-energize to cause all associated fire doors to close.
4. Shut down HVAC units as indicated.
5. LCD displays on main fire alarm control and all secondary panels with LCD displays shall display alarm condition, device initiating the alarm and location of device.
6. Signal fire shutters to close without delay. Coordinate with architectural hardware schedule.
7. Transmit alarm condition to local Fire Department and on campus monitoring station via leased telephone line. Coordinate with local authorities and Owner for exact requirements and provisions necessary for a complete interface.
8. Activation of two or more smoke detectors located on stage is to send a signal to the fusible link and release the smoke hatches.
9. If any (2) smoke detectors in an atrium zone or any (1) fire protection system flow switch in an atrium zone are in alarm, the BMS shall be signaled to initiate atrium smoke exhaust sequence.

B. Activation of a smoke detector shall cause all of the above to occur, plus it shall cause its integral alarm lamp to be energized until the alarm condition of the detector has been reset.

C. Activation of AHU duct smoke detectors shall cause the same sequence as space smoke detectors and shall shut down associated AHU fans.

D. Alarm activation of any (2) cross zoned elevator lobby smoke detectors, elevator machine room smoke detectors or any single elevator shaft smoke detector shall cause the same sequence as space smoke detector and shall cause the following:

1. Shall cause the recall of that bank of elevators to the terminal floor and the lockout of controls. In the event of recall initiation by detector(s) in the terminal floor, the recall shall be to the alternate floor.
2. Elevator recall activation shall also cause activation of all required hoistway vents to open and mechanical ventilation fans to operate in fire emergency smoke evacuation mode.

E. Alarm activation of a preaction system control panel due to preaction system detector initiation shall cause the same sequence as a space detector.

F. Activation of any initiating device shall cause all of the following to occur in the areas designated for voice evacuation only:

1. All system emergency evacuation speakers to sound a pre-signal "slow whoop" tone for a period of six (6) seconds.
2. All system visual alarm devices to flash until the alarm condition has been acknowledged and reset.
3. "Slow whoop" tone shall again sound for six (6) seconds followed by another round of the emergency evacuation message.
4. "Slow whoop" tone shall then sound continuously until the alarm condition has been acknowledged and reset.
5. Signal dimming system(s) to bring lighting to full intensity.

G. The emergency voice evacuation message shall be recorded in a female voice and shall be approved by the Authority Having Jurisdiction.

H. Sprinkler Supervisory Devices

1. The activation of any sprinkler supervisory tamper switch shall activate the system supervisory service audible signal and cause a discrete LCD readout to indicate supervisory condition at the control panel. Differentiation between valve tamper activation and opens and/or grounds on the initiation circuit shall be provided.
2. Pressing the supervisory service acknowledge key shall silence the supervisory audible signal while maintaining the supervisory discrete LCD display indication condition.
3. Restoring the valve to the normal position shall cause restoration of the fire alarm system to normal.

I. Any alarms shall be displayed on an 80 character LCD display. The top line of 40 characters shall be the point label and the second line shall be the device type identifier. The system alarm LED shall flash on the control panel until the alarm has been acknowledged. Once acknowledged, this same LED shall latch on. A subsequent alarm received from another zone shall flash the system alarm LED on the control panel. The LCD display shall show the alarm information.

J. The remote status panel shall mimic the control panel operation.

K. All alarms shall be displayed on an LCD style annunciator. Annunciator shall list all alarm zones and be located next to or integrated into the Main Control Panel.

L. Visual Signals: All visual signals shall be synchronized to flash in unison. Visual signals shall be wired on a separate signal circuit from audible devices.

2.05 FIRE ALARM SYSTEM - SUPERVISION

A. Sprinkler valve and low pressure supervisory devices shall be wired through an addressable module on the addressable loop. Device activation shall cause a supervisory alarm at the control panel.

B. Disarrangement of conditions of any circuit shall not affect the operation of other circuits.

C. Each independently supervised circuit shall include a discrete LCD readout to indicate disarrangement conditions per circuit.

D. Each addressable device shall have a discrete LCD readout to indicate status (alarm or trouble condition).

E. The incoming power to the system shall be supervised so that any power failure must be audibly and visually indicated at the control panel. A green "power" LED shall be displayed continuously while incoming power is present.

F. The system batteries shall be supervised so that a low battery condition or disconnection of the battery shall be audibly and visually indicated on the control panel.

G. The system modules shall be electrically supervised for module placement. Should a module become disconnected, the system trouble indicator shall illuminate and the audible trouble signal shall sound.

H. The system shall have provisions for disabling and enabling all circuits individually for maintenance or testing purposes.

I. Wiring to annunciator and serial status panel shall be supervised for open and ground conditions. A separate annunciator trouble LCD readout shall be provided. It shall illuminate an audible trouble signal shall sound at the control panel upon the detection of an open or ground condition.

2.06 FIRE ALARM CONTROL PANEL (FACP)

A. General Description:

1. Modular, microprocessor-based Central Processing Unit (CPU), power-limited design with electronic modules, UL 864 listed.
2. System shall be provided with 250 addressable initiating points at a minimum.
3. Addressable initiation devices that communicate device identity and status.

   a. Smoke sensors shall additionally communicate sensitivity setting and allow for adjustment of sensitivity at the FACP.
   b. Temperature sensors shall additionally test for and communicate the sensitivity range of the device.

4. Addressable control circuits for operation of mechanical equipment.

B. Alphanumeric Display and System Controls: Arranged for interface between human operator at the FACP and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.

1. Annunciator and Display: Liquid-crystal type, three lines of 80 characters, minimum.
2. Keypad: Arranged to permit entry and execution of programming, display, and control commands; and to indicate control commands to be entered into the system for control of smoke-detector sensitivity and other parameters.

C. Circuits:

1. Signaling Line Circuits: NFPA 72, Class B, Style 4.

   a. System Layout: Install no more than 50 addressable devices on each signaling line circuit. Provide a minimum of two line circuits per floor. SLC circuits shall be arranged such that if one-half of a floor becomes inoperable it will not inhibit the operation of the other half.

2. Notification-Appliance Circuits: NFPA 72, Class B, Style Y.
3. A single ground or open on the system signaling line circuit shall not cause system malfunction, loss of operating power or the ability to report an alarm.
4. Alarm signals arriving at the main FACP shall not be lost following a primary power failure or outage until the alarm signal is processed and recorded.
5. Notification Appliance Circuit speaker circuits shall be arranged such that there is a minimum of two speaker circuits per floor of the building or smoke zone whichever is greater.
6. Audio amplifiers and tone generating equipment shall be electrically supervised for normal and abnormal conditions.
7. Notification Appliance Circuit horn circuits and control equipment shall be arranged such that loss of any one (1) horn circuit will not cause the loss of any other horn circuit in the system.
8. Actuation of alarm notification appliances, annunciation, smoke control, elevator recall, and actuation of suppression systems shall occur within 10 seconds after the activation of an initiating device.
9. Audible Notification Circuits shall be provided with 20% spare capacity per circuit for future expansion.

   a. Speaker circuit capacity shall be based on all speakers set at a minimum of 2 watts per speaker unless higher wattage speakers are specified on drawings.

10. Visual Notification Circuits shall be provided with 20% capacity per circuit for future expansion.

    a. Visual circuit capacity shall be based on each visual unit having a light output of 110 candela.

11. Electrical monitoring for the integrity of wiring external to the FACP for mechanical equipment shutdown and magnetic door-holding circuits is not required, provided a break in the circuit will cause doors to close and mechanical equipment to shut down.

D. Smoke-Alarm Verification for Space Smoke Detectors:

1. Initiate audible and visible indication of an "alarm verification" signal at the FACP.
2. Activate a listed and approved "alarm verification" sequence at the FACP and the detector.
3. Record events by the system printer.
4. Sound general alarm if the alarm is verified.
5. Cancel FACP indication and system reset if the alarm is not verified.

E. Notification-Appliance Circuit: Operation shall sound in a temporal pattern, complying with ANSI S3.41.

F. Elevator Controls: Heat detector operation shuts down elevator power by operating a shunt trip in a circuit breaker feeding the elevator.

1. A field-mounted relay actuated by the fire detector or the FACP closes the shunt trip circuit and operates building notification appliances and annunciator.

G. Power Supply for Supervision Equipment: Supply for audible and visual equipment for supervision of the ac power shall be from a dedicated dc power supply, and power for the dc component shall be from the ac supply.

H. Acknowledge Switch:

1. Activation of the control panel acknowledge switch in response to new alarms and/or troubles shall silence the local panel piezo electric signal and change the alarm and trouble LEDs from flashing mode to steady-ON mode. If multiple alarm or trouble conditions exist, depression of this switch shall advance the 80-character LCD display to the next alarm or trouble condition.
2. Depression of the Acknowledge Switch shall also silence all remote annunciator piezo sounders.

I. Alarm Silencing, Trouble, and Supervisory Alarm Reset: Manual reset at the FACP and remote annunciators, after initiating devices are restored to normal.

1. Silencing-switch operation halts alarm operation of notification appliances and activates an "alarm silence" light. Display of identity of the alarm zone or device is retained.
2. Subsequent alarm signals from other devices or zones reactivate notification appliances until silencing switch is operated again.
3. When alarm-initiating devices return to normal and system reset switch is operated, notification appliances operate again until alarm silence switch is reset.
4. The selection of notification circuits and relays that are silenceable by this switch shall be fully field programmable within the confines of all applicable standards. The FACP software shall include silence inhibit and auto-silence timers.

J. Walk Test: A test mode to allow one person to test alarm and supervisory features of initiating devices. Enabling of this mode shall require the entry of a password. The FACP and annunciators shall display a test indication while the test is underway. If testing ceases while in walk-test mode, after a preset delay, the system shall automatically return to normal.

K. System Reset Switch:

1. Activation of the System Reset switch shall cause all electronically-latched initiating devices, appliances or software zones, as well as all associated output devices and circuits, to return to their normal condition.

L. Lamp Test:

1. The Lamp Test switch shall activate all system LEDs and light each segment of the liquid crystal display.

M. The remote annunciator panel at the fire fighter building entrance shall have an externally mounted "on-off-auto" switch for fire department manual control of atrium smoke exhaust system.

N. Remote Smoke-Detector Sensitivity Adjustment: Controls shall select specific addressable smoke detectors for adjustment, display their current status and sensitivity settings, and control of changes in those settings. Allow controls to be used to program repetitive, time-scheduled, and automated changes in sensitivity of specific detector groups. Record sensitivity adjustments and sensitivity-adjustment schedule changes in system memory, and make a print-out of the final adjusted values on the system printer.

O. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, trouble, and supervisory signals to a remote alarm station through a DACT and telephone lines.

P. Service Modem: Ports shall be RS-232 for system printer and for connection to a dial-in terminal unit.

1. The dial-in port shall allow remote access to the FACP for programming changes and system diagnostic routines. Access by a remote terminal shall be by encrypted password algorithm.

Q. Printout of Events: On receipt of signal, print alarm, supervisory, and trouble events. Identify zone, device, and function. Include type of signal (alarm, supervisory, or trouble), and date and time of occurrence. Differentiate alarm signals from all other printed indications. Also print system reset event, including the same information for device, location, date, and time. Commands initiate the printing of a list of existing alarm, supervisory, and trouble conditions in the system and a historical log of events.

R. Primary Power: 24-V dc obtained from 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signal, supervisory signal shall be powered by the 24-V dc source.

1. The alarm current draw of the entire fire alarm system shall not exceed 80 percent of the power-supply module rating.
2. Power supply shall have a dedicated fused safety switch for this connection at the service entrance equipment. Paint the switch box red and identify it with "FIRE ALARM SYSTEM POWER."

S. Secondary Power: 24-V dc supply system with batteries and automatic battery charger and an automatic transfer switch.

1. Batteries: Sealed lead acid.
2. Batteries shall provide 24 hours of standby and 15 minutes of alarm notification without recharging.
3. Battery capacity shall be a minimum of 125% of calculated requirement.

T. Surge Protection:

1. Provide surge protectors as recommended by the FACP on all system wiring external to the building housing the FACP.
2. Transient voltage surge suppressor manufacturer nameplate to be visible without mechanically removing panels, equipment, etc. If nameplate cannot be readily visible, provide manufacturer, model number and surge rating on exterior of enclosure.

U. Instructions: Computer printout or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

2.07 NOTIFICATION APPLIANCE CIRCUIT POWER EXTENDER

A. The power extender panel shall be stand-alone capable of powering a minimum of four (4) notification appliance circuits. Notification appliance circuits shall be Class B, Style Y rated at 2 Amp each. Panel shall provide capability to be expanded to eight (8) notification appliance circuits.

B. The internal power supply and battery charger shall be capable of charging up necessary Amp/hour batteries internally or externally mounted.

C. The power extender panel may be mounted close to the host control panel or can be remotely located. The addressable extender panel, when connected to an addressable panel, shall connect to the host panel via a communications channel. Via the channel, each output can be individually controlled for general alarm or selective area notification.

D. For network connected power extender panels, up to five panels may be connected on a single (Class A wired) channel.

E. When connected to a conventional (non-addressable panel) one or two standard notification appliance circuits from the main control panel may be used to activate all the circuits on the power extender panel.

F. Alarms from the host fire panel shall signal the power extender panel to activate. The panel shall monitor itself and each of its notification appliance circuits for trouble conditions and shall report trouble conditions to the host panel.

2.08 MANUAL FIRE ALARM BOXES

A. Description: UL 38 listed; finished in red with molded, raised-letter operating instructions in contrasting color. Station shall show visible indication of operation. Mounted on recessed outlet box; if indicated as surface mounted, provide manufacturer's surface back box.

1. Single-action mechanism, with integral addressable module, arranged to communicate manual-station status (normal, alarm, or trouble) to the FACP.
2. Double-action mechanism requiring two actions to initiate an alarm with integral addressable module, arranged to communicate manual-station status (normal, alarm, or trouble) to the FACP.
3. Station Reset: Key- or wrench-operated switch.
4. Indoor Protective Shield: Factory-fabricated clear plastic enclosure, hinged at the top to permit lifting for access to initiate an alarm. Lifting the cover actuates an integral battery-powered audible horn intended to discourage false-alarm operation.
5. Weatherproof Protective Shield: Factory-fabricated clear plastic enclosure, hinged at the top to permit lifting for access to initiate an alarm.

2.09 SYSTEM SMOKE DETECTORS

A. General Description:

1. UL 268 listed, operating at 24-V dc, nominal.
2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to the FACP.
3. Multipurpose type, containing the following:
    a. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to the FACP.
    b. Piezoelectric sounder rated at 88 dBA at 10 feet (3 m) according to UL 464.
    c. Heat sensor, combination rate-of-rise and fixed temperature.
4. Plug-in Arrangement: Detector and associated electronic components shall be mounted in a plug-in module that connects to a fixed base. Provide terminals in the fixed base for connection of building wiring.
5. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
6. Integral Visual-Indicating Light: LED type. Indicating detector has operated and power-on status.
7. Remote Control: Unless otherwise indicated, detectors shall be analog-addressable type, individually monitored at the FACP for calibration, sensitivity, and alarm condition, and individually adjustable for sensitivity from the FACP.
    a. Rate-of-rise temperature characteristic shall be selectable at the FACP for 15 or 20 deg F (8 or 11 deg C) per minute.
    b. Fixed-temperature sensing shall be independent of rate-of-rise sensing and shall be settable at the FACP to operate at 135 or 155 deg F (57 or 68 deg C).
    c. Provide multiple levels of detection sensitivity for each sensor.

B. Photoelectric Smoke Detectors:

1. Sensor: LED or infrared light source with matching silicon-cell receiver.
2. Detector Sensitivity: Between 2.5 and 3.5 percent/foot (0.008 and 0.011 percent/mm) smoke obscuration when tested according to UL 268A.

C. Ionization Smoke Detector:

1. Sensor: Responsive to both visible and invisible products of combustion. Self-compensating for changes in environmental conditions.
2. Detector Sensitivity: Between 0.5 and 1.7 percent/foot (0.0016 and 0.0056 percent/mm) smoke obscuration when tested according to UL 268A.

D. Beam-Type Smoke Detector: Each detector shall consist of a separate transmitter and receiver, and shall have the following features:

1. UL 268 listed, operating at 24-V dc, nominal.
2. Adjustable Sensitivity: At least six sensitivity levels, settable at the receiver, measured as percent of obscuration.
3. Two selectable alarm delay settings, allowing each to be associated with a corresponding sensitivity.
4. Trouble signal delay, fixed at 20 seconds.
5. Separate Color-Coded LEDs: Indicate normal, alarm, and trouble status with remote indicator panels.

E. Remote Air-Sampling Detector System: Includes air-sampling pipe network, a laser-based photoelectric detector, a sample transport fan, and a control unit.

1. UL 268 listed, operating at 24-V dc, nominal.
2. Pipe Network: Electrical metallic tubing connects control unit with designated sampling holes.
3. Smoke Detector: Particle-counting type with continuous laser beam. Sensitivity adjustable to a minimum of three preset values.
4. Sample Transport Fan: Centrifugal type, creating a minimum static pressure of 0.05-inch wg (12.5 Pa) at all sampling ports.
5. Control Unit: Single or multi-zone unit as indicated. Provides same system power supply, supervision, and alarm features as specified for the central FACP plus separate trouble indication for airflow and detector problems.
6. Signals to the Central FACP: Any type of local system trouble is reported to the central FACP as a composite "trouble" signal. Alarms on each system zone are individually reported to the central FACP as separately identified zones.

F. Duct Smoke Detectors:

1. Photoelectric Smoke Detectors:

    a. Sensor: LED or infrared light source with matching silicon-cell receiver.
    b. Verify detector sensitivity below with manufacturers selected. Increased and decreased sensitivities are available to meet special environmental requirements.

c. Detector Sensitivity: Between 2.5 and 3.5 percent/foot (0.008 and 0.011 percent/mm) smoke obscuration when tested according to UL 268A.

2. Ionization Smoke Detectors:

a. Sensor: Responsive to both visible and invisible products of combustion. Self-compensating for changes in environmental conditions.
b. Verify detector sensitivity below with manufacturers selected. Increased and decreased sensitivities are available to meet special environmental requirements.
c. Detector Sensitivity: Between 0.5 and 1.7 percent/foot (0.0016 and 0.0056 percent/mm) smoke obscuration when tested according to UL 268A.

3. UL 268A listed, operating at 24-V dc, nominal.
4. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to the FACP.
5. Plug-in Arrangement: Detector and associated electronic components shall be mounted in a plug-in module that connects to a fixed base. The fixed base shall be designed for mounting directly to the air duct. Provide terminals in the fixed base for connection to building wiring.

a. Weatherproof Duct Housing Enclosure: UL listed for use with the supplied detector. The enclosure shall comply with NEMA 250 requirements for Type 4X.

6. Self-Restoring: Detectors shall not require resetting or readjustment after actuation to restore them to normal operation.
7. Integral Visual-Indicating Light: LED type. Indicating detector has operated and power-on status. Provide remote status and alarm indicator and test station where indicated.
8. Remote Control: Unless otherwise indicated, detectors shall be analog-addressable type, individually monitored at the FACP for calibration, sensitivity, and alarm condition, and individually adjustable for sensitivity from the FACP.
9. Each sensor shall have multiple levels of detection sensitivity.
10. Sampling Tubes: Design and dimensions as recommended by manufacturer for the specific duct size, air velocity, and installation conditions where applied.
11. Relay Fan Shutdown: Rated to interrupt fan motor-control circuit.

2.10 SYSTEM HEAT DETECTORS

A. General: UL 521 listed.

B. Heat Detector, Combination Type: Actuated by either a fixed temperature of 135 deg F (57 deg C) or rate-of-rise of temperature that exceeds 15 deg F (8 deg C) per minute, unless otherwise indicated.

1. Mounting: Plug-in base, interchangeable with smoke-detector bases.
2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to the FACP.

C. Heat Detector, Fixed-Temperature Type: Actuated by temperature that exceeds a fixed temperature of 190 deg F (88 deg C).

1. Mounting: Plug-in base, interchangeable with smoke-detector bases.
2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to the FACP.

2.11 NOTIFICATION APPLIANCES

A. Description: Equipped for mounting as indicated and with screw terminals for system connections.

1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly.

B. Bells: Electric-vibrating, 24-V dc, under-dome type; with provision for housing the operating mechanism behind the bell. Bells shall produce a sound-pressure level of 94 dBA, measured 10 feet (3 m) from the bell. 10-inch (254-mm) size, unless otherwise indicated. Bells are weatherproof where indicated.

C. Chimes, Low-Level Output: Vibrating type, 75-dBA minimum rated output.

D. Chimes, High-Level Output: Vibrating type, 81-dBA minimum rated output.

E. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Horns shall produce a sound-pressure level of 90 dBA, measured 10 feet (3 m) from the horn. Horns are weatherproof where indicated.

F. Visible Alarm Devices: Xenon strobe lights listed under UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch- (25-mm-) high letters on the lens.

1. Rated Light Output: 75 candela, unless otherwise noted on drawings.
2. Strobe Leads: Factory connected to screw terminals.
3. All strobe flashes to be synchronized.
4. Strobes are weatherproof where indicated.

2.12 SPRINKLER SYSTEM REMOTE INDICATORS

A. Remote status and alarm indicator and test stations, with LED indicating lights. Light is connected to flash when the associated device is in an alarm or trouble mode. Lamp is flush mounted in a single-gang wall plate. A red, laminated, phenolic-resin identification plate at the indicating light identifies, in engraved white letters, device initiating the signal and room where the smoke detector or valve is located. For water-flow switches, the identification plate also designates protected spaces downstream from the water-flow switch.

2.13 MAGNETIC DOOR HOLDERS

A. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching door plate.

1. Electromagnet: Requires no more than 3 W to develop 25-lbf (111-N) holding force.
2. Wall-Mounted Units: Flush mounted, unless otherwise indicated.
3. Rating: 24-V ac or dc.
4. Rating: 120-V ac.

B. Material and Finish: Match door hardware.

2.14 REMOTE ANNUNCIATOR

A. Description: Duplicate annunciator functions of the FACP for alarm, supervisory, and trouble indications. Also duplicate manual switching functions of the FACP, including acknowledging, silencing, resetting, and testing.

1. Mounting: Flush cabinet, NEMA 250, Class 1.

B. Display Type and Functional Performance: Alphanumeric display same as the FACP. Controls with associated LEDs permit acknowledging, silencing, resetting, and testing functions for alarm, supervisory, and trouble signals identical to those in the FACP.

2.15 ADDRESSABLE INTERFACE DEVICE

A. Description: Microelectronic monitor module listed for use in providing a system address for listed alarm-initiating devices for wired applications with normally open contacts.

B. Integral Relay: Control module capable of providing a direct signal.

2.16 DIGITAL ALARM COMMUNICATOR TRANSMITTER (DACT)

A. Listed and labeled according to UL 632.

B. Functional Performance: Unit receives an alarm, supervisory, or trouble signal from the FACP, and automatically captures one or two telephone lines and dials a preset number for a remote central station. When contact is made with the central station(s), the signal is transmitted. The unit supervises up to two telephone lines. Where supervising 2 lines, if service on either line is interrupted for longer than 45 seconds, the unit initiates a local trouble signal and transmits a signal indicating loss of telephone line to the remote alarm receiving station over the remaining line. When telephone service is restored, unit automatically reports that event to the central station. If service is lost on both telephone lines, the local trouble signal is initiated.

C. Secondary Power: Integral rechargeable battery and automatic charger. Battery capacity is adequate to comply with NFPA 72 requirements.

D. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

2.17 SYSTEM PRINTER

A. Listed and labeled as an integral part of the fire alarm system.

2.18 GUARDS FOR PHYSICAL PROTECTION

A. Description: Welded wire mesh of size and shape for the manual station, smoke detector, gong, or other device requiring protection.

1. Factory fabricated and furnished by manufacturer of the device.
2. Finish: Paint of color to match the protected device.

2.19 WIRE AND CABLE

A. Wire and cable for fire alarm systems shall be UL listed and labeled as complying with NFPA 70, Article 760.

B. Signaling Line Circuits: Twisted, shielded pair, but sized as recommended by system manufacturer not less than No. 18 AWG.

1. Circuit Integrity Cable: Twisted shielded pair, NFPA 70 Article 760, Classification CI, for power-limited fire alarm signal service. UL listed as Type FPL, and complying with requirements in UL 1424 and in UL 2196 for a 2-hour rating.

C. Non-Power-Limited Circuits: Solid-copper conductors with 600-V rated, 75 deg C, color-coded insulation.

1. Low-Voltage Circuits: No. 14 AWG, minimum.
2. Line-Voltage Circuits: No. 12 AWG, minimum.
3. Multi-conductor Armored Cable: NFPA 70 Type MC, copper conductors, TFN/THHN conductor insulation, copper drain wire, copper armor with red identifier stripe, UL listed for fire alarm and cable tray installation, plenum rated, and complying with requirements in UL 2196 for a 2-hour rating.

D. Notification circuit wiring assembly from the point the notification circuit leaves the fire alarm system control panel or transponder to the point the circuit enters the notification zone it serves shall be listed with a 2-hour fire rating by a recognized testing agency.

E. Wiring for networking cabling between fire alarm system control panels and transponders shall be listed with a 2-hour rating by a recognized testing agency. Acceptable 2-hour rated cabling systems are:

1. Type "CI" cable in metal raceway.
2. Type "MI" cable.

2.20 SMOKE CONTROL SYSTEM INTERFACE

A. Provide a dry contact closure output to signal the BMS for each of the points shown below. Coordinate with Division 23. Contact outputs for the fans systems shall be located in each of the mechanical rooms and output for general alarm and atrium alarm shall be located in the fire command center.

1. Any alarm condition
2. Atrium alarm condition
3. Duct smoke alarm condition for air handling units return fans as required
4. Duct smoke alarm condition for other stair pressurization fans as required

B. Provide six spare dry contact outputs and related programming for future needs.

C. Provide all interface modules required for complete system interface.

2.21 ADDITIONAL MATERIALS AND DEVICES

A. Include the following quantities of materials and devices that are in addition to that shown on the drawings. All materials and devices noted here shall be inspected for physical damage and missing parts. Materials and devices that have no physical damage and no missing parts shall be repackaged into original packaging and stored onsite where directed by the Agency's Representative for "Attic Stock". Any materials and devices that were damaged or have missing parts shall be replaced.

QUANTITY	**DESCRIPTION**
4	Magnetic door holder
4	Strobe only unit
8	Speaker/Strobe or Horn/Strobe
4	Pull station
12	Smoke Detector
2	Heat Detector
4	Fire alarm addressable interface module

PART 3 - EXECUTION

3.01 GENERAL

A. General: Install system and materials in accordance with manufacturer's instructions, rough-in drawings and details on the drawings. Install electrical work and use electrical products complying with requirements of applicable Division 26 sections. Wiring types shall be included in shop drawings.

B. Wiring: The term wiring is defined to include the providing of cable, wire, conduit and miscellaneous materials as required for mounting and connecting of electrical devices.

C. Duct detector sampling tubes will be furnished by Division 26 and installed by Division 23. Flow and tamper switches will be furnished and installed by Division 23 and will be wired by Division 26. Coordinate with Division 23.

D. Wet or damp locations shall require a NEMA rated enclosure suitable for the environment in which an addressable field device or module are to be installed. (i.e., monitoring of sprinkler water flow, tamper switches and OS&Y valves).

E. Termination enclosures shall be, as a minimum, NEMA 12 rated. Termination junction boxes shall be of adequate size and room to facilitate ease of accessibility to work on wiring and to provide ample space for roper identification labeling. Enclosure design shall incorporate the use of a back plate within the enclosure to provide ease of installation. Terminal blocks shall be affixed to a secured mounting rail. Terminal enclosures shall be painted fire department red and stenciled "Interior Fire Alarm System".

F. All conduits shall be bonded to the grounded electrode system by approved ground clamps with a conductor equal in size to the largest conductor used in the system; but in no case shall the ground conductor be smaller than No. 12 AWG.

G. All openings in fire rated walls, floors or ceilings where conduits, cables or wiring trays pass through shall be fire-stopped with an approved fire-proofing material rated to meet or exceed the rating of the assembly penetrated.

H. Structural steel fireproofing shall not be removed or degraded during the installation of fire protection conduits, conduit hangers, clamps, enclosures or cabling unless properly repaired or replaced with an approved compatible fireproofing material consisting of proper depth and density. Should the fireproofing repairs prove inadequate, the installing contractor shall be responsible for adhesion and cohesion testing by an independent testing company and repair as needed.

I. Wire nuts or other solderless splicing devices shall not be used.

J. All nominal voltage branch circuit power feeds (120 VAC) shall be identified (labeled) at both ends of the circuit to indicate its source and purpose.

K. Splices in electrical conductors in vertical risers are prohibited except when the length of conductors exceeds 150 feet in vertical risers, an approved terminal cabinet shall be used.

3.02 EQUIPMENT INSTALLATION

A. Smoke or Heat Detector Spacing:

1. Smooth ceiling spacing shall not exceed 30 feet (9 m).
2. Spacing of smoke and heat detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas, shall be determined according to Appendix A in NFPA 72.

B. HVAC: Locate detectors not closer than 3 feet (1 m) from air-supply diffuser or return-air opening.

C. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of the duct.

D. Heat Detectors in Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location.

E. Single-Station Smoke Detectors: Where more than one smoke alarm is installed within a dwelling or suite, they shall be connected so that the operation of any smoke alarm causes the alarm in all smoke alarms to sound.

F. Remote Status and Alarm Indicators: Install near each smoke detector and each sprinkler water-flow switch and valve-tamper switch that is not readily visible from normal viewing position.

G. Audible Alarm-Indicating Devices: Install not less than 6 inches (150 mm) below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille.

H. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inches (150 mm) below the ceiling, but no higher than 80 inches AFF in accordance with ADA requirements.

I. Final locations of audio notification devices shall be coordinated with Architect. Final placement and audible levels selected shall ensure that any occupied space receives an audible alarm signal 15 dB higher than the average ambient noise level or 5 dB higher than the highest sound level having a minimum one minute duration. During testing, sound levels shall be measured and recorded to demonstrate compliance.

J. Audible circuits shall be provided to allow every device in the circuit to operate at its highest sound output setting.

K. Visual devices shall be installed and located in accordance with ANSI 117.A, NFPA 72, and manufacturer's recommendations. Where requirements conflict, the strictest of the three requirements shall be followed.

L. Visual circuits shall be provided with sufficient capacity to allow every visual unit in the circuit to be rated for 110 candela.

M. Smoke detectors shall not be installed prior to the system programming and test period. If construction is ongoing during this period, measures shall be taken to protect smoke detectors from contamination and physical damage. Detectors installed prior to final trade cleanup shall be replaced at no cost to the Owner.

N. All fire detection and alarm system devices, control panels and remote annunciators shall be flush mounted when located in finished areas and may be surface mounted when located in unfinished areas.

O. Wiring shall be installed exposed or in EMT. Conduit fill shall not exceed 40 percent of interior cross sectional area where three or more cables are contained within a single conduit. Wiring shall not be installed in plenum spaces unless permitted by the NEC.

P. Cable must be separated from any open conductors of power, or Class 1 circuits, and shall not be placed in any conduit, junction box or raceway containing these conductors.

Q. All circuits shall be provided with transient suppression devices and the system shall be designed to permit simultaneous operation of all circuits without interference or loss of signals.

R. Transposing or changing color coding of wires shall not be permitted. All conductors shall be labeled on each end and at all splices with "Brady type tags" identifying circuit type and number.

S. Device Location-Indicating Lights: Locate in public space near the device they monitor.

T. FACP: Surface mount with tops of cabinets not more than 72 inches (1830 mm) above the finished floor.

U. Annunciator: Install with top of panel not more than 72 inches (1830 mm) above the finished floor.

3.03 RACEWAY INSTALLATION

A. All conduits and junction boxes shall be painted red.

B. Conduit shall not enter the fire alarm control panel, or any other remotely mounted control panel equipment or backboxes, except where conduit entry is specified by the FACP manufacturer.

C. All conduit, junction boxes, conduit supports and hangers shall be concealed in finished areas and may be exposed in unfinished areas. Where conduit cannot be run concealed in finished areas, coordinate locations of surface-mounted metal raceway with Architect prior to installation.

3.04 WIRING INSTALLATION

A. Install wiring according to the following:

1. NECA 1.
2. TIA/EIA 568-A.

B. Where notification circuit wiring is installed in a smoke zone other than the smoke zone the circuit serves, the wiring shall be installed as a 2-hour fire-rated assembly from the point the wiring exits the source panel to the smoke zone being served.

C. Network between control panels, transponders and fire command panels shall be installed as 2-hour fire-rated assembly.

D. A minimum of two notification circuits shall be provided for each smoke zone.

E. Wiring Method:

1. Cables and raceways used for fire alarm circuits, and equipment control wiring associated with the fire alarm system, may not contain any other wire or cable.
2. Fire-Rated Cables: Use of 2-hour fire-rated fire alarm cables, NFPA 70 Types MI and CI, is permitted. Type "MI" cable shall be bundled together with stainless steel straps 2'-0" on center.
3. Signaling Line Circuits: Power-limited fire alarm cables may be installed in the same cable or raceway as signaling line circuits.

F. Wiring within Enclosures: Separate power-limited and non-power-limited conductors as recommended by manufacturer. Install conductors parallel with or at right angles to sides and back of the enclosure. Conductors in cabinets shall be carefully formed and harnessed so that each drops off directly opposite to its terminal. Cabinet terminals shall be numbered and coded. All controls, function switches, etc., shall be clearly labeled on all equipment panels. Bundle, lace, and train conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with the fire alarm system to terminal blocks. Mark each terminal according to the system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

1. All terminations in FACP and other junction points shall have "Brady type tags" indicating circuit type, identifying number, and opposite end termination point.

G. Cable Taps: Use numbered terminal strips in junction, pull, and outlet boxes, cabinets, or equipment enclosures where circuit connections are made.

H. Color-Coding: Color-code fire alarm conductors differently from the normal building power wiring. Use one color-code for alarm circuit wiring and a different color-code for supervisory circuits. Color-code audible alarm-indicating circuits differently from alarm-initiating circuits. Use different colors for visible alarm-indicating devices. Paint fire alarm system junction boxes and covers red.

I. Risers: Install at least two vertical cable risers to serve the fire alarm system. Separate risers in close proximity to each other with a minimum 1-hour-rated wall, so the loss of one riser does not prevent the receipt or transmission of signals from other floors or zones.

3.05 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals according to Division 26 Section "Basic Electrical Materials and Methods - Electrical."

B. Install instructions frame in a location visible from the FACP.

C. Paint power-supply disconnect switch red and label "FIRE ALARM."

3.06 GROUNDING

A. Ground the FACP and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to the FACP.

3.07 FIELD QUALITY CONTROL

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

1. Provide manufacturer certified and trained technicians and representatives for testing, supervision and assistance in the installation of the fire alarm system. Connections and terminations shall be made under the direct supervision of the fire alarm manufacturer. Equipment manufacturer shall be responsible for tests, programming, adjustment and calibration of the equipment.

B. Perform the following field tests and inspections and prepare test reports:

1. Before requesting final approval of the installation, submit a written statement using the form for Record of Completion shown in NFPA 72.

2. Perform each electrical test and visual and mechanical inspection listed in NFPA 72. Certify compliance with test parameters. All tests shall be conducted under the direct supervision of a NICET technician certified under the Fire Alarm Systems program at Level III.

   a. Include the existing system in tests and inspections.

3. Visual Inspection: Conduct a visual inspection before any testing. Use as-built drawings and system documentation for the inspection. Identify improperly located, damaged, or nonfunctional equipment, and correct before beginning tests.
4. Testing: Follow procedure and record results complying with requirements in NFPA 72, and shall include, but not be limited to, the following:

   a. Test every device and operation, including test by simulation of trouble, in presence of Owner and Architect. Notify Owner, Architect and interested parties of testing, 72 hours in advance.

   b. The service of a competent, factory-trained engineer or technician authorized by the manufacturer of the fire alarm equipment shall be provided to technically supervise and participate during all of the adjustments and tests for the system. All testing shall be in accordance with NFPA 72.

      1) Before energizing the cables and wires, check for correct connections and test for short circuits, ground faults, continuity and insulation.

      2) Close each sprinkler system flow valve and verify proper supervisory alarm at the FACP.

      3) Verify activation of all waterflow switches.

      4) Open initiating device circuits and verify that the trouble signal actuates.

      5) Open and short signaling line circuits and verify that the trouble signal actuates.

      6) Open and short notification appliance circuits and verify that trouble signal actuates.

      7) Ground all circuits and verify response of trouble signals.

      8) Check presence and audibility of tone at all alarm notification devices.

      9) Check installation, supervision and operation of all intelligent smoke detectors using the walk test.

      10) Each of the alarm conditions that the system is required to detect should be introduced on the system. Verify the proper receipt and the proper processing of the signal at the FACP and the correct activation of the control points.

      11) When the system is equipped with optional features, the manufacturer's manual shall be consulted to determine the proper testing procedures. This is intended to address such items as verifying controls performed by individually addressed or groped devices, sensitivity monitoring, verification functionality and similar.

c. Engineer/Architect shall be notified prior to test, and written documentation of successful test forwarded to the Architect and Engineer for record.

5. Test and Inspection Records: Prepare according to NFPA 72, including demonstration of sequences of operation by using the matrix-style form in Appendix A in NFPA 70.

3.08 ACCEPTANCE TESTING

A. Pre-test the entire system and all functions to verify complete operation. After correct operation is verified, notify the Fire Department or Authority Having Jurisdiction, Owner and the Architect that system is complete and ready for acceptance testing. Provide testing at a time mutually agreeable to all parties. Provide a minimum one-week notice.

B. Operate every building fire alarm device to ensure proper operation, correct annunciation at each remote annunciator and control panel. One-half of all tests shall be performed on standby power. Where applying heat would destroy any detector, they may be manually operated. The initiating circuit and signaling circuits shall be opened in at least two locations per zone to check to the presence of correct supervisory circuitry.

C. The Contractor shall perform all electrical and mechanical tests required by the equipment manufacturer's certification form. All test and report costs shall be in the contract price. A checkout report shall be prepared by the installation technicians and submitted in triplicate, one copy of which will be registered with the equipment manufacturer. The report shall include, but not be limited to:

1. A complete list of equipment installed and wired.
2. Indication that all equipment is properly installed and functions and conforms to these specifications.
3. Test of individual devices.
4. Locations by zone address and model number for each installed devices.
5. Voltage (sensitivity) settings for each photoelectric detector as measured in place with the HVAC system operating.
6. Response time on the thermostats and flame detectors (if used).
7. Technician's name, state license number and date.

D. Manufacturer's representative shall provide written certificate from equipment supplier indicating his acceptance of the entire system. Certificate shall be addressed to the Architect, with a copy to the Engineer.

E. Final approval of the completed system and the testing shall be by the Authority Having Jurisdiction.

3.09 FINAL INSPECTION

A. At the final inspection, a factory-trained representative of the manufacturer of the major equipment shall demonstrate that the system functions properly in every respect.

3.10 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project outside normal occupancy hours for this purpose.

B. Follow-Up Tests and Inspections: After date of Substantial Completion, test the fire alarm system complying with testing and visual inspection requirements in NFPA 72. Perform tests and inspections listed for three monthly, and one quarterly, periods.

C. Semiannual Test and Inspection: Six months after date of Substantial Completion, test the fire alarm system complying with the testing and visual inspection requirements in NFPA 72. Perform tests and inspections listed for monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.

D. Annual Test and Inspection: One year after date of Substantial Completion, test the fire alarm system complying with the testing and visual inspection requirements in NFPA 72. Perform tests and inspections listed for monthly, quarterly, semiannual, and annual periods. Use forms developed for initial tests and inspections.

3.11 SYTEM INSTRUCTION, TRAINING AND SERVICE

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain the fire alarm system, appliances, and devices. Refer to Division 1 Sections for Closeout Procedures and Demonstration and Training.

B. Instruction shall be provided as required for operating the system. Hands-on demonstrations of the operation of all system components and the entire system including program changes and functions shall be provided.

C. Training

1. Conduct two (2) training sessions of four (4) hours each to familiarize the Owner's personnel with the features, operation and maintenance of the new systems. Training sessions shall be scheduled with the Owner at a time mutually agreeable to the Contractor and the Owner.

D. The Contractor and/or the systems manufacturer's representative shall provide a typewritten "Sequence of Operation" to the Owner.

3.12 COORDINATION WITH AUTHORITY HAVING JURISDICTION

A. All programming and visual identification shall be approved by the local authority prior to installation.

PART 4 - UNIT PRICING

4.01 UNIT PRICING – CEILING SMOKE DETECTORS

A. Identify the cost associated with the installation of ceiling smoke detectors including wiring and conduit system to the nearest node.

4.02 UNIT PRICING – AUDIO/VISUAL AND VISUAL ONLY FIRE ALARM DEVICES

A. Identify the cost associated with the installation of audio/visual fire alarm devices, including wiring and conduit system to the nearest node.

B. Identify the cost associated with the installation of visual only fire alarm devices, including wiring and conduit system to the nearest node.

END OF SECTION 283111

SECTION 31 10 00

SITE CLEARING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Protecting existing trees, shrubs, groundcovers, plants and grass to remain.
2. Removing existing trees, shrubs, groundcovers, plants and grass.
3. Clearing and grubbing.
4. Stripping and stockpiling topsoil.
5. Removing above- and below-grade site features and appurtenances.
6. Disconnecting, capping or sealing, and abandoning site utilities in place and/or removing site utilities.

B. Related Sections include the following:

1. Division 01 Section "Temporary Facilities and Controls" for temporary utilities, temporary construction and support facilities, temporary security and protection facilities.
2. Division 02 Section "Existing Utilities and Structures"
3. Division 02 Section "Selected Site Demolition"
4. Division 31 Section "Earth Moving" for soil materials, excavating, backfilling, and site grading.
5. Division 32 Section "Turf and Grasses" for finish grading including preparing and placing planting soil mixes and testing of topsoil material.
6. Division 32 Section "Planting" for soil materials required for plantings.
7. Drawing C300 "Erosion & Sedimentation Control Details & Specifications"" for erosion and sedimentation control measures.

1.3 DEFINITIONS

A. Topsoil: Natural or cultivated surface-soil layer containing organic matter and friable sand, silt, and clay particles found in a depth of not less that 4 inches; reasonably free of subsoil, clay lumps, gravel, and other objects more than 2 inches (50 mm) in diameter; and free of subsoil and weeds, roots, toxic materials, or other nonsoil materials.

B. Tree Protection Zone: Area surrounding individual trees or groups of trees to be protected during construction, and defined by the drip line of individual trees or the perimeter drip line of groups of trees, unless otherwise indicated.

1.4 MATERIAL OWNERSHIP

A. Except for stripped topsoil or other materials indicated to remain Owner's property, cleared materials shall become Contractor's property and shall be removed from Project site.

1.5 SUBMITTALS

A. Record drawings, according to Division 01 Section "Project Record Documents," identifying and accurately locating capped utilities and other subsurface structural, electrical, and mechanical conditions.

1.6 PROJECT CONDITIONS

A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent facilities during site-clearing operations.

1. Do not close or obstruct streets, walks, or other adjacent facilities without permission from Owner and authorities having jurisdiction.
2. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.

B. Utility Locator Service: Notify utility locator service for area where Project is located before site clearing.

C. Do not commence site clearing operations until temporary erosion and sedimentation control measures are in place.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect and maintain benchmarks and survey control points from disturbance during construction.

B. Locate and clearly flag trees and vegetation to remain or to be relocated.

C. Protect existing site improvements to remain from damage during construction.

1. Restore damaged improvements to their original condition, as acceptable to Owner.

3.2 TREE PROTECTION

A. Erect and maintain temporary fencing around tree protection zones before starting site clearing. Remove fence when construction is complete.

1. Do not store construction materials, debris, or excavated material within fenced area.
2. Do not permit vehicles, equipment, or foot traffic within fenced area.
3. Maintain fenced area free of weeds and trash.

B. Do not excavate within tree protection zones, unless otherwise indicated or directed.

C. Where excavation for new construction is required within tree protection zones, hand clear and excavate to minimize damage to root systems. Use narrow-tine spading forks, comb soil to expose roots, and cleanly cut roots as close to excavation as possible.

1. Cover exposed roots with burlap and water regularly.
2. Temporarily support and protect roots from damage until they are permanently redirected and covered with soil.
3. Coat cut faces of roots more than 1-1/2 inches (38 mm) in diameter with an emulsified asphalt or other approved coating formulated for use on damaged plant tissues.
4. Backfill with soil as soon as possible.

D. Repair or replace trees and vegetation indicated to remain that are damaged by construction operations, in a manner approved by Owner's Representative.

1. Employ an arborist, licensed in jurisdiction where Project is located, to submit details of proposed repairs and to repair damage to trees and shrubs.
2. Replace trees that cannot be repaired and restored to full-growth status, as determined by Owner's Representative.

3.3 CLEARING AND GRUBBING

A. Remove obstructions, trees, shrubs, grass, and other vegetation to permit installation of new construction.

1. Do not remove trees, shrubs, and other vegetation indicated to remain or to be relocated.
2. Unsound or unsightly branches of trees and shrubs designated to remain, and not specified to be removed under another item shall be removed as directed. All such removing and the disposal shall be a part of and incidental to this item
3. Cut minor roots and branches of trees indicated to remain in a clean and careful manner where such roots and branches obstruct installation of new construction.
4. Grind stumps and remove roots, obstructions, and debris extending to a depth of 18 inches (450 mm) below exposed subgrade.
5. Use only hand methods for grubbing within tree protection zone.
6. Chip removed tree branches and stockpile in areas as indicated or as directed by Owner's Representative.

B. Fill depressions caused by clearing and grubbing operations with satisfactory soil material unless further excavation or earthwork is indicated.

1. Place fill material in horizontal layers not exceeding a loose depth of 8 inches (200 mm), and compact each layer to a density equal to adjacent original ground.

3.4 TOPSOIL STRIPPING

A. Remove sod and grass before stripping topsoil.

B. Strip topsoil to whatever depths are encountered in a manner to prevent intermingling with underlying subsoil or other waste materials.

   1. Remove subsoil and nonsoil materials from topsoil, including trash, debris, weeds, roots, and other waste materials.

C. Where trees are indicated to be left standing, stop topsoil stripping at the free drip line or as necessary to prevent damage to the main root system

D. Stockpile topsoil materials away from edge of excavations, or where directed, without intermixing with subsoil. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust.

   1. Limit height of topsoil stockpiles to 72 inches (1800 mm).
   2. Do not stockpile topsoil within tree protection zones.
   3. Dispose of excess topsoil as specified for waste material disposal.
   4. Stockpile surplus topsoil to allow for respreading deeper topsoil.

3.5 SITE IMPROVEMENTS

A. Remove existing above- and below-grade improvements as indicated and as necessary to facilitate new construction.

B. Remove slabs, paving, curbs, gutters, and aggregate base as indicated.

   1. Unless existing full-depth joints coincide with line of demolition, neatly saw-cut length of existing pavement to remain before removing existing pavement. Saw-cut faces vertically.
   2. Paint cut ends of steel reinforcement in concrete to remain to prevent corrosion.

3.6 DISPOSAL

A. Disposal: Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off Owner's property, unless otherwise directed by Owner's Representative

END OF SECTION

SECTION 31 20 00

EARTH MOVING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:
1. Preparing subgrades for walks.
2. Preparing subgrades for pavements.
3. Preparing subgrades for lawns and grasses.
4. Preparing subgrades for exterior plants.
5. Subbase and base course for asphalt paving.
6. Excavating and backfilling for utility trenches.
7. Excavating and backfilling trenches for buried mechanical and electrical utilities and pits for buried utility structures.

B. Related Sections include the following:
1. Division 01 Section "Temporary Facilities" for temporary controls, utilities, and support facilities.
2. Division 02 Section "Existing Utilities and Structures" for coordination of work on existing utilities and structures.
3. Division 31 Section "Site Clearing" for site stripping, grubbing, stripping and stockpiling topsoil, and removal of above- and below-grade improvements and utilities.
4. Division 31 Section "Rock Removal" for rock excavation.
5. Division 31 Section "Dewatering" for lowering and disposing of ground water during construction.
6. Division 31 Section "Erosion and Sedimentation Control" for temporary erosion and sedimentation control measures
7. Division 31 Section "Excavation Support and Protection" for shoring, bracing, and sheet piling of excavations.
8. Division 32 Section "Turf and Grasses" for finish grading, including preparing and placing topsoil and planting soil for lawns.
9. Division 32 Section "Plants" for planting bed establishment and tree and shrub pit excavation and planting.
10. Drawing C300 "Erosion & Sedimentation Control Details & Specifications"" for erosion and sedimentation control measures.

1.3 DEFINITIONS

A. Backfill: Soil material or controlled low-strength material used to fill an excavation.

B. Base Course: Course placed between the subbase course and hot-mix asphalt paving.

C. Bedding Course: Course placed over the excavated subgrade in a trench before laying pipe.

D. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill.

E. Drainage Course: Course supporting the slab-on-grade.

F. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.

1. Authorized Additional Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions as directed by Owner's Representative. Authorized additional excavation and replacement material will be paid for according to arrangements with Owner's Representative.
2. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions without direction by Owner's Representative. Unauthorized excavation, as well as remedial work directed by Owner's Representative, shall be without additional compensation.

G. Fill: Soil materials used to raise existing grades.

H. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.

I. Subbase Course: Course placed between the subgrade and base course for hot-mix asphalt pavement, or course placed between the subgrade and a cement concrete pavement or a cement concrete or hot-mix asphalt walk.

J. Subgrade: Surface or elevation remaining after completing excavation, or top surface of a fill or backfill immediately below subbase, drainage fill, or topsoil materials.

K. Utilities: On-site underground pipes, conduits, ducts, and cables, as well as underground services within buildings.

1.4 SUBMITTALS

A. Product Data: For the following:

1. Each type of plastic warning tape.
2. Geotextile.
3. Controlled low-strength material, including design mixture.
4. Geofoam.

B. Samples: 12-by-12-inch (300-by-300-mm) Sample of geotextiles.

C. Material Test Reports: From a qualified testing agency indicating and interpreting test results for compliance of the following with requirements indicated:

1. Classification according to ASTM D 2487 of each on-site and borrow soil material proposed for fill and backfill.
2. Laboratory compaction curve according to ASTM D 698 or ASTM D 1557 for each on-site and borrow soil material proposed for fill and backfill.

D. Blasting Plan and Seismic Survey Report: Submit if necessary to perform the Work.

1.5 QUALITY ASSURANCE

A. Use of Explosives: Do not bring explosives onto site or use in work without prior written permission from authorities having jurisdiction. Contractor is solely responsible for handling, storage, and use of explosive materials when their use in permitted.

B. Geotechnical Testing Agency Qualifications: An independent testing agency qualified according to ASTM E 329 to conduct soil materials and rock-definition testing, as documented according to ASTM D 3740 and ASTM E 548.

1.6 PROJECT CONDITIONS

A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted in writing by Owner's Representative and then only after arranging to provide temporary utility services according to requirements indicated.

1. Notify Owner's Representative not less than five days in advance of proposed utility interruptions.
2. Do not proceed with utility interruptions without Owner's Representative written permission.
3. Contact utility-locator service for area where Project is located before excavating.

B. Demolish and completely remove from site existing underground utilities indicated to be removed. Coordinate with utility companies to shut off services if lines are active.

C. Should uncharted, or incorrectly charted, piping or other utilities be encountered during excavation, consult the Utility Owner immediately for directions. Cooperate with Owner and utilities companies in keeping respective services and facilities in operation. Repair damaged utilities to satisfaction of Utility Owner.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from on-site excavations.

2.2 SOIL MATERIALS FOR ROADWAYS AND PARKING LOTS

A. Aggregate Subbase Material: Naturally or artificially graded mixture of crushed gravel, crushed stone, and natural or crushed sand which are free from vegetable matter, lumps, or balls of clay, and other deleterious substances with no particles of rock that will not pass the 6-in. square mesh sieve. The gradation of the portion which will pass a 3-inch sieve shall meet the grading requirements of MDOT 703.06 (b) Type D.

B. Aggregate Base Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand which are free from vegetable matter, lumps or balls of clay, and other deleterious substances. The gradation of the base materials shall meet the grading requirements of MDOT 703.06(a) Type A – Crushed.

2.3 SOIL MATERIALS FOR STRUCTURES

A. See Geotechnical Report by Haley & Aldrich dated Nov. 2, 2007

2.4 PIPE BEDDING MATERIALS

A. Granular Pipe Bedding Material: Shall be clean and free of organic matter, silt, or clay lamps, and deleterious materials. The material shall meet the following graduation requirements:

Sieve Designation	Percent by Weight Passing Square Mesh Sieve
1/2 inch	100
No. 4	95-100
No. 40	20-45
No. 200	0-5

B. Crushed Stone Pipe Bedding Material: Shall be screened or crushed stone free of organic matter, silt, or clay lumps, and deleterious material. The material shall meet the following graduation requirements:

Sieve Designation	Percent by Weight Passing Square Mesh Sieve
1 inch	100
1/4 inch	0-5

2.5 ON-SITE MATERIALS

A. Material on the site is the property of the Owner and shall be incorporated in the work if possible. The Owner's Representative shall classify the material under Article 2.01 headings. Any sample testing needed for this classification will be performed by an approved laboratory at the Owner's expense.

B. Material not incorporated in the work because it is unsuitable will be hauled away and disposed of at the Contractor's expense.

1. Material designated to be wasted by the Owner's Representative will be disposed of by the Contractor.
2. Material designated to be saved by the Owner's Representative will be stockpiled at a location shown on the drawings or designated by the Owner's Representative.
3. Unsuitable material shall consist of grubbings or other materials which contain rock of size exceeding specifications, organic materials, or other materials of a deleterious nature as deemed by the Owner's Representative.

2.6 MISCELLANEOUS MATERIALS

A. Common Borrow: Shall be earth, suitable for embankment construction. It shall be free of frozen material, perishable rubbish, peat, organic matter, large rock fragments, or other unsuitable material. AASHTO M145 "The classification of soils and soil aggregate mixtures for highway construction purposes AASHTO Designation M145-82 Part 1 Specifications latest edition Classifications A-1 through A-5 may be used. Use of other materials as common borrow is at the discretion of the Owner's Representative and only in approved areas.

B. Gravel Borrow: Shall consist of uniformly graded granular material having no rocks with a maximum dimension of over 6 in. and that portion passing a 3-in. square mesh sieve shall contain not more than 70 percent passing a 1/4 - in. mesh sieve and not more than 10 percent passing a No. 200 mesh sieve.

C. Rock Borrow: Shall consist of hard durable rock broken to various sizes that will form a compact embankment with a minimum of voids. The maximum size for any rock shall be 3 feet in its greatest dimension.

D. Filter Material: Narrowly graded mixture of natural or crushed gravel, or crushed stone and natural sand; ASTM D 448; coarse-aggregate grading Size 67; with 100 percent passing a 1-inch (25-mm) sieve and 0 to 5 percent passing a No. 4 (4.75-mm) sieve.

E. Impervious Fill: Clayey gravel and sand mixture capable of compacting to a dense state.

F. Sand: ASTM C 33; fine aggregate, natural, or manufactured sand.

G. Topsoil (Loam): Shall be in accordance with Division 31 Section "Turf and Grasses."

H. Satisfactory Excavated Material (Onsite): Shall conform to the requirements of Common and/or Impervious Borrow as a minimum as determined by the Owner's Representative and be of an appropriate water content to facilitate obtaining the required compaction.

2.7 GEOTEXTILES

A. Refer to the drawings for geotextile fabrics.

2.8 CONTROLLED LOW-STRENGTH MATERIAL

A. Controlled Low-Strength Material (Flowable Fill): Low-density, self-compacting, flowable concrete material as follows:

1. Portland Cement: ASTM C 150, Type I, II, or III.
2. Fly Ash: ASTM C 618, Class C or F.
3. Normal-Weight Aggregate: ASTM C 33, [3/4-inch (19-mm)] [3/8-inch (10-mm)] nominal maximum aggregate size.
4. Water: ASTM C 94/C 94M.

B. Produce conventional-weight, controlled low-strength material with the following compressive strength when tested according to ASTM C 495.

1. 80-psi (550-kPa).

2.9 ACCESSORIES

A. Detectable Warning Tape: Acid- and alkali-resistant polyethylene film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches (150 mm) wide and 4 mils (0.1 mm) thick, continuously inscribed with a description of the utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches (750 mm) deep; colored as follows:

1. Red: Electric.
2. Yellow: Gas, oil, steam, and dangerous materials.
3. Orange: Telephone and other communications.
4. Blue: Water systems.
5. Green: Sewer systems.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earthwork operations.

B. Preparation of subgrade for earthwork operations including removal of vegetation, topsoil, debris, obstructions, and deleterious materials from ground surface is specified in Division 31 Section "Site Clearing."

C. Protect and maintain erosion and sedimentation controls, which are specified in Division 31 Section "Erosion Control" and as noted on the drawings during earthwork operations.

D. Provide protective insulating materials to protect subgrades and foundation soils against freezing temperatures or frost.

3.2 DEWATERING

A. Prevent surface water and ground water from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area.

B. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation.

1. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations. Do not use excavated trenches as temporary drainage ditches.
2. Install a dewatering system, specified in Division 31 Section "Dewatering," as necessary to keep subgrades dry and convey ground water away from excavations. Maintain until dewatering is no longer required.

3.3 EXPLOSIVES

A. Explosives: Do not use explosives without written authorization from Owner's Representative.

3.4 EXCAVATION, GENERAL

A. Classified Excavation: Excavate to subgrade elevations. Material to be excavated will be classified as earth and rock. Do not excavate rock until it has been classified and cross sectioned by Owner's Representative. The Contract Sum will be adjusted for rock excavation according to unit prices included in the Contract Documents. Changes in the Contract time may be authorized for rock excavation.

1. Earth excavation includes excavating pavements and obstructions visible on surface; underground structures, utilities, and other items indicated to be removed; together with soil, boulders, and other materials not classified as rock or unauthorized excavation.

    a. Intermittent drilling; blasting, if permitted; ram hammering; or ripping of material not classified as rock excavation is earth excavation.

2. Rock excavation includes removal and disposal of rock. Remove rock to lines and subgrade elevations indicated to permit installation of permanent construction without exceeding the following dimensions:

    a. 24 inches (600 mm) outside of concrete forms other than at footings.
    b. 12 inches (300 mm) outside of concrete forms at footings.
    c. 6 inches (150 mm) outside of minimum required dimensions of concrete cast against grade.
    d. Outside dimensions of concrete walls indicated to be cast against rock without forms or exterior waterproofing treatments.
    e. 6 inches (150 mm) beneath bottom of concrete slabs on grade.
    f. 6 inches (150 mm) beneath pipe in trenches, and 24 inches (600 mm) wider than pipe.

B. Excavation of Unsuitable Material: Excavate and remove all fill materials including loose, uncompacted soils material, buried vegetation and other organic or inorganic debris shown on the plans, encountered during the prosecution of the work, or as directed by the Owner's Representative. The excavation shall extend to the limits and depth necessary to remove all fill and unsuitable native material.

C. Muck Excavation: Excavate and dispose of saturated and unsaturated mixtures soils and organic matter not suitable for foundation or embankment material, regardless of moisture content.

3.5 EXCAVATION FOR STRUCTURES

A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 1/2 inch (13 mm). If applicable, extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.

1. Excavations for Footings and Foundations: Do not disturb bottom of excavation. Excavate by hand to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grades to leave solid base to receive other work.
2. Pile Foundations: Stop excavations 6 to 12 inches (150 to 300 mm) above bottom of pile cap before piles are placed. After piles have been driven, remove loose and displaced material. Excavate to final grade, leaving solid base to receive concrete pile caps.
3. Excavation for Underground Tanks, Basins, and Mechanical or Electrical Utility Structures: Excavate to elevations and dimensions indicated within a tolerance of plus or minus 1 inch (25 mm). Do not disturb bottom of excavations intended as bearing surfaces.

3.6 EXCAVATION FOR WALKS AND PAVEMENTS

A. Excavate surfaces under walks and pavements to indicated lines, cross sections, elevations, and subgrades, within a vertical tolerance of one (1) in.

3.7 EXCAVATION FOR UTILITY TRENCHES

A. Excavate trenches to indicated gradients, lines, depths, and elevations, within a vertical tolerance of one (1) in.

B. Excavate trenches to uniform widths to provide the following clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to 12 inches (300 mm) higher than top of pipe or conduit, unless otherwise indicated.

1. Clearance: Excavate to the uniform width shown or required for the particular item to be installed. Provide adequate working space for compactive equipment.

C. Trench Bottoms: Excavate and shape trench bottoms to provide uniform bearing and support of pipes and conduit. Shape subgrade to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits. Remove projecting stones and sharp objects along trench subgrade.

1. For pipes and conduit less than 6 inches (150 mm) in nominal diameter and flat-bottomed, multiple-duct conduit units, hand-excavate trench bottoms and support pipe and conduit on an undisturbed subgrade.

2. For pipes and conduit 6 inches (150 mm) or larger in nominal diameter, shape bottom of trench to support bottom 90 degrees of pipe circumference. Fill depressions with tamped sand backfill.
3. Excavate trenches 6 inches (150 mm) deeper than elevation required in rock or other unyielding bearing material and backfill with crushed stone or gravel prior to installing pipe.

D. Trench Bottoms: Excavate trenches as necessary to allow for bedding course. Hand excavate for bell of pipe.

1. Excavate trenches 6 inches (150 mm) deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.

3.8 SUBGRADE INSPECTION

A. Notify Owner's Representative when excavations have reached required subgrade.

B. If Owner's Representative determines that unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed.

C. Proof-roll subgrade below the building slabs or pavements with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.

1. Completely proof-roll subgrade in one direction, repeating proof-rolling in direction perpendicular to first direction. Limit vehicle speed to 3 mph (5 km/h).
2. Proof-roll with a loaded 10-wheel, tandem-axle dump truck weighing not less than 15 tons (13.6 tonnes).
3. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Owner's Representative, and replace with compacted backfill or fill as directed.

D. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by Owner's Representative, without additional compensation.

3.9 UNAUTHORIZED EXCAVATION

A. Fill unauthorized excavation under foundations or wall footings by extending bottom elevation of concrete foundation or footing to excavation bottom, without altering top elevation. Lean concrete fill, with 28-day compressive strength of 2500 psi (17.2 MPa), may be used when approved by Owner's Representative.

1. Fill unauthorized excavations under other construction or utility pipe as directed by Owner's Representative.

3.10 STORAGE OF SOIL MATERIALS

A. Stockpile borrow soil materials and excavated satisfactory soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.

1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees. Locations to be approved by Owner's Representative.

3.11 BACKFILL

A. Place and compact backfill in excavations promptly, but not before completing the following:

1. Construction below finish grade including, where applicable, subdrainage, dampproofing, waterproofing, and perimeter insulation.
2. Surveying locations of underground utilities for Record Documents.
3. Testing and inspecting underground utilities.
4. Removing concrete formwork.
5. Removing trash and debris.
6. Removing temporary shoring and bracing, and sheeting and backfilling of voids with satisfactory materials. Temporary sheet piling driven below bottom of structures shall be removed in manner to prevent settlement of the structure or utilities, or cut off and left in place if required.
7. Installing permanent or temporary horizontal bracing on horizontally supported walls.

B. Place backfill on subgrades free of mud, frost, snow, or ice.

3.12 UTILITY TRENCH BACKFILL

A. Trench excavations in public streets and other confined areas where trench walls cannot be sloped must be supported by sheeting, shoring, or other methods acceptable to meet the requirement that the Contractor provide inspection of excavations.

B. In pipe trenches, use material specified in typical trench section.

C. Place backfill on subgrades free of mud, frost, snow, or ice.

D. Place and compact bedding course on trench bottoms and where indicated. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.

E. Controlled Low-Strength Material (Flowable Fill): Place initial backfill of controlled low-strength material to a height of 12 inches (300 mm) over the utility pipe or conduit.

F. Backfill voids with satisfactory soil while installing and removing shoring and bracing.

G. Place and compact final backfill of satisfactory soil to final subgrade elevation.

H. Controlled Low-Strength Material (Flowable Fill): Place final backfill of controlled low-strength material to final subgrade elevation.

I. Install warning tape directly above utilities, 12 inches (300 mm) below finished grade, except 6 inches (150 mm) below subgrade under pavements and slabs.

3.13 SOIL FILL

A. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.

B. Place and compact fill material in layers to required elevations as follows:

1. Under grass and planted areas, use acceptable excavated or borrow material.
2. Under walks and pavements, use material specified in the typical pavement section.
3. Under steps and ramps, aggregate subbase material.
4. Under building slabs, use structural fill material.
5. Under footings and foundations, use structural fill material.

C. Place soil fill on subgrades free of mud, frost, snow, or ice.

3.14 SOIL MOISTURE CONTROL

A. Uniformly moisten subgrade and each subsequent fill or backfill soil layer in proper quantities to prevent free water appearing on surface during or subsequent to compaction operations to within 2 percent of optimum moisture content.

1. Do not place backfill or fill soil material on surfaces that are muddy, frozen, or contain frost or ice.
2. Remove and replace, or scarify and air dry otherwise satisfactory soil material that exceeds optimum moisture content by 2 percent and is too wet to compact to specified dry unit weight.

3.15 COMPACTION OF SOIL BACKFILLS AND FILLS

A. Place backfill and fill soil materials in layers not more than 8 inches (200 mm) in loose depth for material compacted by heavy compaction equipment, and not more than 4 inches (100 mm) in loose depth for material compacted by hand-operated tampers.

B. Place backfill and fill soil materials evenly on all sides of structures to required elevations, and uniformly along the full length of each structure.

C. Compact soil materials to not less than the following percentages of maximum dry unit density according to ASTM D 1557:

1. Under structures, building slabs, steps, and pavements, scarify and recompact top 12 inches (300 mm) of existing subgrade and each layer of backfill or fill soil material at 95 percent.
2. Adjacent to Structures: Compact each layer of backfill or fill soil materials at 92 percent.
3. Under walkways, scarify and recompact top 6 inches (150 mm) below subgrade and compact each layer of backfill or fill soil material at 93 percent.
4. Under lawn or unpaved areas, scarify and recompact top 6 inches (150 mm) below subgrade and compact each layer of backfill or fill soil material at 85 percent.
5. For utility trenches, compact each layer of initial and final backfill soil material at 90 percent.

6. Phosphorus Pond and Detention Basins Embankments: Compact Impervious Borrow to at least 92 percent.

3.16 GRADING

A. General: Uniformly grade areas to a smooth surface, free of irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.

1. Provide a smooth transition between adjacent existing grades and new grades.
2. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.

B. Site Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to required elevations within the following tolerances:

1. Lawn or Unpaved Areas: Plus or minus 1 inch (25 mm).
2. Walks: Plus or minus 1/2 inch (13 mm).

C. Grading Inside Building Lines: Finish subgrade to a tolerance of 1/2 inch (13 mm) when tested with a 10-foot (3-m) straightedge.

3.17 SUBSURFACE DRAINAGE

A. Subdrainage Pipe: Specified in Division 33 Section "Subdrainage."

B. Subsurface Drain: Place subsurface drainage geotextile around perimeter of subdrainage trench as indicated.

C. Drainage Backfill: Place and compact filter material over subsurface drain, as indicated, in compacted layers 6 inches (150 mm) thick. Overlay drainage backfill with 1 layer of subsurface drainage geotextile, overlapping sides and ends at least 6 inches (150 mm).

1. Compact each filter material layer with a minimum of two passes of a plate-type vibratory compactor.
2. Place and compact fill over drainage backfill in 6-inch- (150-mm-) thick compacted layers to final subgrade.

3.18 PAVEMENT SUBBASE AND BASE COURSES

A. Place subbase and base course on subgrades free of mud, frost, snow, or ice.

B. On prepared subgrade, place subbase and base course under pavements and walks as follows:

1. Install separation geotextile, if indicated, on prepared subgrade according to manufacturer's written instructions, overlapping sides and ends.
2. Place base course material over subbase course under hot-mix asphalt pavement.
3. Shape subbase and base course to required crown elevations and cross-slope grades.
4. Place subbase and base course 6 inches (150 mm) or less in compacted thickness in a single layer.

5. Place subbase and base course that exceeds 6 inches (150 mm) in compacted thickness in layers of equal thickness, with no compacted layer more than 6 inches (150 mm) thick or less than 3 inches (75 mm) thick.
6. Compact subbase and base course at optimum moisture content to required grades, lines, cross sections, and thickness to not less than 95 percent of maximum dry unit weight according to ASTM D 1557.

3.19 DRAINAGE COURSE

A. Place drainage course on subgrades free of mud, frost, snow, or ice.

B. On prepared subgrade, place and compact drainage course under cast-in-place concrete slabs-on-grade as follows:

1. Install subdrainage geotextile on prepared subgrade according to manufacturer's written instructions, overlapping sides and ends.
2. Place drainage course 6 inches (150 mm) or less in compacted thickness in a single layer.
3. Place drainage course that exceeds 6 inches (150 mm) in compacted thickness in layers of equal thickness, with no compacted layer more than 6 inches (150 mm) thick or less than 3 inches (75 mm) thick.
4. Compact each layer of drainage course to required cross sections and thicknesses to not less than 95 percent of maximum dry unit density according to ASTM D 1557.

3.20 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified independent geotechnical engineering testing agency to perform field quality-control testing.

B. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earthwork only after test results for previously completed work comply with requirements.

C. Footing Subgrade: At footing subgrades, at least one test of each soil stratum will be performed to verify design bearing capacities. Subsequent verification and approval of other footing subgrades may be based on a visual comparison of subgrade with tested subgrade when approved by Owner's Representative.

D. Testing agency will test compaction of soils in place according to ASTM D 1556 (sand cone method), ASTM D 2167 (rubber balloon method), ASTM D 2922 (Nuclear Device), as applicable. Tests will be performed at the following locations and frequencies:

1. Paved and Building Slab Areas: At subgrade and at each compacted fill and backfill layer, at least 1 test for every 2000 sq. ft. (186 sq. m) or less of paved area or building slab, but in no case fewer than 3 tests. In each compacted fill layer, make one field density test for every 2000 sq. ft. of overlaying building slab or paved area, but in no case less than 3 tests
2. Foundation Wall Backfill: At each compacted backfill layer, at least 1 test for each 100 feet (30 m) or less of wall length, but no fewer than 2 tests.

3. Trench Backfill: At each compacted initial and final backfill layer, at least 1 test for each 150 feet (46 m) or less of trench length, but no fewer than 2 tests.

E. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil to depth required; recompact and retest until specified compaction is obtained.

3.21 PROTECTION

A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.

B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.

1. Scarify or remove and replace soil material to depth as directed by Owner's Representative; reshape and recompact.

C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.

1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.22 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Disposal: Remove surplus satisfactory soil and waste material, including unsatisfactory soil, trash, and debris, and legally dispose of it off Owner's property.

END OF SECTION

SECTION 31 23 16

ROCK REMOVAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Excavating rock for open areas and utility trenches.

B. Related Sections include the following:
1. Division 31 – Earth Moving.

1.3 DEFINITIONS

A. Backfill: Soil material or controlled low-strength material used to fill an excavation.

B. Rock Excavation: Removal of rock encountered above subgrade elevations and to lines and dimensions indicated or as specified herein.

1. Authorized Rock Excavation: Excavation below subgrade elevations or beyond indicated or specified limits as directed by the Owner's Representative. Authorized additional excavation and replacement material will be paid for according to Contract provisions for changes in the Work or as otherwise agreed upon prior to said excavation
2. Bulk Rock Excavation: Excavation outside of typical utility and infrastructure trenches.
3. Unauthorized Rock Excavation: Excavation below subgrade elevations or beyond indicated or specified limits without direction by Owner's Representative. Unauthorized Rock excavation, as well as remedial work directed by the Owner's Representative, shall be without additional compensation.

C. Rock: Rock material in beds, ledges, unstratified masses, conglomerate deposits, and boulders of rock material 1 (one) cu. yd. (0.76 cu. m) or more in volume that exceed a standard penetration resistance of 100 blows/2 inches (97 blows/50 mm) when tested by an independent geotechnical testing agency, according to ASTM D 1586.

1.4 Utilities: On-site underground pipes, conduits, ducts, and cables, as well as underground services within buildings.

1.5 LIMITS OF ROCK REMOVAL

A. Rock when encountered shall be measured in place in a manner acceptable to the Owner's Representative.

B. Rock shall be removed to the following minimums:

1. 24 inches (600 mm) outside of concrete forms other than at footings.
2. 12 inches (300 mm) outside of concrete forms at footings.
3. 6 inches (150 mm) outside of minimum required dimensions of concrete cast against grade.
4. Outside dimensions of concrete walls indicated to be cast against rock without forms or exterior waterproofing treatments.
5. To the limit of subgrades indicated under slab-on-grades, foundations and footing, or if subgrades are not indicated then 6 inches (150 mm) beneath bottom of concrete.
6. To the limit of subgrades indicated under roadways and sidewalks.
7. In pipe trenches to the limits indicated on the drawings or if no limits are indicated then: 6 inches (150 mm) beneath pipe inverts in trenches, and 24 inches (600 mm) wider than pipe or a minimum of 36 inches (900 mm).
8. In utility trenches to the limits indicated on the drawings or if no limits are indicated then: 6 inches (150 mm) beneath conduit inverts , and 24 inches (600 mm) wider than conduits or a minimum of 36 inches (900 mm).

C. Measurement for Payment for Rock Bid Items (see Division 01) shall be to the limits indicated above.

1.6 SUBMITTALS

A. Pre-Blast Survey: For record purposes.

B. Seismic Survey Report: For record purposes; from seismic survey agency.

1.7 QUALITY ASSURANCE

A. Use of Explosives: Do not bring explosives onto site or use in work without prior written permission from authorities having jurisdiction and the Owner's Representative. Contractor is solely responsible for handling, storage, and use of explosive materials when their use is permitted.

B. Blasting: All blasting shall be performed in accordance with all pertinent provisions of the "Manual of Accident Prevention in Construction" issued by the Associated General Contractors of America, Inc. and Maine Department of Transportation "Standard Specifications," December 2002 Revision or most current Section 105.2.6, Use of Explosives and prepare a blasting plan reporting the following:

1. Types of explosive and sizes of charge to be used in each area of rock removal, types of blasting mats, sequence of blasting operations, and procedures that will prevent damage to site improvements and structures on Project site and adjacent properties.
2. Seismographic monitoring during blasting operations.

C. No blasting shall be done except by those authorized, and in a manner to comply with all State and Municipal regulations relating thereto.

D. Any site where electrical blasting caps are located or where explosive charges are being placed or have been placed shall be designated as a "Blasting Area".

E. A "Blasting Area" within three hundred (300) feet of any traveled way shall be marked by approved signs with information similar to the following:

"BLASTING AREA. TURN OFF RADIO TRANSMITTERS"

And on the reverse side:

“END OF BLASTING AREA”

F. Geotechnical Testing Agency Qualifications: An independent testing agency qualified according to ASTM E 329 to conduct soil materials and rock-definition testing, as documented according to ASTM D 3740 and ASTM E 548.

G. Preexcavation Conference: Conduct conference at Project site to comply with requirements in Division 01 Section "Project Management and Coordination."

1.8 PROJECT CONDITIONS

A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted in writing by Owner's Representative and then only after arranging to provide temporary utility services according to requirements indicated.

1. Notify each public utility company having structures in proximity to the site of the work of the impending use of explosives and give such notice sufficiently in advance to enable the companies to take such steps as they may deem necessary to protect their property from injury.
2. Such notice shall not relieve the Contractor of responsibility for any damage resulting from his blasting operations.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Store explosives in accordance with the laws and ordinances relating thereto, and in accordance with and to the satisfaction of the Chief of the Fire Department or other authorities having jurisdiction.

B. Bring explosives upon the work only as needed and in small quantities.

PART 3 - EXECUTION

3.1 PREPARATION

A. Conduct a pre-blast survey of all structures within the blasting area and provide the Owner's Representative a written report of the pre-blast survey.

B. Provide the Owner's Representative with a blasting log for the work, containing the following information:

1. Location.
2. Time and date.
3. Number of holes.
4. Amount and type of explosives used per hole.
5. The names of persons, companies, corporations, or public utilities contacted, owning, leasing of occupying property or structures in proximity to the site of the work of the Contractor's intention to use explosives.

C. Ledge which has been drilled for blasting shall be adequately covered with mats, and heavy timbers or earth backfill. The Contractor is responsible to take every and all precautions necessary for the protection of the work, traffic, adjacent buildings, and other property and for the correction for any and all damages should they occur to those entities as a result of the blasting operations.

END OF SECTION

SECTION 31 23 19

DEWATERING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes construction dewatering.

B. Related Sections:

1. Division 31 Section "Earth Moving" for excavating, backfilling, site grading, and for site utilities.
2. Division 31 Section "Excavation Support and Protection" for shoring, bracing, and sheet piling of excavations.

1.3 PERFORMANCE REQUIREMENTS

A. Dewatering Performance: Furnish, install, test, operate, monitor, and maintain dewatering system of sufficient scope, size, and capacity to control hydrostatic pressures and to lower, control, remove, and dispose of ground water and permit excavation and construction to proceed on dry, stable subgrades.

1. Continuously monitor and maintain dewatering operations to ensure erosion control, stability of excavations and constructed slopes, that excavation does not flood, and that damage to subgrades and permanent structures is prevented.
2. Prevent surface water from entering excavations by grading, dikes, or other means.
3. Accomplish dewatering without damaging existing buildings, structures, and site improvements adjacent to excavation.
4. Remove dewatering system when no longer required for construction.

B. The Contractor shall make provisions on the site to detain and filter water from the excavation operation so that sediments from the dewatering operation are contained. In no case will direct discharge from the dewatering operations to off-site drainage facilities be allowed.

C. Sediment Control Guidelines:

1. U.S. Environmental Protection Agency Publication 430/9-73- 007 Processes, Procedures and Methods to Control Pollution Resulting from All Construction Activity.

2. Maine Erosion and Sediment Control Handbook for Construction: Best Management Practices. Department of Environmental Protection, latest edition.

1.4 SUBMITTALS

A. Shop Drawings: For dewatering system. Show arrangement, locations, and details of wells and well points; locations of risers, headers, filters, pumps, power units, and discharge lines; and means of discharge, control of sediment, and disposal of water.

1. Include a written plan for dewatering operations including control procedures to be adopted if dewatering problems arise.

1.5 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with governing EPA notification regulations before beginning dewatering. Comply with hauling and disposal regulations of authorities having jurisdiction.

B. Preinstallation Conference: Conduct conference at Project site.

1. Review methods and procedures related to dewatering including, but not limited to, the following:

a. Inspection and discussion of condition of site to be dewatered including coordination with temporary erosion control measures and temporary controls and protections.
b. Geotechnical report if available
c. Proposed site clearing and excavations.
d. Existing utilities and subsurface conditions.
e. Coordination for interruption, shutoff, capping, and continuation of utility services.
f. Construction schedule. Verify availability of Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
g. Testing and monitoring of dewatering system.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by dewatering operations.

1. Prevent surface water and subsurface or ground water from entering excavations, from ponding on prepared subgrades, and from flooding site and surrounding area.

2. Protect subgrades and foundation soils from softening and damage by rain or water accumulation.

B. Install dewatering system to ensure minimum interference with roads, streets, walks, and no impact on adjoining properties.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner's Representative. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.

C. Provide temporary grading to facilitate dewatering and control of surface water.

D. Monitor dewatering systems continuously.

E. Promptly repair damages to adjacent properties caused by dewatering.

F. Protect and maintain temporary erosion and sedimentation controls, which are specified in Division 31 Section "Erosion and Sedimentation Control" during construction activities.

3.2 INSTALLATION

A. Install dewatering system utilizing wells, well points, or similar methods complete with pump equipment, standby power and pumps, filter material gradation, valves, appurtenances, water disposal, and surface-water controls.

1. Space well points or wells at intervals required to provide sufficient dewatering.
2. Use filters or other means to prevent pumping of fine sands or silts from the subsurface.

B. Before excavating below ground-water level, place system into operation to lower water to specified levels. Operate system continuously until drains, sewers, and structures have been constructed and fill materials have been placed or until dewatering is no longer required.

C. Provide an adequate system to lower and control ground water to permit excavation, construction of structures, and placement of fill materials on dry subgrades. Install sufficient dewatering equipment to drain water-bearing strata above and below bottom of foundations, drains, sewers, and other excavations.

1. Do not permit open-sump pumping that leads to loss of fines, soil piping, subgrade softening, and slope instability.

D. Reduce hydrostatic head in water-bearing strata below subgrade elevations of foundations, drains, sewers, and other excavations.

1. Maintain piezometric water level a minimum of 24 inches (600 mm) below surface of excavation.

E. Dispose of water removed by dewatering in a manner that avoids endangering public health, property, and portions of work under construction or completed. Dispose of water and sediment in a manner that avoids inconvenience to others and all authorities having jurisdiction. Provide sumps, sedimentation tanks, and other flow-control devices as required by authorities having jurisdiction.

F. Provide standby equipment on site, installed and available for immediate operation, to maintain dewatering on continuous basis if any part of system becomes inadequate or fails. If dewatering requirements are not satisfied due to inadequacy or failure of dewatering system, restore damaged structures and foundation soils at no additional expense to Owner.

1. Remove dewatering system from Project site on completion of dewatering. Plug or fill well holes with sand or cut off and cap wells a minimum of 36 inches (900 mm) below overlying construction.

G. Damages: Promptly repair damages to adjacent facilities caused by dewatering operations.

END OF SECTION

SECTION 31 50 00

EXCAVATION SUPPORT AND PROTECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes temporary excavation support and protection systems where called for on the drawings, where directed by the Owner's Representative for protection of structures and where required to meet safety requirements of the U.S. Department of Labor's Construction Safety Act designated as Title 29-LABOR-Part 1926 Safety and Health Regulations for Construction, Subpart P, Sections 926.650 through 653.

B. Trench excavations in public streets and other confined areas where trench walls cannot be sloped must be supported by sheeting, shoring, trench boxes, or other methods acceptable to meet the requirement that the Contractor provide inspection of excavations.

C. Related Sections:

1. Division 31 Section "Dewatering" for dewatering system for excavations.

2. Division 31 Section “Earth Moving”.

3. Division 32 Section “Rock Removal”.

1.3 PERFORMANCE REQUIREMENTS

A. Design, furnish, install, monitor, and maintain excavation support and protection system capable of supporting excavation sidewalls and of resisting soil and hydrostatic pressure and superimposed and construction loads.

1. Design excavation support and protection system, including comprehensive engineering analysis by a qualified professional engineer, to meet site conditions.
2. Prevent surface water from entering excavations by grading, dikes, or other means.
3. Install excavation support and protection systems without damaging existing buildings, structures, and site improvements adjacent to excavation.
4. Monitor vibrations, settlements, and movements.

1.4 SUBMITTALS

A. Shop Drawings: For excavation support and protection system. Submit for review at least ten (10) days prior to beginning related construction.

1.5 PROJECT CONDITIONS

A. Project-Site Information: A geotechnical report has been prepared for this Project and is available for information only. The opinions expressed in this report are those of geotechnical engineer and represent interpretations of subsoil conditions, tests, and results of analyses conducted by geotechnical engineer. Owner will not be responsible for interpretations or conclusions drawn from the data.

1. Make additional test borings and conduct other exploratory operations necessary for excavation support and protection.
2. The geotechnical report is included elsewhere in the Project Manual.

PART 2 - PRODUCTS

2.1 MATERIALS

A. General: Provide materials that are either new or in serviceable condition.

B. Structural Steel: ASTM A 36/A 36M, ASTM A 690/A 690M, or ASTM A 992/A 992M.

C. Steel Sheet Piling: ASTM A 328/A 328M, ASTM A 572/A 572M, or ASTM A 690/A 690M; with continuous interlocks.

1. Corners: Site-fabricated mechanical interlock or roll-formed corner shape with continuous interlock.

D. Wood Lagging: Lumber, mixed hardwood, nominal rough thickness of size and strength required for application.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards that could develop during excavation support and protection system operations.

1. Shore, support, and protect utilities encountered.

B. Install excavation support and protection systems to ensure minimum interference with roads, streets, walks, and other adjacent occupied and used facilities.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.

C. Locate excavation support and protection systems clear of permanent construction so that forming and finishing of concrete surfaces are not impeded.

D. Monitor excavation support and protection systems daily during excavation progress and for as long as excavation remains open. Promptly correct bulges, breakage, or other evidence of movement to ensure that excavation support and protection systems remain stable.

E. Promptly repair damages to adjacent facilities caused by installing excavation support and protection systems.

3.2 SOLDIER PILES AND LAGGING

A. Install steel soldier piles before starting excavation. Extend soldier piles below excavation grade level to depths adequate to prevent lateral movement. Space soldier piles at regular intervals not to exceed allowable flexural strength of wood lagging. Accurately align exposed faces of flanges to vary not more than 2 inches (50 mm) from a horizontal line and not more than 1:120 out of vertical alignment.

B. Install wood lagging within flanges of soldier piles as excavation proceeds. Trim excavation as required to install lagging. Fill voids behind lagging with soil, and compact.

C. Install wales horizontally, as dictated by the design and site conditions, and secure to soldier piles.

3.3 SHEET PILING

A. Before starting excavation, install one-piece sheet piling lengths and tightly interlock to form a continuous barrier. Accurately place the piling, using templates and guide frames unless otherwise recommended in writing by the sheet piling manufacturer. Limit vertical offset of adjacent sheet piling to 60 inches (1500 mm). Accurately align exposed faces of sheet piling to vary not more than 2 inches (50 mm) from a horizontal line and not more than 1:120 out of vertical alignment. Cut tops of sheet piling to uniform elevation at top of excavation.

3.4 TIEBACKS

A. Tiebacks: Drill, install, grout, and tension tiebacks. Test load-carrying capacity of each tieback and replace and retest deficient tiebacks.

1. Test loading shall be observed by a qualified professional engineer responsible for design of excavation support and protection system.
2. Maintain tiebacks in place until permanent construction is able to withstand lateral soil and hydrostatic pressures.

3.5 BRACING

A. Bracing: Locate bracing to clear columns, floor framing construction, and other permanent work. If necessary to move brace, install new bracing before removing original brace.

1. Do not place bracing where it will be cast into or included in permanent concrete work unless otherwise approved by Owner's Representative.
2. Install internal bracing, if required, to prevent spreading or distortion of braced frames.
3. Maintain bracing until structural elements are supported by other bracing or until permanent construction is able to withstand lateral earth and hydrostatic pressures.

3.6 REMOVAL AND REPAIRS

A. Remove excavation support and protection systems when construction has progressed sufficiently to support excavation and bear soil and hydrostatic pressures. Remove in stages to avoid disturbing underlying soils or damaging structures, pavements, facilities, and utilities.

1. Remove excavation support and protection systems to a minimum depth of 48 inches (1200 mm) below overlaying construction and abandon remainder.
2. Fill voids immediately with approved backfill compacted to density specified in Division 31 Section "Earth Moving."
3. Repair or replace, as approved by Owner's Representative, adjacent work damaged or displaced by removing excavation support and protection systems.

B. If indicated on the drawings, leave excavation support and protection systems permanently in place.

END OF SECTION

SECTION 32 12 16

ASPHALT PAVING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Hot-mix asphalt patching.
   2. Hot-mix asphalt paving.

B. Related Work Specified Elsewhere:

   1. Division 31 Section "Earth Moving" for aggregate subbase and base courses and for aggregate pavement shoulders.
   2. Maine Department of Transportation (MDOT) Standard Specification, latest edition.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include technical data and tested physical and performance properties.

   1. Submit laboratory test reports of the stockpiled aggregates initially used in the mix and additional test reports for each change of source per MDOT Section 401.
   2. Submit laboratory test reports for asphalt cement used in the initial mix and additional test reports for each change of source per MDOT Section 401.
   3. Job-Mix Designs: Certification, by MDOT, of approval of each job mix proposed for the Work per MDOT Section 401.

B. Samples: For the following products, in manufacturer's standard sizes unless otherwise indicated:

C. Qualification Data: For qualified manufacturer.

D. Material Test Reports: For each paving material.

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications: A paving-mix manufacturer registered with and approved by the Maine Department of Transportation.

B. Installer Qualifications: Imprinted-asphalt manufacturer's authorized installer who is trained and approved for installation of imprinted asphalt required for this Project.

C. Testing Agency Qualifications: Qualified according to ASTM D 3666 for testing indicated.

D. Regulatory Requirements: Comply with materials, workmanship, and other applicable requirements of the Maine Department of Transportation Standard Specifications for asphalt paving work.

1.5 PROJECT CONDITIONS

A. For weather limitations the State will be considered to be divided into 2 paving zones.

1. Zone 1 – All area north of U.S. Route 2 from Gilead to Bangor and north of Route 9 from Bangor to Calais.
2. Zone 2 – All area south of Zone 1 including the U.S. Route 2 and Route 9 boundaries.

B. Hot Mix Asphalt Pavement (HMA) for use other than traveled way, wearing course may be placed in either zone between the dates of April 15th and November 15th, provided that the air temperature as determined by an approved thermometer (placed in the shade at the paving location) is 40°F or higher and the area to be paved is not frozen.

C. Hot Mix Asphalt Pavement (HMA) to be placed as traveled way, wearing course may be placed in Zone 1 between the dates of May 1st and the Saturday following October 1st and in Zone 2 between the dates of April 15th and the Saturday following October 15th provided the air temperature determined as above is 50°F or higher. The traveled way as used herein shall also truck lanes, ramps, approach roads and auxiliary lanes.

D. Hot bituminous mixtures used for curb, driveways, sidewalks, islands or other incidentals are not subject to season limitations, except that weather conditions shall be satisfactory for proper handling and finishing of the mixture. Unless otherwise specified, bituminous plant mix shall not be placed on a wet surface or a frozen surface. The air temperature shall be 40°F or higher.

E. When it is in the public interest for service to traffic, the Owner's Representative may authorize construction of Hot Mix Asphalt Pavements at lower atmospheric temperatures than those specified or extend the dates of the paving season.

PART 2 - PRODUCTS

2.1 MATERIALS

A. The materials and their use shall conform to the requirements of Section 401 – Hot Mix Asphalt Pavement of the MDOT Standard Specifications.

2.2 AUXILIARY MATERIALS

A. Sand: AASHTO M 29, Grade Nos. 2 or 3.

B. Joint Sealant: AASHTO M 324, Type IV, hot-applied, single-component, polymer-modified bituminous sealant.

2.3 MIXES

A. The materials and their use shall conform to the requirements of Section 401 – Hot Mix Asphalt Pavement of the MDOT Standard Specifications.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that subgrade is dry and in suitable condition to begin paving.

B. Proof-roll subgrade below pavements with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.

1. Completely proof-roll subgrade in one direction[, repeating proof-rolling in direction perpendicular to first direction]. Limit vehicle speed to 3 mph (5 km/h).
2. Proof roll with a loaded 10-wheel, tandem-axle dump truck weighing not less than 15 tons (13.6 tonnes).
3. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Architect, and replace with compacted backfill or fill as directed.

C. Proceed with paving only after unsatisfactory conditions have been corrected.

D. Verify that utilities, traffic loop detectors, and other items requiring a cut and installation beneath the asphalt surface have been completed and that asphalt surface has been repaired flush with adjacent asphalt prior to beginning installation of imprinted asphalt.

3.2 PATCHING

A. Hot-Mix Asphalt Pavement: Saw cut perimeter of patch and excavate existing pavement section to sound base. Excavate rectangular or trapezoidal patches, extending 12 inches (300 mm) into adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically. Remove excavated material. Recompact existing unbound-aggregate base course to form new subgrade.

B. Tack Coat: Apply uniformly to vertical surfaces abutting or projecting into new, hot-mix asphalt paving at a rate of 0.05 to 0.15 gal./sq. yd. (0.2 to 0.7 L/sq. m).

1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

C. Patching: Fill excavated pavements with hot-mix asphalt base mix for full thickness of patch and, while still hot, compact flush with adjacent surface.

3.3 REPAIRS

A. Leveling Course: Install and compact leveling course consisting of hot-mix asphalt surface course to level sags and fill depressions deeper than 1 inch (25 mm) in existing pavements.

   1. Install leveling wedges in compacted lifts not exceeding 3 inches (75 mm) thick.

B. Crack and Joint Filling: Remove existing joint filler material from cracks or joints to a depth of 1/4 inch (6 mm).

   1. Clean cracks and joints in existing hot-mix asphalt pavement.
   2. Use emulsified-asphalt slurry to seal cracks and joints less than 1/4 inch (6 mm) wide. Fill flush with surface of existing pavement and remove excess.
   3. Use hot-applied joint sealant to seal cracks and joints more than 1/4 inch (6 mm) wide. Fill flush with surface of existing pavement and remove excess.

3.4 SURFACE PREPARATION

A. General: Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces. Ensure that prepared subgrade is ready to receive paving.

B. Tack Coat: Apply uniformly to surfaces of existing pavement at a rate of 0.05 to 0.15 gal./sq. yd. (0.2 to 0.7 L/sq. m).

   1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
   2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

3.5 HOT-MIX ASPHALT PLACING

A. The construction requirements shall be as specified in Section 401 – Hot Mix Asphalt Pavement of the MDOT Standard Specifications.

3.6 INSTALLATION TOLERANCES

A. Per MDOT Standard Specifications.

3.7 FIELD QUALITY CONTROL

A. General: Comply with requirements of the MDOT Standard Specifications.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Thickness: In-place compacted thickness of hot-mix asphalt courses will be as indicated on the drawings and determined according to ASTM D 3549.

D. Surface Smoothness: Finished surface of each hot-mix asphalt course will be tested for compliance with smoothness tolerances.

E. In-Place Density: Testing agency will take samples of (cores) taken from the in-place, compacted pavement indicating the percentage of theoretical maximum density (TMD), based on laboratory specimens of the mix combined in the proportions of the job mix formula.

1. Asphalt Pavement Density: Submit laboratory test reports at frequencies not less than one of the following:

    a. Every 150 Mg placed.
    b. Each day's placement.
    c. Each course, each day's placement.

F. Replace and compact hot-mix asphalt where core tests were taken.

G. Remove and replace or install additional hot-mix asphalt where test results or measurements indicate that it does not comply with specified requirements.

3.8 DISPOSAL

A. Except for material indicated to be recycled, remove excavated materials from Project site and legally dispose of them in an EPA-approved landfill.

1. Do not allow milled materials to accumulate on-site.

END OF SECTION

SECTION 32 16 19

ASPHALT CURBING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Asphalt curbing.

B. Related Sections include the following:

1. Division 31 Section "Earth Moving" for excavation and compacted subgrade.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include technical data and tested physical and performance properties.

1. Submit laboratory test reports of the stockpiled aggregates initially used in the mix and additional test reports for each change of source per MDOT Section 401.
2. Submit laboratory test reports for asphalt cement used in the initial mix and additional test reports for each change of source per MDOT Section 401.
3. Job-Mix Designs: Certification, by MDOT, of approval of each job mix proposed for the Work per MDOT Section 401.

1.4 QUALITY ASSURANCE

A. State of Maine Department of Transportation (MDOT): Standard Specifications for Highways and Bridges (Latest Edition).

1.5 PROJECT CONDITIONS

A. Hot bituminous mixtures used for curb or other incidentals are not subject to season limitations, except that weather conditions shall be satisfactory for proper handling and finishing of the mixture. Unless otherwise specified, bituminous plant mix shall not be placed on a wet surface or a frozen surface. The air temperature shall be 40°F or higher.

PART 2 - PRODUCTS

2.1 MATERIALS

A. The materials and their use shall conform to the requirements of Section 401 – Hot Mix Asphalt Pavement of the MDOT Standard Specifications.

2.2 MIXES

A. The materials and their use shall conform to the requirements of Section 401 – Hot Mix Asphalt Pavement of the MDOT Standard Specifications.

PART 3 - EXECUTION

3.1 ASPHALT CURBS

A. Construct hot-mix asphalt curbs over compacted pavement surfaces. Apply a light tack coat unless pavement surface is still tacky and free from dust. Spread mix at minimum temperature of 250 deg F (121 deg C).

1. Asphalt Mix: Same as pavement surface-course mix.

B. Place hot-mix asphalt to curb cross section indicated or, if not indicated, to local standard shapes, by machine or by hand in wood or metal forms. Tamp hand-placed materials and screed to smooth finish. Remove forms after hot-mix asphalt has cooled.

3.2 PROTECTION

A. Protect the curb and keep in good condition. Clean all exposed surfaces smeared or discolored and restored to a satisfactory condition or the curb removed and replaced.

END OF SECTION

SECTION 32 17 23

PAVMENT MARKINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Pavement-marking paint.

B. Related Sections:

1. Division 32 Section "Asphalt Paving" for paving installation.

1.3 DEFINITION

A. Hot-Mix Asphalt Paving Terminology: Refer to ASTM D 8 for definitions of terms.

1.4 SUBMITTALS

A. Product Data: Provide data on paint products.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver pavement-marking materials to Project site in original packages with seals unbroken and bearing manufacturer's labels containing brand name and type of material, date of manufacture, and directions for storage.

B. Store pavement-marking materials in a clean, dry, protected location within temperature range required by manufacturer. Protect stored materials from direct sunlight.

1.6 PROJECT CONDITIONS

A. Pavement-Marking Paint: Proceed with pavement marking only on clean, dry surfaces and at a minimum ambient or surface temperature of 55 deg F (12.8 deg C) for water-based materials, and not exceeding 95 deg F (35 deg C).

PART 2 - PRODUCTS

2.1 MATERIALS

A. Pavement-Marking Paint: Latex, waterborne emulsion, lead and chromate free, ready mixed, complying with MDOT Specifications, Section 708.03 (Type F).

1. Color: White

2.2 EQUIPMENT

A. Equipment used for the application of pavement striping shall be fully powered and of standard commercial manufacture. Truck mounted equipment may be approved is, in the opinion of the Owner's Representative, the quality of the work of the machine is satisfactory.

PART 3 - EXECUTION

3.1 PREPARATION

A. The use of white and yellow materials will require thorough cleaning of equipment so as not to mix the colors. Any mixture of colors will be deemed sufficient reason for rejection of the work be the Owner's Representative and replacement by the Contractor.

3.2 LAYOUT

A. The transverse lines, established by the Contractor for control of striping, shall be chalked as a guide and shall be approved by the Owner's Representative before the application of any striping. The length of line shall be measured and marked by the Contractor for the locations listed below. All pavement markings shall be in accordance with the applicable sections of the Manual of Uniform Traffic Control Devices for Streets and Highways, most recent addition.

B. Stripe parking lot spaces and any other pavement graphics shown/detailed on Drawings with 4" wide striping. Fire lanes, crosswalks, etc. to be marked as shown on Drawings. The Universal Handicap Symbol, as detailed on Plans, shall be painted at the designated handicapped stalls. The drop-off strips between the handicapped stalls shall be painted solid blue with non-skid surfaces.

3.3 PAVEMENT MARKING

A. Do not apply pavement-marking paint until layout, colors, and placement have been verified with Owner's Representative.

B. Allow paving to age for 48 hours before starting pavement marking.

C. Sweep and clean surface to eliminate loose material and dust.

D. Apply paint in accordance with MDOT Standard Specifications, Section 627.

E. Apply paint with mechanical equipment to produce pavement markings, of dimensions indicated, with uniform, straight edges. Apply at manufacturer's recommended rates to provide a minimum wet film thickness of 15 mils (0.4 mm).

1. Broadcast glass beads uniformly into wet pavement markings at a rate of 6 lb/gal. (0.72 kg/L).

3.4 CLEANING

A. If for any reason, paint is spilled or tracked on the pavement, or any markings applied by the Contractor, in the Owner's Representative's judgment, fail to conform to the requirements of this Section, because of a deviation from the desired pattern, the Contractor shall remove such paint by a method that is not injurious to the pavement surface and is acceptable to the Owner's Representative, clean the pavement surface and prepare the surface for a reapplication of markings; and reapply the markings as directed without additional compensation for any of the foregoing corrective operations.

END OF SECTION

SECTION 32 17 29

TRAFFIC SIGNS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Parking and Traffic signs.
2. Directional signs.
3. Information signs.

PART 2 - PRODUCTS

2.1 SIGNS

A. Provide signs conforming to the requirements of MDOT standards and section 645 of the MUTCD standards.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in conformance to the requirements of MDOT standards.

END OF SECTION

SECTION 32 92 00

TURF AND GRASSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Seeding.
2. Hydro-seeding.
3. Sodding.

1.3 DEFINITIONS

A. Duff Layer: The surface layer of native topsoil that is composed of mostly decayed leaves, twigs, and detritus.

B. Finish Grade: Elevation of finished surface of planting soil.

C. Manufactured Topsoil: Soil produced off-site by homogeneously blending mineral soils or sand with stabilized organic soil amendments to produce topsoil or planting soil.

D. Planting Soil (Topsoil): Standardized topsoil; existing, native surface topsoil; existing, in-place surface soil; imported topsoil; or manufactured topsoil that is modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.

E. Sod: Locally grown turf grass sod of species indicated and capable of vigorous growth and development when planted.

F. Subgrade: Surface or elevation of subsoil remaining after excavation is completed, or top surface of a fill or backfill before planting soil is placed.

G. Subsoil: All soil beneath the topsoil layer of the soil profile, and typified by the lack of organic matter and soil organisms.

H. Surface Soil: Soil that is present at the top layer of the existing soil profile at the Project site. In undisturbed areas, the surface soil is typically topsoil, but in disturbed areas such as urban environments, the surface soil can be subsoil.

1.4 SUBMITTALS

A. Certification of Grass Seed: From seed vendor for each grass-seed monostand or mixture stating the botanical and common name, percentage by weight of each species and variety, and percentage of purity, germination, and weed seed. Include the year of production and date of packaging.

1. Certification of each seed mixture for turfgrass sod. Include identification of source and name and telephone number of supplier.
2. For topsoil, submit topsoil analysis done by a plant and soil testing agency such as the Maine Soil Testing and Analytical Lab (207-581-2934) for review by the Owner's Representative. State recommended quantities for amendments (lime, fertilizer and organic matter) necessary to produce satisfactory topsoil as stated in the specifications herein.
3. Submit product information with mix ratios and amounts for hydro mulching to be used during hydro seeding for Owner's Representative's approval.
4. Submit fertilizer, herbicide and fungicide products for application as required for Owner's Representative's approval.

B. Product Certificates: For soil, soil amendments and fertilizers, from manufacturer.

1.5 QUALITY ASSURANCE

A. Soil-Testing Laboratory Qualifications: An independent laboratory with the experience and capability to conduct the testing indicated and that specializes in types of tests to be performed.

B. Soil Analysis: For each unamended soil type, furnish soil analysis and a written report by a qualified soil-testing laboratory stating percentages of organic matter; textural analysis; cation exchange capacity; deleterious material; organic content; pH; and mineral and plant-nutrient content of the soil.

1. Testing methods and written recommendations shall comply with USDA's Handbook No. 60.
2. Report suitability of tested soil for turf growth.

   a. Based on the test results, state recommendations for soil treatments and soil amendments to be incorporated. State recommendations in weight per 1000 sq. ft. (92.9 sq. m) or volume per cu. yd. (0.76 cu. m) for nitrogen, phosphorus, and potash nutrients and soil amendments to be added to produce satisfactory planting soil suitable for healthy, viable plants.
   b. Report presence of problem salts, minerals, or heavy metals, including aluminum, arsenic, barium, cadmium, chromium, cobalt, lead, lithium, and vanadium. If such problem materials are present, provide additional recommendations for corrective action.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Seed and Other Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws, as applicable.

B. Sod: Harvest, deliver, store, and handle sod according to requirements in "Specifications for Turfgrass Sod Materials" and "Specifications for Turfgrass Sod Transplanting and Installation" in TPI's "Guideline Specifications to Turfgrass Sodding." Deliver sod in time for planting within 24 hours of harvesting. Protect sod from breakage and drying. Store in a cool, dry, shaded area.

C. Bulk Materials:

1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
3. Accompany each delivery of bulk fertilizers, lime, and soil amendments with appropriate certificates.

D. Use all means necessary to protect seed from moisture and other contaminants which may adversely effect proper germination.

E. Use all means necessary to protect fertilizers, amendments and other materials from moisture and other contaminants which may adversely effect their efficacy.

1.7 PROJECT CONDITIONS

A. Planting Restrictions: Plant during one of the following periods. Coordinate planting periods with initial maintenance periods to provide required maintenance from date of planting completion.

1. Spring Planting: April 15 to June 15.
2. Fall Planting: August 15 to October 15.
3. The Contractor may seed at times other than those specified, only upon authorization of the Owner's Representative.

B. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions.

1.8 MAINTENANCE SERVICE

A. Initial Turf Maintenance Service: Provide full maintenance by skilled employees of landscape Installer. Maintain as required in Part 3. Begin maintenance immediately after each area is planted and continue until acceptable turf is established but for not less than the following periods:

1. Seeded Turf: 60 days from date of planting completion.

   a. When initial maintenance period has not elapsed before end of planting season, or if turf is not fully established, continue maintenance during next planting season.

2. Sodded Turf: 30 days from date of planting completion.

PART 2 - PRODUCTS

2.1 TOPSOIL

A. Topsoil stockpiled from on-site stripping may be utilized if in compliance with the requirements for new topsoil.

B. New Topsoil:
   1. Natural, fertile loam typical of cultivated topsoil of the locality, containing not less than 3.5 percent or more than 8 percent by weight, of decayed organic matter (humus) as determined by ASTM F1647.
   2. Obtain from a well drained arable site, free of subsoil, earth clods, large stones, sticks, stumps, clay lumps, roots, or other objectionable, extraneous matter or debris. Screen topsoil to a maximum stone size of 3/4 inch.
   3. Provide topsoil that is free of Quack-grass rhizones, *Agropyron Repens*, and the nut-like tubers of Nutgrass, *Cyperus Esculentus*, and all other primary noxious weeds.
   4. Provide topsoil with a pH of not less than 6.0 or greater than 6.8.
   5. Provide topsoil with a loam texture classification and do not deliver or use while in a frozen or muddy condition.
   6. Provide topsoil that conforms to the following particle size distribution, as determined by pipette method in compliance with ASTM F1632.

      a. Sand: 40-60 percent.
      b. Silt: 30-40 percent.
      c. Clay: 5-20 percent.

   7. If determined by a soil test the existing topsoil that was stripped does not meet this specifications, the topsoil may be amended to provide and acceptable topsoil for use or replaced by an imported topsoil which conforms to the topsoil specification.

2.2 SEED

A. Grass Seed: Fresh, clean, dry, new-crop seed complying with AOSA's "Journal of Seed Technology; Rules for Testing Seeds" for purity and germination tolerances.

B. Seed Species: Seed of grass species as indicated on the drawings and with not less than 95 percent germination, not less than 85 percent pure seed, and not more than 0.5 percent weed seed:

2.3 TURFGRASS SOD

A. Turfgrass Species: Sod of grass species as follows, with not less than 95 percent germination, not less than 85 percent pure seed, and not more than 0.5 percent weed seed:

1. Proportioned by weight as follows:

   a. 80 percent Kentucky Bluegrass Minimum (2 varieties minimum).
   b. 20 percent Perennial Ryegrass Maximum (2 varieties minimum).

2.4 INORGANIC SOIL AMENDMENTS

A. Lime: ASTM C 602, agricultural liming material containing a minimum of 80 percent calcium carbonate equivalent and as follows:

1. Class: O, with a minimum of 98 percent passing through No. 20 sieve and a minimum of 55 percent passing through No. 60 sieve.
2. Provide lime in form of ground dolomitic limestone.

2.5 ORGANIC SOIL AMENDMENTS

A. Compost: Well-composted, stable, and weed-free organic matter, pH range of 6.1 to 7.8; moisture content 40 to 60 percent by weight; 100 percent passing through 1/2-inch (12.5-mm) sieve; soluble salt content of less than 2mnho/cm in final topsoil mix; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:

1. Organic Matter Content: 30 to 60 percent of dry weight.
2. Nutrients: Provide NPK level information.
3. Feedstock: Agricultural, food, or industrial residuals; biosolids; yard trimmings; or source-separated or compostable mixed solid waste.

B. Sphagnum Peat: Partially decomposed sphagnum peat moss, finely divided or of granular texture, with a pH range of 3.4 to 4.8 and an ash content not exceeding 15 percent as determined by ASTM D2974.

2.6 FERTILIZERS

A. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:

1. Composition: 15 percent nitrogen, 15 percent phosphorous, and 15 percent potassium, by weight or as otherwise recommended by the soil analysis.
2. Registration: Fertilizer must be registered with the Maine State Department of Agriculture and shall meet their standard requirements.

2.7 PLANTING SOILS

A. New Planting Soil: Natural, fertile topsoil, with pH range of 6 to 6.8, not less than 3.5 percent or more than 8 percent by weight of organic material content; free of stones 3/4 inch (19 mm) or larger in any dimension and other extraneous materials harmful to plant growth. Mix topsoil with the following soil amendments and fertilizers in the following quantities to produce planting soil:

1. Provide topsoil free of obnoxious weeds and invasive plants including quackgrass, Johnsongrass, poison ivy, nutsedge, nimblewill, Canada thistle, bindweed, bentgrass, wild garlic, ground ivy, perennial sorrel, and bromegrass.
2. Provide topsoil having a pH of not less than 6.0 or greater tha 6.8.
3. Do not deliver or use while in a frozen or muddy condition.
4. Topsoil shall conform to the following particle size distribution, as determined by pipette method in compliance with ASTM F-1632:

a. Sand: 40 to 60 percent.
b. Silt: 30 to 40 percent.
c. Clay: 5 to 20 percent.

B. Existing Planting Soil: Existing, native surface topsoil formed under natural conditions with the duff layer retained during excavation process and stockpiled on-site. Verify suitability of native surface topsoil to produce viable planting soil. Clean soil of roots, plants, sod, stones, clay lumps, and other extraneous materials harmful to plant growth.

1. Supplement with new planting soil when quantities are insufficient.
2. Mix existing, native surface topsoil with soil amendments and fertilizers to produce planting soil equal to new planting soil.
3. If determined by a soil test the existing topsoil that was stripped does not meet the specification for new planting soil, the topsoil may be amended to provide an acceptable topsoil for use or replaced by an imported topsoil which conforms to the new planting soil specification.

2.8 MULCHES

A. Straw Mulch: Provide air-dry, clean, mildew- and seed-free, salt hay or threshed straw of wheat, rye, oats, or barley. No material shall be used which is too wet, decayed or compacted as to inhibit even uniform spreading.

B. Fiber Mulch: Biodegradable, green dyed wood, cellulose-fiber mulch; nontoxic and free of plant-growth or germination inhibitors; with a maximum moisture content of 15 percent and a pH range of 4.5 to 6.5. Provide in moisture resistant sealed bags marked with the manufacturer's name, the air dry weight and composition of the contents.

C. Hydro mulch: Shall be Terra-Sorb GB, or an approved equal. Add Terra-Sorb to the hydro seed tank at the amount of 60 pounds per acre.

D. Mulch Binder: Asphalt emulsion; ASTM D 977, Grade SS-1; nontoxic and free of plant-growth or germination inhibitors.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to be planted for compliance with requirements and other conditions affecting performance.

1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
2. Do not mix or place soils and soil amendments in frozen, wet, or muddy conditions.
3. Suspend soil spreading, grading, and tilling operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
4. Uniformly moisten excessively dry soil that is not workable and which is too dusty.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

C. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Architect and replace with new planting soil.

3.2 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities, trees, shrubs, and plantings from damage caused by planting operations.

1. Protect adjacent and adjoining areas from hydro-seeding and hydro-mulching overspray.
2. Protect grade stakes set by others until directed to remove them.

3.3 TURF AREA PREPARATION

A. Limit turf subgrade preparation to areas to be planted.

B. Newly Graded Subgrades: Loosen subgrade to a minimum depth of 4 inches (100 mm). Remove stones larger than 1 inch (25 mm) in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.

1. Spread topsoil, apply soil amendments and fertilizer on surface, and thoroughly blend planting soil.

   a. Delay mixing fertilizer with planting soil if planting will not proceed within a few days.
   b. Mix lime with dry soil before mixing fertilizer.

2. Spread planting soil to a minimum depth of 6 inches (150 mm), unless noted otherwise, but not less than required to meet finish grades after light rolling and natural settlement. Do not spread if planting soil or subgrade is frozen, muddy, or excessively wet.

C. Unchanged Subgrades: If turf is to be planted in areas unaltered or undisturbed by excavating, grading, or surface-soil stripping operations, prepare surface soil as follows:

1. Remove existing grass, vegetation, and turf. Do not mix into surface soil.
2. Loosen surface soil to a depth of at least 6 inches (150 mm). Apply soil amendments and fertilizers according to planting soil mix proportions and mix thoroughly into top 4 inches (100 mm) of soil. Till soil to a homogeneous mixture of fine texture.
3. Remove stones larger than 1 inch (25 mm) in any dimension and sticks, roots, trash, and other extraneous matter.
4. Legally dispose of waste material, including grass, vegetation, and turf, off Owner's property.

D. Finish Grading: Grade planting areas to a smooth, uniform surface plane with loose, uniformly fine texture. Grade to within plus or minus 1/2 inch (13 mm) of finish elevation. Roll and rake, remove ridges, and fill depressions to meet finish grades. Limit finish grading to areas that can be planted in the immediate future.

E. Moisten prepared area before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

F. Before planting, obtain Owner's Representative acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

G. Provide fertilizer and lime application if recommended by the soil testing lab. Apply with broadcast spreader and incorporate into the top 4 inches of topsoil.

3.4 SEEDING

A. Method of seeding may be varied at discretion of Contractor. It is his or her responsibility to establish a smooth, uniform turf composed of approved grasses.

B. Sow seed with spreader or seeding machine. Do not broadcast or drop seed when wind velocity exceeds 5 mph (8 km/h). Evenly distribute seed by sowing equal quantities in two directions at right angles to each other.

1. Do not use wet seed or seed that is moldy or otherwise damaged.
2. Do not seed against existing trees. Limit extent of seed to outside edge of planting saucer.

C. Sow seed at rate recommended by the supplier.

D. Rake seed lightly into top 1/8 inch (3 mm) of soil, roll lightly, and water with fine spray.

E. Protect seeded areas with slopes exceeding 1:4 with erosion-control blankets and 1:6 with erosion-control fiber mesh installed and stapled according to manufacturer's written instructions.

F. Mulch seeded areas with straw mulch, 1-1/2 to 2 tons per acre. Secure mulch at Contractor's discretion as to method or need.

3.5 HYDRO-SEEDING

A. Method of seeding may be varied at discretion of Contractor. It is his or her responsibility to establish a smooth, uniform turf composed of approved grasses.

B. Hydro-seeding: Mix specified seed, fertilizer, and fiber mulch in water, using equipment specifically designed for hydro-seed application. Continue mixing until uniformly blended into homogeneous slurry suitable for hydraulic application.

1. Mix slurry with asphalt-emulsion tackifier.
2. Apply slurry uniformly to all areas to be seeded in a two-step process. Apply first slurry coat at a rate so that mulch component is deposited at not less than 500-lb/acre (5.2-kg/92.9 sq. m) dry weight, and seed component is deposited at not less than the specified seed-sowing rate. Apply slurry cover coat of fiber mulch (hydromulching) at a rate of 1400 lb/acre.

3.6 SODDING

A. Lay sod within 24 hours of harvesting. Do not lay sod if dormant or if ground is frozen or muddy.

B. Lay sod to form a solid mass with tightly fitted joints. Butt ends and sides of sod; do not stretch or overlap. Stagger sod strips or pads to offset joints in adjacent courses. Avoid damage to subgrade or sod during installation. Tamp and roll lightly to ensure contact with subgrade, eliminate air pockets, and form a smooth surface. Work sifted soil or fine sand into minor cracks between pieces of sod; remove excess to avoid smothering sod and adjacent grass.

1. Lay sod across angle of slopes exceeding 1:3.
2. Anchor sod on slopes exceeding 1:6 with wood pegs or steel staples spaced as recommended by sod manufacturer but not less than 2 anchors per sod strip to prevent slippage.

C. Saturate sod with fine water spray within two hours of planting. During first week after planting, water daily or more frequently as necessary to maintain moist soil to a minimum depth of 1-1/2 inches (38 mm) below sod.

3.7 TURF MAINTENANCE

A. Maintain and establish turf by watering, fertilizing, weeding, mowing, trimming, replanting, and performing other operations as required to establish healthy, viable turf. Roll, regrade, and replant bare or eroded areas and additional mulch to produce a uniformly smooth turf. Provide materials and installation the same as those used in the original installation.

1. Fill in as necessary soil subsidence that may occur because of settling or other processes. Replace materials and turf damaged or lost in areas of subsidence.
2. In areas where mulch has been disturbed by wind or maintenance operations, add new mulch and anchor as required to prevent displacement.

3. Apply treatments as required to keep turf and soil free of pests and pathogens or disease. Use integrated pest management practices whenever possible to minimize the use of pesticides and reduce hazards.
4. Schedule watering to prevent wilting, puddling, erosion, and displacement of seed or mulch. Lay out temporary watering system to avoid walking over muddy or newly planted areas.
5. Water turf with fine spray at a minimum rate of 1 inch (25 mm) per week unless rainfall precipitation is adequate.

B. Mow turf as soon as top growth is tall enough to cut. Repeat mowing to maintain specified height without cutting more than 1/3 of grass height. Remove no more than 1/3 of grass-leaf growth in initial or subsequent mowings. Do not delay mowing until grass blades bend over and become matted. Do not mow when grass is wet. Schedule initial and subsequent mowings to maintain a grass height of 2-1/2 to 3 inches.

3.8 INSPECTION AND ACCEPTANCE

A. Turf installations shall meet the following criteria as determined by Owner's Representative. The Owner's Representative will inspect lawns upon written request by the Contractor. The request shall be received at least ten (10) days before the anticipated date of inspection.

1. Satisfactory Seeded Turf: At end of maintenance period, a healthy, uniform, close stand of grass has been established, free of weeds and surface irregularities, with coverage exceeding 90 percent over any 10 sq. ft. (0.92 sq. m) and bare spots not exceeding 5 by 5 inches (125 by 125 mm).
2. Satisfactory Sodded Turf: At end of maintenance period, a healthy, well-rooted, even-colored, viable turf has been established, free of weeds, open joints, bare areas, and surface irregularities.

B. Use specified materials to reestablish turf that does not comply with requirements and continue maintenance until turf is satisfactory.

C. If the grass is in satisfactory condition, the Contractor's care and maintenance responsibilities will end. If the grass stand is unsatisfactory, the Contractor's maintenance responsibility shall continue, including a normal program of mowing, trimming, reseeding, fertilization and repair until and acceptable stand of grass is achieved.

3.9 CLEANUP AND PROTECTION

A. Promptly remove soil and debris created by turf work from paved areas. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.

B. Erect temporary fencing or barricades and warning signs as required to protect newly planted areas from traffic. Maintain fencing and barricades throughout initial maintenance period and remove after plantings are established.

C. Remove nondegradable erosion-control measures after grass establishment period.

END OF SECTION

SECTION 32 93 00

PLANTINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Plants.
2. Planting soils.
3. Tree stabilization.

B. Related Sections:

1. Division 31 Section "Site Clearing" for protection of existing trees and plantings, topsoil stripping and stockpiling, and site clearing.
2. Division 31 Section "Earth Moving" for excavation, filling, and rough grading and for subsurface aggregate drainage and drainage backfill materials.
3. Division 32 Section "Turf and Grasses" for turf (lawn) and roadway planting, hydro-seeding, and erosion-control materials.

1.3 DEFINITIONS

A. Backfill: The earth used to replace or the act of replacing earth in an excavation.

B. Balled and Burlapped Stock: Plants dug with firm, natural balls of earth in which they were grown, with ball size not less than sizes indicated; wrapped with burlap, tied, rigidly supported, and drum laced with twine with the root flare visible at the surface of the ball as recommended by ANSI Z60.1.

C. Balled and Potted Stock: Plants dug with firm, natural balls of earth in which they are grown and placed, unbroken, in a container. Ball size is not less than sizes indicated.

D. Bare-Root Stock: Plants with a well-branched, fibrous-root system developed by transplanting or root pruning, with soil or growing medium removed, and with not less than minimum root spread according to ANSI Z60.1 for type and size of plant required.

E. Container-Grown Stock: Healthy, vigorous, well-rooted plants grown in a container, with a well-established root system reaching sides of container and maintaining a firm ball when removed from container. Container shall be rigid enough to hold ball shape and protect root mass during shipping and be sized according to ANSI Z60.1 for type and size of plant required.

F. Finish Grade: Elevation of finished surface of planting soil.

G. Planting Area: Areas to be planted.

H. Planting Soil: Standardized topsoil; existing, native surface topsoil; existing, in-place surface soil; imported topsoil; or manufactured topsoil that is modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.

I. Plant; Plants; Plant Material: These terms refer to vegetation in general, including trees, shrubs, vines, ground covers, ornamental grasses, bulbs, corms, tubers, or herbaceous vegetation.

J. Root Flare: Also called "trunk flare." The area at the base of the plant's stem or trunk where the stem or trunk broadens to form roots; the area of transition between the root system and the stem or trunk.

K. Stem Girdling Roots: Roots that encircle the stems (trunks) of trees below the soil surface.

L. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.

M. Subsoil: All soil beneath the topsoil layer of the soil profile, and typified by the lack of organic matter and soil organisms.

N. Surface Soil: Soil that is present at the top layer of the existing soil profile at the Project site. In undisturbed areas, the surface soil is typically topsoil; but in disturbed areas such as urban environments, the surface soil can be subsoil.

1.4 SUBMITTALS

A. Product Certificates: For each type of manufactured product, from manufacturer, and complying with the following:

1. Manufacturer's certified analysis of standard products.
2. Analysis of other materials by a recognized laboratory made according to methods established by the Association of Official Analytical Chemists, where applicable.

B. Maintenance Instructions: Recommended procedures to be established by Owner for maintenance of plants during a calendar year. Submit before start of required maintenance periods.

C. Warranty: Sample of special warranty.

1.5 QUALITY ASSURANCE

A. Provide quality, size, genus, species, and variety of plants indicated, complying with applicable requirements in ANSI Z60.1.

B. Plant Material Observation: Owner's Representative may observe plant material either at place of growth or at site before planting for compliance with requirements for genus, species, variety, cultivar, size, and quality. Owner's Reprsentative retains right to observe trees and shrubs further for size and condition of balls and root systems, pests, disease symptoms, injuries, and latent defects and to reject unsatisfactory or defective material at any time during progress of work. Remove rejected trees or shrubs immediately from Project site.

1. Notify Owner's Representative of sources of planting materials seven days in advance of delivery to site.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws if applicable.

B. Bulk Materials:

1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.

C. Deliver bare-root stock plants freshly dug. Immediately after digging up bare-root stock, pack root system in wet straw, hay, or other suitable material to keep root system moist until planting.

D. Do not prune trees and shrubs before delivery. Protect bark, branches, and root systems from sun scald, drying, wind burn, sweating, whipping, and other handling and tying damage. Do not bend or bind-tie trees or shrubs in such a manner as to destroy their natural shape. Provide protective covering of plants during shipping and delivery. Do not drop plants during delivery and handling.

E. Handle planting stock by root ball.

F. Store bulbs, corms, and tubers in a dry place at 60 to 65 deg F (16 to 18 deg C) until planting.

G. Deliver plants after preparations for planting have been completed, and install immediately. If planting is delayed more than six hours after delivery, set plants and trees in their appropriate aspect (sun, filtered sun, or shade), protect from weather and mechanical damage, and keep roots moist.

1. Heel-in bare-root stock. Soak roots that are in dry condition in water for two hours. Reject dried-out plants.
2. Set balled stock on ground and cover ball with soil, peat moss, sawdust, or other acceptable material.
3. Do not remove container-grown stock from containers before time of planting.

4. Water root systems of plants stored on-site deeply and thoroughly with a fine-mist spray. Water as often as necessary to maintain root systems in a moist, but not overly-wet condition.

1.7 PROJECT CONDITIONS

A. Field Measurements: Verify actual grade elevations, service and utility locations, irrigation system components, and dimensions of plantings and construction contiguous with new plantings by field measurements before proceeding with planting work.

B. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions and warranty requirements.

C. Coordination with Turf Areas (Lawns): Plant trees, shrubs, and other plants after finish grades are established and before planting turf areas unless otherwise indicated.

   1. When planting trees, shrubs, and other plants after planting turf areas, protect turf areas, and promptly repair damage caused by planting operations.

1.8 WARRANTY

A. Special Warranty: Installer agrees to repair or replace plantings and accessories that fail in materials, workmanship, or growth within specified warranty period.

   1. Failures include, but are not limited to, the following:

      a. Death and unsatisfactory growth, except for defects resulting from abuse, lack of adequate maintenance, or neglect by Owner, or incidents that are beyond Contractor's control.
      b. Structural failures including plantings falling or blowing over.
      c. Faulty performance of tree stabilization, edgings, or tree grates.
      d. Deterioration of metals, metal finishes, and other materials beyond normal weathering.

   2. Warranty Periods from Date of Acceptance: 12 months.

   3. Include the following remedial actions as a minimum:

      a. Immediately remove dead plants and replace unless required to plant in the succeeding planting season.
      b. Replace plants that are more than 25 percent dead or in an unhealthy condition at end of warranty period.
      c. Provide extended warranty for period equal to original warranty period, for replaced plant material.

1.9 MAINTENANCE SERVICE

A. Initial Maintenance Service for Trees and Shrubs: Provide maintenance by skilled employees of landscape Installer. Maintain as required in Part 3. Begin maintenance immediately after plants are installed and continue until plantings are acceptably healthy and well established but for not less than maintenance period below.

1. Maintenance Period: Until date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PLANT MATERIAL

A. General: Furnish nursery-grown plants true to genus, species, variety, cultivar, stem form, shearing, and other features indicated in Plant Schedule or Plant Legend shown on Drawings and complying with ANSI Z60.1; and with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully branched, healthy, vigorous stock, densely foliated when in leaf and free of disease, pests, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement.

1. Trees with damaged, crooked, or multiple leaders; tight vertical branches where bark is squeezed between two branches or between branch and trunk ("included bark"); crossing trunks; cut-off limbs more than 3/4 inch (19 mm) in diameter; or with stem girdling roots will be rejected.
2. Collected Stock: Do not use plants harvested from the wild, from native stands, from an established landscape planting, or not grown in a nursery unless otherwise indicated.

B. Provide plants of sizes, grades, and ball or container sizes complying with ANSI Z60.1 for types and form of plants required. Plants of a larger size may be used if acceptable to Owner's Representative, with a proportionate increase in size of roots or balls.

C. Root-Ball Depth: Furnish trees and shrubs with root balls measured from top of root ball, which shall begin at root flare according to ANSI Z60.1. Root flare shall be visible before planting.

D. Labeling: Label at least one plant of each variety, size, and caliper with a securely attached, waterproof tag bearing legible designation of common name and full scientific name, including genus and species. Include nomenclature for hybrid, variety, or cultivar, if applicable for the plant as shown on Drawings.

E. Annuals and Biennials: Provide healthy, disease-free plants of species and variety shown or listed, with well-established root systems reaching to sides of the container to maintain a firm ball, but not with excessive root growth encircling the container. Provide only plants that are acclimated to outdoor conditions before delivery.

2.2 FERTILIZERS

A. Planting Tablets: Tightly compressed chip type, long-lasting, slow-release, commercial-grade planting fertilizer in tablet form. Tablets shall break down with soil bacteria, converting nutrients into a form that can be absorbed by plant roots.

1. Size: 10-gram tablets.
2. Nutrient Composition: 20 percent nitrogen, 10 percent phosphorous, and 5 percent potassium, by weight plus micronutrients.

2.3 PLANTING SOILS

A. Refer to Division 32 Section "Turf and Grasses" for topsoil requirements and plans for planting soil mix.

2.4 MULCHES

A. Organic Mulch: Free from deleterious materials and suitable as a top dressing of trees and shrubs, consisting of one of the following:

1. Type: Aged spruce and pine bark, consisting of the outer bark of the trees with minimum hardwood bark. Bark shall be thoroughly mixed and aged in stock piles a minimum of 6 months, partially decomposed, dark brown in color, and generally free of chunks of wood thicker than 1/4". Aged mulch containing an excess of fine particles will not be acceptable.

2.5 TREE STABILIZATION MATERIALS

A. Stakes and Guys:

1. Upright and Guy Stakes: Rough-sawn, sound, new hardwood, free of knots, holes, cross grain, and other defects, 2-by-2-inch nominal (38-by-38-mm actual) by length indicated, pointed at one end.
   a. Guying: 30 inches long.
   b. Staking: 96 inches long.
2. Guys and Tie Wires: ASTM A 641/A 641M, Class 1, galvanized-steel wire, two-strand, twisted, 14 gage in diameter, with rubber hose or Chain Lock brand plastic tree tie or approved equivalent.
3. Wrapping Material: First quality, heavy, waterproof crepe paper manufactured for this purpose; not less than 4" wide. Install only when required as noted on the drawings.

B. Root-Ball Stabilization Materials:

1. Upright Stakes and Horizontal Hold-Down: Rough-sawn, sound, new hardwood or softwood, free of knots, holes, cross grain, and other defects, 2-by-2-inch nominal (38-by-38-mm actual) by length indicated; stakes pointed at one end.
2. Wood Screws: ASME B18.6.1.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive plants for compliance with requirements and conditions affecting installation and performance.

1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
2. Do not mix or place soils and soil amendments in frozen, wet, or muddy conditions.
3. Suspend soil spreading, grading, and tilling operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
4. Uniformly moisten excessively dry soil that is not workable and which is too dusty.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

C. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Architect and replace with new planting soil.

3.2 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities and turf areas and existing plants from damage caused by planting operations.

B. Lay out individual tree and shrub locations and areas for multiple plantings. Stake locations, outline areas, adjust locations when requested, and obtain Owner's Representative acceptance of layout before excavating or planting. Make minor adjustments as required.

C. Wrap trees and shrubs with burlap fabric over trunks, branches, stems, twigs, and foliage to protect from wind and other damage during digging, handling, and transportation.

3.3 PLANTING AREA ESTABLISHMENT

A. Loosen subgrade of planting areas to a minimum depth of 12 inches (300 mm). Remove stones larger than 1 inch (25 mm) in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.

1. Spread planting soil to a depth of 12 inches (300 mm) unless indicated or directed otherwise but not less than required to meet finish grades after natural settlement. Do not spread if planting soil or subgrade is frozen, muddy, or excessively wet.

B. Finish Grading: Grade planting areas to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

C. Before planting, obtain Owner's Representative acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

D. Application of Mycorrhizal Fungi: Apply as required for best plant growth.

3.4 EXCAVATION FOR TREES AND SHRUBS

A. Planting Pits and Trenches: Excavate circular planting pits as indicated on the Drawings.

B. Subsoil and topsoil removed from excavations may be used as planting soil if determined suitable for site conditions and plant selections.

C. Obstructions: Notify Owner's Representative if unexpected rock or obstructions detrimental to trees or shrubs are encountered in excavations.

D. Drainage: Notify Owner's Representative if subsoil conditions evidence unexpected water seepage or retention in tree or shrub planting pits.

E. Fill excavations with water and allow to percolate away before positioning trees and shrubs.

3.5 TREE, SHRUB, AND VINE PLANTING

A. Before planting, verify that root flare is visible at top of root ball according to ANSI Z60.1. If root flare is not visible, remove soil in a level manner from the root ball to where the top-most root emerges from the trunk. After soil removal to expose the root flare, verify that root ball still meets size requirements.

B. Remove stem girdling roots and kinked roots. Remove injured roots by cutting cleanly; do not break.

C. Set balled and burlapped stock plumb and in center of planting pit or trench with root flare as indicated to adjacent finish grades.

1. Use planting soil as specified on the drawings.
2. After placing some backfill around root ball to stabilize plant, carefully cut and remove burlap, rope, and wire baskets from tops of root balls and from sides, but do not remove from under root balls. Remove pallets, if any, before setting. Do not use planting stock if root ball is cracked or broken before or during planting operation.
3. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
4. Place planting tablets in each planting pit when pit is approximately one-half filled; in amounts recommended in soil reports from soil-testing laboratory. Place tablets beside the root ball about 1 inch (25 mm) from root tips; do not place tablets in bottom of the hole.
5. Continue backfilling process. Water again after placing and tamping final layer of soil.

D. When planting on slopes, set the plant so the root flare on the uphill side is flush with the surrounding soil on the slope; the edge of the root ball on the downhill side will be above the surrounding soil. Apply enough soil to cover the downhill side of the root ball.

3.6 TREE, SHRUB, AND VINE PRUNING

A. Prune, thin, and shape trees, shrubs, and vines according to standard professional horticultural and arboricultural practices. Unless otherwise indicated by Owner's Representative, do not cut tree leaders; remove only injured, dying, or dead branches from trees and shrubs; and prune to retain natural character.

B. Do not apply pruning paint to wounds.

3.7 TREE STABILIZATION

A. Install trunk stabilization when indicated on the Drawings as follows:

1. Upright Staking and Tying: Stake trees of 2- through 5-inch (50- through 125-mm) caliper. Stake trees of less than 2-inch (50-mm) caliper only as required to prevent wind tip out. Use a minimum of two stakes of length required to penetrate at least 18 inches (450 mm) below bottom of backfilled excavation. Set vertical stakes and space to avoid penetrating root balls or root masses.
2. Use two stakes for trees up to 12 feet (3.6 m) high; three stakes for trees less than 14 feet (4.2 m) high and greater than 2-1/2 inches (63 mm) in caliper. Space stakes equally around trees.
3. Support trees with two strands of tie wire, connected to the brass grommets of tree-tie webbing at contact points with tree trunk. Allow enough slack to avoid rigid restraint of tree.

3.8 GROUND COVER AND PLANT PLANTING

A. Set out and space ground cover and plants other than trees, shrubs, and vines as indicted on the drawing in even rows with triangular spacing for review by Owner's Representative.

B. Use planting soil for backfill.

C. Dig holes large enough to allow spreading of roots.

D. For rooted cutting plants supplied in flats, plant each in a manner that will minimally disturb the root system but to a depth not less than two nodes.

E. Work soil around roots to eliminate air pockets and leave a slight saucer indentation around plants to hold water.

F. Water thoroughly after planting, taking care not to cover plant crowns with wet soil.

G. Protect plants from hot sun and wind; remove protection if plants show evidence of recovery from transplanting shock.

3.9 PLANTING AREA MULCHING

A. Mulch backfilled surfaces of planting areas and other areas indicated.

3.10 EDGING INSTALLATION

A. Wood Edging: Install edging where indicated on the drawings. Fasten each cut joint or connection with two galvanized nails. Anchor with wood stakes spaced up to 36 inches (900 mm) apart, driven at least 1 inch (25 mm) below top elevation of edging.

B. Steel Edging: Install steel edging where indicated on the drawings according to manufacturer's written instructions. Anchor with steel stakes spaced approximately 30 inches (760 mm) apart, driven below top elevation of edging.

C. Aluminum Edging: Install aluminum edging where indicated on the drawings according to manufacturer's written instructions. Anchor with aluminum stakes spaced approximately 36 inches (900 mm) apart, driven below top elevation of edging.

D. Plastic Edging: Install plastic edging where indicated on the drawings according to manufacturer's written instructions. Anchor with steel stakes spaced approximately 36 inches (900 mm) apart, driven through upper base grooves or V-lip of edging.

E. Shovel-Cut Edging (turf cut edge): Separate mulched areas from turf areas, curbs, and paving with a 45-degree, 4- to 6-inch- (100- to 150-mm-) deep, shovel-cut edge as shown on Drawings.

3.11 PLANT MAINTENANCE

A. Maintain plantings by pruning, cultivating, watering, weeding, fertilizing, mulching, restoring planting saucers, adjusting and repairing tree-stabilization devices, resetting to proper grades or vertical position, and performing other operations as required to establish healthy, viable plantings. Spray or treat as required to keep trees and shrubs free of insects and disease.

B. Fill in as necessary soil subsidence that may occur because of settling or other processes. Replace mulch materials damaged or lost in areas of subsidence.

C. Apply treatments as required to keep plant materials, planted areas, and soils free of pests and pathogens or disease. Use integrated past management practices whenever possible to minimize the use of pesticides and reduce hazards. Treatments include physical controls such as hosing off foliage, mechanical controls such as traps, and biological control agents.

3.12 PESTICIDE APPLICATION

A. Apply pesticides and other chemical products and biological control agents in accordance with authorities having jurisdiction and manufacturer's written recommendations. Coordinate applications with Owner's operations and others in proximity to the Work. Notify Owner before each application is performed.

B. Pre-Emergent Herbicides (Selective and Non-Selective): Apply only as directed to tree, shrub, and ground-cover areas in accordance with manufacturer's written recommendations. Do not apply to seeded areas.

C. Post-Emergent Herbicides (Selective and Non-Selective): Apply only as necessary to treat already-germinated weeds and in accordance with manufacturer's written recommendations.

3.13 CLEANUP AND PROTECTION

A. During planting, keep adjacent paving and construction clean and work area in an orderly condition.

B. Protect plants from damage due to landscape operations and operations of other contractors and trades. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged plantings.

C. After installation and before Substantial Completion, remove nursery tags, nursery stakes, tie tape, labels, wire, burlap, and other debris from plant material, planting areas, and Project site.

3.14 DISPOSAL

A. Remove surplus soil and waste material including excess subsoil, unsuitable soil, trash, and debris and legally dispose of them off Owner's property.

END OF SECTION

SECTION 33 05 14

MANHOLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes concrete structures outside of buildings as follows:

1. Sanitary Manholes.

B. Related Sections include the following:

1. Division 31 Section "Earth Moving" for soil materials, excavating, backfilling, and site grading.
2. Division 31 Section "Dewatering" for dewatering of excavations.
3. Division 31 Section "Excavation Support and Protection" for protection of excavations.

1.3 SUBMITTALS

A. Shop Drawings: For the following:

1. Manholes: Include plans, elevations, sections, details, and frames and covers. Include design calculations, and concrete design-mix report for cast-in-place manholes.

B. Field quality-control test reports.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Handle manholes according to manufacturer's written rigging instructions.

PART 2 - PRODUCTS

2.1 MANHOLES

A. Standard Precast Concrete Manholes: ASTM C 478 (ASTM C 478M), precast, reinforced concrete, of depth indicated, with provision for sealant joints.

1. Diameter: 48 inches (1200 mm) minimum, unless otherwise indicated.
2. Ballast: Increase thickness of precast concrete sections or add concrete to base section, as required to prevent flotation.
3. Base Section: 6-inch (150-mm) minimum thickness for floor slab and 4-inch (102-mm) minimum thickness for walls and base riser section, and having separate base slab or base section with integral floor.
4. Riser Sections: 4-inch (102-mm) minimum thickness, and lengths to provide depth indicated.
5. Top Section: Eccentric-cone type unless concentric-cone or flat-slab-top type is indicated. Top of cone of size that matches grade rings.
6. Joint Sealant: ASTM C 990 (ASTM C 990M), bitumen or butyl rubber. Approved lubricant shall be applied over the inside tongue and over the rubber gasket immediately prior to setting one section on top of another if "O"-Ring joints are used.
7. Resilient Pipe Connectors: ASTM C 923 (ASTM C 923M), cast or fitted into manhole walls, for each pipe connection. Install in accordance with the manufacturer's requirements.
8. Steps: Individual FRP steps or FRP ladder, wide enough to allow worker to place both feet on 1 step and designed to prevent lateral slippage off of step. Cast or anchor steps into sidewalls at 12- to 16-inch (300- to 400-mm) intervals. Omit steps if total depth from floor of manhole to finished grade is less than 60 inches (1500 mm).
9. Adjusting Rings: Interlocking rings with level or sloped edge in thickness and diameter matching manhole frame and cover. Include sealant recommended by ring manufacturer.
10. Grade Rings: Reinforced-concrete rings, 6- to 9-inch (150- to 225-mm) total thickness, to match diameter of manhole frame and cover.
11. Protective Coating: Plant-applied, SSPC-Paint 16, coal-tar, epoxy-polyamide paint; 10-mil (0.26-mm) minimum thickness applied to exterior surfaces.
12. Manhole Frames and Covers: Ferrous; 24-inch (610-mm) ID by 7- to 9-inch (175- to 225-mm) riser with 4-inch- (102-mm-) minimum width flange and 26-inch- (660-mm-) diameter cover. Include indented top design with lettering cast into cover, using the word "STORM" or "SEWER" as applicable.

    a. Material: ASTM A 48, Class 35 gray iron, unless otherwise indicated.
    b. Protective Coating: Foundry-applied, SSPC-Paint 16, coal-tar, epoxy-polyamide paint; 10-mil (0.26-mm) minimum thickness applied to all surfaces, unless otherwise indicated.

2.2 CONCRETE

A. General: Cast-in-place concrete according to ACI 318/318R, ACI 350R, and the following:

1. Cement: ASTM C 150, Type II.
2. Fine Aggregate: ASTM C 33, sand.
3. Coarse Aggregate: ASTM C 33, crushed gravel.
4. Water: Potable.

B. Portland Cement Design Mix: 4000 psi (27.6 MPa) minimum, with 0.45 maximum water-cementitious materials ratio.

1. Reinforcement Fabric: ASTM A 185, steel, welded wire fabric, plain.
2. Reinforcement Bars: ASTM A 615/A 615M, Grade 60 (420 MPa), deformed steel.

C. Ballast and Pipe Supports: Portland cement design mix, 3000 psi (20.7 MPa) minimum, with 0.58 maximum water-cementitious materials ratio.

1. Reinforcement Fabric: ASTM A 185, steel, welded wire fabric, plain.
2. Reinforcement Bars: ASTM A 615/A 615M, Grade 60 (420 MPa), deformed steel.

2.3 MORTAR

A. The cement shall be Type II. The mix shall be one (1) part cement to three (3) parts clean, well graded, hard, durable sand. Hydrated lime may be added to the mixture in an amount not to exceed 15% by weight of the cement. The amount of water shall be only the amount necessary to make a workable mix.

2.4 BRICK

A. Brick for manholes shall meet the latest AASHTO Specification Designation M-91.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavation, trenching, and backfilling are specified in Division 31 Section "Earth Moving."

3.2 MANHOLE INSTALLATION

A. General: Install manholes, complete with appurtenances and accessories indicated.

B. Bases shall be placed on a layer of compacted stone bedding as indicated.

C. Install precast concrete manhole sections according to ASTM C 891.

D. Set tops of frames and covers flush with finished surface of manholes that occur in pavements. Set tops 3 inches (76 mm) above finished surface elsewhere, unless otherwise indicated.

1. Set frame on mortared brick courses true to grade and concentric with the opening. All voids beneath the bottom flange and in the brick courses shall be completely filled to make a watertight fit. A ring of mortar at least 1 inch thick shall be placed around the outside of the bottom flange, extending to the edge of the manhole all around its circumference. The bricks and mortar shall not extend beyond the top of precast concrete cone section.

3.3 CONCRETE PLACEMENT

A. Place cast-in-place concrete according to ACI 318/318R.

3.4 FIELD QUALITY CONTROL

A. Leakage tests shall be made and observed by the Owner's Representative on each manhole. The test shall be an exfiltration test or air vacuum test made as described below, as selected by the Owner's Representative.

B. Exfiltration Test: After the manhole has been assembled in place, all lifting holes shall be filled and pointed with an approved non- shrinking mortar. The test shall be made prior to placing the shelf and invert and before filling and pointing the horizontal joints. If the groundwater table has been allowed to rise above the bottom of the manhole, it shall be lowered for the duration of the test. All pipes and other openings into the manhole shall be suitably plugged and the plugs braced to prevent blow out.

1. Test Procedure: The manhole shall then be filled with water to the top of the cone section. If the excavation has not been backfilled and observation indicates no visible leakage, that is, no water visibly moving down the surface of the manhole, the manhole may be considered to be satisfactorily watertight. If the test as described above is unsatisfactory as determined by the Owner's Representative or if the manhole excavation has been backfilled, the test shall be continued. A period of time may be permitted if the Contractor so wishes, to allow for absorption. At the end of this period, the manhole shall be refilled to the top of the cone, if necessary, and a measuring time of at least 8 hours begun. At the end of the test period, the manhole shall be refilled to the top of the cone, measuring the volume of water added. This amount shall be extrapolated to a 24-hour rate and the leakage determined on the basis of depth. The leakage for each manhole shall not exceed 1 gallon per vertical foot for a 24 hour period. If the test fails this requirement, but the leakage does not exceed 3 gallons per vertical foot per day, repairs by approved methods may be made as directed by the Owner's Representative to bring the leakage within the allowable rate of 1 gallon per foot per day. Leakage due to a defective section or joint or exceeding the 3 gallon per vertical foot per day, shall be cause for the rejection of the manhole. It shall be the Contractor's responsibility to uncover the manhole as necessary and to disassemble, reconstruct or replace it as directed by the Owner's Representative. The manhole shall then be retested and, if satisfactory, all interior joints and those exterior joints within 6 feet of the surface shall be filled and pointed.
2. Backfilling: The test may be conducted either before or after backfilling around the manhole. However, if the Contractor elects to backfill prior to testing, for any reason, it shall be at his own risk and it shall be incumbent upon the Contractor to determine the reason for any failure of the test. No adjustment in the leakage allowance will be made for unknown causes such as leaking plugs, absorption, etc., i.e., it will be assumed that all loss of water during the test is a result of leaks through the joints or through the concrete. Furthermore, the Contractor shall take any steps necessary to assure the Owner's Representative that the water table is below the bottom of the manhole throughout the test.

C. Infiltration Test: If the groundwater table is above the highest joint in the manhole, and if there is no leakage into the manhole as determined by the Owner's Representative, such a test can be used to evaluate the water tightness of the manhole. However, if the Owner's Representative is not satisfied, the Contractor shall lower the water table and carry out the test as described hereinbefore.

D. Air Vacuum Test:

1. Manholes shall be tested by a vacuum test immediately after assembly of the manhole and connecting pipes and before any backfill is placed around the manholes.
2. All lift holes shall be plugged with non-shrink grout from both inside and outside the manhole and all pipes entering the manhole shall be plugged and braced.
3. The test shall be made using an inflatable compression band, vacuum pump and appurtenances specifically designed for vacuum testing manholes. Test procedures shall be in accordance with the equipment manufacturer's recommendations.
4. After the testing equipment is in place, a vacuum of 10 inches of Hg shall be drawn on the manhole. The manhole will be considered to have passed the test if the vacuum does not drop more than 1 inch of Hg in two minutes, for manholes up to 10' deep, and less than 1 inch drop in three minutes for manholes greater than 10' deep.
5. If the manhole fails the initial test, the Contractor shall locate the leakage and make proper repairs as directed by the Owner's Representative, and re-test until a satisfactory test result is obtained.
6. After the manholes have been backfilled and prior to final acceptance of the project, any signs of leaks or weeping visible from the inside of the manhole shall be repaired as directed by the Owner's Representative and the manhole made watertight.

END OF SECTION

SECTION 33 05 15

CATCH BASINS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes storm drainage structures outside the building, with the following components:

1. Catch basins.

B. Related Sections include the following:

1. Division 31 Section "Earth Moving" for soil materials, excavating, backfilling, and site grading.
2. Division 31 Section "Dewatering" for dewatering of excavations.
3. Division 31 Section "Excavation Support and Protection" for protection of excavations.

1.3 SUBMITTALS

A. Shop Drawings: For the following:

1. Catch Basins: Include plans, elevations, sections, details, and frames, covers, and grates.

B. Field quality-control test reports.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Handle catch basins according to manufacturer's written rigging instructions.

PART 2 - PRODUCTS

2.1 CATCH BASINS

A. Standard Precast Concrete Catch Basins: ASTM C 478 (ASTM C 478M), precast, reinforced concrete, of depth indicated, with provision for sealant joints per the following, unless indicated otherwise on the drawings.

1. Base Section: 6-inch (150-mm) minimum thickness for floor slab and 4-inch (102-mm) minimum thickness for walls and base riser section, and having separate base slab or base section with integral floor.
2. Riser Sections: 4-inch (102-mm) minimum thickness, and lengths to provide depth indicated.
3. Top Section: Eccentric-cone type unless concentric-cone or flat-slab-top type is indicated. Top of cone of size that matches grade rings.
4. Joint Sealant: ASTM C 990 (ASTM C 990M), bitumen or butyl rubber. Approved lubricant shall be applied over the inside tongue and over the rubber gasket immediately prior to setting one section on top of another if "O"-Ring joints are used.
5. Adjusting Rings: Interlocking rings with level or sloped edge in thickness and shape matching catch basin frame and grate. Include sealant recommended by ring manufacturer.
6. Grade Rings: Include 2 or 3 reinforced-concrete rings, of 6- to 9-inch (150- to 229-mm) total thickness, that match 24-inch- (610-mm-) diameter frame and grate.
7. Steps: Individual FRP steps or FRP ladder, wide enough to allow worker to place both feet on 1 step and designed to prevent lateral slippage off of step. Cast or anchor steps into sidewalls at 12- to 16-inch (300- to 400-mm) intervals. Omit steps if total depth from floor of catch basin to finished grade is less than 60 inches (1500 mm).
8. Pipe Connectors: ASTM C 923 (ASTM C 923M), resilient, of size required, for each pipe connecting to base section. Install in accordance with the manufacturer's requirements.

B. Frames and Grates: ASTM A 536, Grade 60-40-18, ductile iron designed for A-16, structural loading. Include flat grate with small square or short-slotted drainage openings.

1. Size: 24 by 24 inches (610 by 610 mm) minimum, unless otherwise indicated.
2. Grate Free Area: Approximately 50 percent, unless otherwise indicated.

C. Frames and Grates: ASTM A 536, Grade 60-40-18, ductile iron designed for A-16, structural loading. Include 24-inch (610-mm) ID by 7- to 9-inch (178- to 229-mm) riser with 4-inch (102-mm) minimum width flange, and 26-inch- (660-mm-) diameter flat grate with small square or short-slotted drainage openings.

1. Grate Free Area: Approximately 50 percent, unless otherwise indicated.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavation, trenching, and backfilling are specified in Division 31 Section "Earth Moving."

3.2 CATCH BASIN INSTALLATION

A. Construct catch basins to sizes and shapes indicated.

B. Set frames and grates to elevations indicated.

1. Set frame on mortared brick courses true to grade and concentric with the opening. All voids beneath the bottom flange and in the brick courses shall be completely filled to make a watertight fit. A ring of mortar at least 1 inch thick shall be placed around the outside of the bottom flange, extending to the edge of the manhole all around its circumference. The bricks and mortar shall not extend beyond the top of precast concrete cone section.

3.3 ALTERING EXISTING CATCH BASINS

A. When altering existing catch basins, the structure shall be dismantled sufficiently to allow reconstruction in accordance with the applicable requirements as shown on the Drawings for complete catch basins. Each altered catch basin shall be cleaned of all accumulated silt, debris or foreign matter prior to final acceptance of work.

END OF SECTION

SECTION 33 11 00

PIPING – WATER SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Sections Includes:
1. This Section includes water-distribution piping and related components outside the building for water service.
2. This Section includes water-distribution piping and related components outside the building for fire-service mains.
3. Utility-furnished products include water meters that will be furnished to the site, ready for installation.

B. Related Sections include the following:
1. Division 02 Section “Existing Utilities and Structures” for construction effecting existing utilities and structures.
2. Division 31 Section "Earth Moving" for soil materials, excavating, backfilling, and site grading.
3. Division 31 Section “Rock Excavation” for rock removal.
4. Division 31 Section "Dewatering" for dewatering of excavations.
5. Division 31 Section "Excavation Support and Protection" for protection of excavations

1.3 SUBMITTALS

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

B. Field quality-control test reports.

C. Operation and Maintenance Data: For water valves and specialties to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Regulatory Requirements:

1. Comply with standards of authorities having jurisdiction for potable-water-service piping, including materials, installation, testing, and disinfection.

2. Comply with standards of authorities having jurisdiction for fire-suppression water-service piping, including materials, hose threads, installation, and testing.

B. Piping materials shall bear label, stamp, or other markings of specified testing agency.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Preparation for Transport: Prepare valves, including fire hydrants, according to the following:

1. Ensure that valves are dry and internally protected against rust and corrosion.
2. Protect valves against damage to threaded ends and flange faces.
3. Set valves in best position for handling. Set valves closed to prevent rattling.

B. During Storage: Use precautions for valves, including fire hydrants, according to the following:

1. Do not remove end protectors unless necessary for inspection; then reinstall for storage.
2. Protect from weather. Store indoors and maintain temperature higher than ambient dew-point temperature. Support off the ground or pavement in watertight enclosures when outdoor storage is necessary.

C. Handling: Use sling to handle valves and fire hydrants if size requires handling by crane or lift. Rig valves to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

D. Deliver piping with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe-end damage and to prevent entrance of dirt, debris, and moisture.

E. Protect stored piping from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor when storing inside.

F. Protect flanges, fittings, and specialties from moisture and dirt.

G. Store plastic piping protected from direct sunlight. Support to prevent sagging and bending.

1.6 PROJECT CONDITIONS

A. Interruption of Existing Water-Distribution Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water-distribution service according to requirements indicated:

1. Notify Owner's Representative or Local Utility no fewer than two days in advance of proposed interruption of service.
2. Do not proceed with interruption of water-distribution service without written authorization from Owner's Representative or Local Utility.

1.7 COORDINATION

A. Coordinate connection to water main with utility company.

PART 2 - PRODUCTS

2.1 DUCTILE-IRON PIPE AND FITTINGS

A. Mechanical-Joint, Ductile-Iron Pipe: AWWA C151, Class 52, with mechanical-joint bell and plain spigot end unless grooved or flanged ends are indicated. The pipe to be centrifugally cast, bituminous coated, double cement lined, seal-coated and manufactured in accordance with the latest revision of AWWA C150 and C151. Note that the cement lining called for above shall be twice the thickness specified in the latest ANSI Specification A21.4 and the interior to be asphalt seal- coated twice. The asphalt seal-coat to be such as not to impart taste or odor to the water contained therein.

1. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
2. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

B. Push-on-Joint, Ductile-Iron Pipe: AWWA C151, Class 52, with push-on-joint bell and plain spigot end unless grooved or flanged ends are indicated. The pipe to be centrifugally cast, bituminous coated, double cement lined, seal-coated and manufactured in accordance with the latest revision of AWWA C150 and C151. Note that the cement lining called for above shall be twice the thickness specified in the latest ANSI Specification A21.4 and the interior to be asphalt seal- coated twice. The asphalt seal-coat to be such as not to impart taste or odor to the water contained therein.

1. Push-on-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
2. Gaskets: AWWA C111, rubber.

C. Flanges: ASME 16.1, Class 125, cast iron.

2.2 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch (3.2-mm) maximum thickness, unless otherwise indicated.

   a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
   b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

2. AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

2.3 PIPING SPECIALTIES

A. Transition Fittings: Manufactured fitting or coupling same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.

B. Tubular-Sleeve Pipe Couplings:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Cascade Waterworks Manufacturing.
    b. Dresser, Inc.; Dresser Piping Specialties.
    c. Ford Meter Box Company, Inc. (The); Pipe Products Div.
    d. Hays Fluid Controls; a division of ROMAC Industries Inc.
    e. JCM Industries.
    f. Smith-Blair, Inc.
    g. Viking Johnson.

2. Description: Metal, bolted, sleeve-type, reducing or transition coupling, with center sleeve, gaskets, end rings, and bolt fasteners and with ends of same sizes as piping to be joined.

    a. Standard: AWWA C219.
    b. Center-Sleeve Material: Manufacturer's standard.
    c. Gasket Material: Natural or synthetic rubber.
    d. Pressure Rating:
        1) 200 psig (1380 kPa).

    e. Metal Component Finish: Corrosion-resistant coating or material.

C. Split-Sleeve Pipe Couplings:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

    a. Victaulic Depend-O-Lok.

2. Description: Metal, bolted, split-sleeve-type, reducing or transition coupling with sealing pad and closure plates, O-ring gaskets, and bolt fasteners.

    a. Standard: AWWA C219.
    b. Sleeve Material: Manufacturer's standard.
    c. Sleeve Dimensions: Of thickness and width required to provide pressure rating.
    d. Gasket Material: O-rings made of EPDM rubber, unless otherwise indicated.
    e. Pressure Rating:
        1) 200 psig (1380 kPa).

    f. Metal Component Finish: Corrosion-resistant coating or material.

2.4 GATE VALVES

A. AWWA, Cast-Iron Gate Valves:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. American Cast Iron Pipe Co.; American Flow Control Div.
b. McWane, Inc.; Clow Valve Co. Div. (Oskaloosa).
c. NIBCO INC.

2. Nonrising-Stem, Metal-Seated Gate Valves:

a. Description: Gray- or ductile-iron body and bonnet; with cast-iron or bronze double-disc gate, bronze gate rings, bronze stem, and stem nut.

1) Standard: AWWA C500.
2) Minimum Pressure Rating: 200 psig (1380 kPa).
3) End Connections: Mechanical joint.
4) Interior Coating: Complying with AWWA C550.

2.5 GATE VALVE ACCESSORIES AND SPECIALTIES

A. Tapping-Sleeve Assemblies:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. American Cast Iron Pipe Co.; Waterous Co. Subsidiary.
b. McWane, Inc.; Clow Valve Co. Div. (Oskaloosa).

2. Description: Sleeve and valve compatible with drilling machine.

a. Standard: MSS SP-60.
b. Tapping Sleeve: Cast- or ductile-iron or stainless-steel, two-piece bolted sleeve with flanged outlet for new branch connection. Include sleeve matching size and type of pipe material being tapped and with recessed flange for branch valve.
c. Valve: AWWA, cast-iron, nonrising-stem, metal-seated gate valve with one raised face flange mating tapping-sleeve flange.

B. Valve Boxes: Comply with AWWA M44 for cast-iron valve boxes. Include top section, adjustable extension of length required for depth of burial of valve, plug with lettering "WATER," and bottom section with base that fits over valve and with a barrel approximately 5 inches (125 mm) in diameter.

1. Operating Wrenches: Steel, tee-handle with one pointed end, stem of length to operate deepest buried valve, and socket matching valve operating nut.

C. Indicator Posts: UL 789, FMG-approved, vertical-type, cast-iron body with operating wrench, extension rod, and adjustable cast-iron barrel of length required for depth of burial of valve.

2.6 CORPORATION VALVES AND CURB VALVES

A. Manufacturers:

1. Available Manufacturers: Subject to compliance with requirements of authorities having jurisdiction and manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. Amcast Industrial Corporation; Lee Brass Co.
   b. Ford Meter Box Company, Inc. (The); Pipe Products Div.
   c. Mueller Co.; Water Products Div.

B. Service-Saddle Assemblies: Comply with AWWA C800. Include saddle and valve compatible with tapping machine.

1. Service Saddle: Copper alloy with seal and AWWA C800, threaded outlet for corporation valve.
2. Corporation Valve: Bronze body and ground-key plug, with AWWA C800, threaded inlet and outlet matching service piping material.

C. Curb Valves: Comply with AWWA C800. Include bronze body, ground-key plug or ball, and wide tee head, with inlet and outlet matching service piping material.

D. Service Boxes for Curb Valves: Similar to AWWA M44 requirements for cast-iron valve boxes. Include cast-iron telescoping top section of length required for depth of burial of valve, plug with lettering "WATER," and bottom section with base that fits over curb valve and with a barrel approximately 3 inches (75 mm) in diameter.

1. Shutoff Rods: Steel, tee-handle with one pointed end, stem of length to operate deepest buried valve, and slotted end matching curb valve.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Refer to Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.

3.2 PIPING INSTALLATION

A. Water-Main Connection: Tap water main according to requirements of water utility company and of size and in location indicated.

B. Make connections NPS 2 (DN 50) and smaller with drilling machine according to the following:

1. Install service-saddle assemblies and corporation valves in size, quantity, and arrangement required by utility company standards.
2. Install service-saddle assemblies on water-service pipe to be tapped. Position outlets for corporation valves.
3. Use drilling machine compatible with service-saddle assemblies and corporation valves. Drill hole in main. Remove drilling machine and connect water-service piping.
4. Install corporation valves into service-saddle assemblies.
5. Install manifold for multiple taps in water main.
6. Install curb valve in water-service piping with head pointing up and with service box.

C. Make connections larger than NPS 2 (DN 50) with tapping machine according to the following:

1. Install tapping sleeve and tapping valve according to MSS SP-60.
2. Install tapping sleeve on pipe to be tapped. Position flanged outlet for gate valve.
3. Use tapping machine compatible with valve and tapping sleeve; cut hole in main. Remove tapping machine and connect water-service piping.
4. Install gate valve onto tapping sleeve. Comply with MSS SP-60. Install valve with stem pointing up and with valve box.

D. Install ductile-iron, water-service piping according to AWWA C600 and AWWA M41.

E. Comply with NFPA 24 for fire-service-main piping materials and installation.

F. Bury piping with minimum depth of cover over top at least 66 inches (1676 mm).

G. Extend water-service piping and connect to water-supply source and building-water-piping systems at outside face of building wall in locations and pipe sizes indicated.

1. Terminate water-service piping at building wall until building-water-piping systems are installed. Terminate piping with caps, plugs, or flanges as required for piping material. Make connections to building-water-piping systems when those systems are installed.

H. Install underground piping with restrained joints at horizontal and vertical changes in direction. Use restrained-joint piping, thrust blocks, anchors, tie-rods and clamps, and other supports.

3.3 JOINT CONSTRUCTION

A. Make pipe joints according to the following:
1. Ductile-Iron Piping, Gasketed Joints for Water-Service Piping: AWWA C600 and AWWA M41.
2. Ductile-Iron Piping, Gasketed Joints for Fire-Service-Main Piping: UL 194.
3. Dissimilar Materials Piping Joints: Use adapters compatible with both piping materials, with OD, and with system working pressure.

3.4 ANCHORAGE INSTALLATION

A. Anchorage, General: Install water-distribution piping with restrained joints. Anchorages and restrained-joint types that may be used include the following:

1. Concrete thrust blocks.

B. Install anchorages for tees, plugs and caps, bends, crosses, valves, and hydrant branches. Include anchorages for the following piping systems:

1. Gasketed-Joint, Ductile-Iron, Water-Service Piping: According to AWWA C600.
2. Fire-Service-Main Piping: According to NFPA 24.

C. Apply full coat of asphalt or other acceptable corrosion-resistant material to surfaces of installed ferrous anchorage devices.

3.5 VALVE INSTALLATION

A. AWWA Gate Valves: Comply with AWWA C600 and AWWA M44. Install each underground valve with stem pointing up and with valve box.

B. Corporation Valves and Curb Valves: Install each underground curb valve with head pointed up and with service box.

3.6 FIELD QUALITY CONTROL

A. Piping Tests: Conduct piping tests before joints are covered and after concrete thrust blocks have hardened sufficiently. Fill pipeline 24 hours before testing and apply test pressure to stabilize system. Use only potable water.

B. Hydrostatic Tests: Test at not less than one-and-one-half times working pressure for two hours.

1. Increase pressure in 50-psig (350-kPa) increments and inspect each joint between increments. Hold at test pressure for 1 hour; decrease to 0 psig (0 kPa). Slowly increase again to test pressure and hold for 1 more hour. Maximum allowable leakage is 2 quarts (1.89 L) per hour per 100 joints. Remake leaking joints with new materials and repeat test until leakage is within allowed limits.

C. Prepare reports of testing activities.

3.7 IDENTIFICATION

A. Install continuous underground detectable warning tape during backfilling of trench for underground water-distribution piping. Locate below finished grade, directly over piping. Underground warning tapes are specified in Division 31 Section "Earth Moving."

3.8 CLEANING & DISINFECTING

A. Clean and disinfect water-distribution piping as follows:

1. Purge new water-distribution piping systems and parts of existing systems that have been altered, extended, or repaired before use.

2. Use purging and disinfecting procedure prescribed by authorities having jurisdiction or, if method is not prescribed by authorities having jurisdiction, use procedure described in NFPA 24 for flushing of piping. Flush piping system with clean, potable water until dirty water does not appear at points of outlet.

B. Prepare reports of purging and disinfecting activities.

END OF SECTION

SECTION 33 31 00

PIPING - SANITARY SEWER

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes gravity-flow, non-pressure sanitary sewerage outside the building.

1.3 PERFORMANCE REQUIREMENTS

A. Gravity-Flow, Nonpressure, Drainage-Piping Pressure Rating: 10-foot head of water (30 kPa).

B. Related Sections include the following:
1. Division 02 Section "Existing Utilities and Structures" for construction effecting existing utilities and structures.
2. Division 31 Section "Earth Moving" for soil materials, excavating, backfilling, and site grading.
3. Division 31 Section "Rock Excavation" for rock removal.
4. Division 31 Section "Dewatering" for dewatering of excavations.
5. Division 31 Section "Excavation Support and Protection" for protection of excavations
6. Division 33 Section "Manholes".

1.4 SUBMITTALS

A. Product Data: For pipe and fittings.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Do not store plastic pipe, and fittings in direct sunlight.

B. Protect pipe, pipe fittings, and seals from dirt and damage.

PART 2 - PRODUCTS

2.1 PVC PIPE AND FITTINGS

A. PVC Sewer Pipe and Fittings, NPS 15 (DN 375) and Smaller: ASTM D 3034, SDR 35, with bell-and-spigot ends for gasketed joints with ASTM F 477, elastomeric seals.

2.2 NONPRESSURE-TYPE PIPE COUPLINGS

A. Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition coupling, for joining underground nonpressure piping. Include ends of same sizes as piping to be joined, and corrosion-resistant-metal tension band and tightening mechanism on each end.

B. Sleeve Materials:
   1. For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
   2. For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.

2.3 PIPE INSULATION

A. Extruded-Polystyrene Board Insulation: ASTM C 578, of type and density indicated below, with maximum flame-spread and smoke-developed indexes of 75 and 450, respectively:

   1. Available Manufacturers:

      a. DiversiFoam Products.
      b. Dow Chemical Company.
      c. Owens Corning.
      d. Pactiv Building Products Division.

   2. Type IV, 1.60 lb/cu. ft. (26 kg/cu. m), unless otherwise indicated.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavation, trenching, and backfilling are specified in Division 31 Section "Earth Moving."

3.2 PIPING INSTALLATION

A. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground storm drainage piping. Location and arrangement of piping layout take design considerations into account. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.

B. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.

C. Install gravity-flow, nonpressure drainage piping according to the following:

1. Install piping pitched down in direction of flow, at minimum slope of 2 percent, unless otherwise indicated.
2. Install piping NPS 6 (DN 150) and larger with restrained joints at tee fittings and at changes in direction. Use cast-in-place concrete supports or anchors.
3. Install PVC sewer piping according to ASTM D 2321 and ASTM F 1668.

D. No pipe installed will be allowed to begin at any point other than a manhole or other appurtenance without the expressed consent of the Owner's Representative. The interior of each length of pipe will be swabbed and wiped clean before installing the next length. No length of pipe shall be installed until the previous length has had sufficient fine material placed and tamped about it to secure it firmly in place to prevent any disturbance. Bell ends shall be installed uphill. Whenever the work is stopped temporarily, or for any reason whatsoever, the end of the pipe shall be carefully protected against dirt, water, or other extraneous material. Bedding shall be as shown on the drawings.

E. The pipe shall be bedded in a compacted pipe bedding material placed on a flat trench bottom to the limits indicated on the drawings.

F. The pipe shall be cut as necessary for appurtenances. Sufficient short lengths of pipe shall be furnished so that pipe entering and leaving appurtenances shall not be more than 2 feet in length measured from the inside face of the manhole or structure

G. Pipe Cutting: The cutting of the pipe shall be done in accordance with the pipe manufacturer's recommendations. The pipe material shall be cut by using a saw or milling process, approved by the pipe manufacturer and not by using any impact device, such as a hammer and chisel, to break the pipe. The pipe shall be cut, not broken. The cut end of the pipe shall be square to the axis of the pipe and any rough edges ground smooth.

3.3 PIPE JOINT CONSTRUCTION

A. Join gravity-flow, nonpressure drainage piping according to the following:

1. Join PVC sewer piping according to ASTM D 2321 and ASTM D 3034 for elastomeric-seal joints or ASTM D 3034 for elastomeric gasket joints.
2. Join dissimilar pipe materials with nonpressure-type flexible couplings.

3.4 PIPE INSULATION

A. Install 2-in. thick x 4-ft. wide insulation over pipe when noted on plans or as directed by the Owner's Representative.

3.5 IDENTIFICATION

A. Materials and their installation are specified in Division 31 Section "Earth Moving." Arrange for installation of green warning tape directly over piping and at outside edge of underground structures.

1. Use detectable warning tape over nonferrous piping.

3.6 FIELD QUALITY CONTROL AND TESTING

A. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspection to be performed with Owner's Representative present. Inspect after approximately 24 inches (610 mm) of backfill is in place, and again at completion of Project.

1. Submit separate reports for each system inspection.
2. Defects requiring correction include the following:

a. Alignment: Less than full diameter of inside of pipe is visible between structures.
b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
c. Crushed, broken, cracked, or otherwise damaged piping.
d. Infiltration: Water leakage into piping.
e. Exfiltration: Water leakage from or around piping.

3. Replace defective piping using new materials, and repeat inspections until defects are within allowances specified.
4. Reinspect and repeat procedure until results are satisfactory.

B. Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.

1. Do not enclose, cover, or put into service before inspection and approval.
2. Test completed piping systems according to requirements of authorities having jurisdiction.
3. Schedule tests and inspections by authorities having jurisdiction with at least 24 hours' advance notice.
4. Submit separate report for each test.

C. Air Tests: Test sanitary sewerage according to requirements of authorities having jurisdiction, UNI-B-6, and the following:

1. Equipment Requirements:

a. Pneumatic Plugs: Sealing length equal to or greater than the diameter of the pipe to be tested.
b. Pneumatic Plugs: Size and type to resist internal test pressures without requiring external bracing or blocking.
c. All air used shall pass through a single control panel.
d. Use three individual hoses for the following connections:

1) From control panel to pneumatic plugs for inflation.
2) From control panel to sealed line for introducing the low pressure air.
3) From sealed line to control panel for continually monitoring the air pressure rise in the sealed line.

2. Procedures:

a. Pneumatic Plug Seal Testing:

1) Before being used in the actual test installation, lay one length of pipe on the ground and seal at both ends with the pneumatic plugs to be checked.
2) Introduce air into the plugs to 25 psig.
3) Sealed pipe shall be pressurized to 5 psig.
4) The plugs shall hold against this pressure without bracing and without movement of the plugs out of the pipe.

b. Pipe:

1) Place plugs in the line and inflate to 25 psig.
2) Introduce low pressure air into sealed line until the internal air pressure reaches 4 psig greater than the average back pressure of groundwater over the pipe.
3) Wait at least two minutes for the air pressure to stabilize.
4) After the stabilization (3.5 psig minimum pressure in the pipe), disconnect the air hose from the control panel to the air supply. The portion of line being tested shall be termed "acceptable" if the time required in minutes for the pressure to decrease from 3.5 to 2.5 psig (greater than the average back pressure of any groundwater that may be over the pipe) is greater than 4 minutes.

c. Where Groundwater is Known to Exist:

1) Install a one-half inch diameter capped pipe nipple, approximately 10′ long, through the manhole wall on top of one of the pipes entering the manhole, at the time the pipe is installed.
2) Immediately prior to the performance of the Line Acceptance Test, determine the groundwater by removing the pipe cap, blowing air through the pipe nipple into the ground so as to clear it, and then connect a clear plastic tube to the nipple.
3) The hose shall be held vertically and a measurement of the height in feet shall be divided by 2.3 to establish the pounds of pressure that will be added to all readings. (For example, if the height of water is 11-1/2 feet, then the added pressure will be 5 psig, add the 2.5 psig to 7.5 psig. The allowable drop of one pound and the timing remain the same).

d. Should the pipe, as laid, fail to meet these requirements, perform the necessary work to meet these requirements, without additional cost to the Owner.

D. Leaks and loss in test pressure constitute defects that must be repaired.

E. Replace leaking piping using new materials, and repeat testing until leakage is within allowances specified.

3.7 CLEANING

A. Clean interior of piping of dirt and superfluous materials. Flush with potable water.

END OF SECTION

SECTION 33 41 00

PIPING - STORM DRAINAGE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes gravity-flow, nonpressure storm drainage outside the building.

B. Related Sections include the following:
   1. Division 02 Section "Existing Utilities and Structures" for construction effecting existing utilities and structures.
   2. Division 31 Section "Earth Moving" for soil materials, excavating, backfilling, and site grading.
   3. Division 31 Section "Rock Excavation" for rock removal.
   4. Division 31 Section "Dewatering" for dewatering of excavations.
   5. Division 31 Section "Excavation Support and Protection" for protection of excavations
   6. Division 33 Section "Catch Basins".

1.3 PERFORMANCE REQUIREMENTS

A. Gravity-Flow, Nonpressure, Drainage-Piping Pressure Rating: Pipe joints shall be at least silttight, unless otherwise indicated.

1.4 SUBMITTALS

A. Product Data: For pipe and fittings.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Do not store plastic pipe, and fittings in direct sunlight.

B. Protect pipe, pipe fittings, and seals from dirt and damage.

PART 2 - PRODUCTS

2.1 HDPE PIPE AND FITTINGS

A. Corrugated HDPE Drainage Pipe and Fittings NPS 10 (DN 250) and Smaller: AASHTO M 252M, Type S, with smooth waterway for coupling joints.

1. Silttight Couplings: HDPE sleeve with ASTM D 1056, Type 2, Class A, Grade 2 gasket material that mates with tube and fittings.

B. Corrugated HDPE Pipe and Fittings NPS 12 to NPS 48 (DN 250 to DN 1200): AASHTO M 294M, Type S, with smooth waterway for coupling joints.

1. Silttight Couplings: HDPE sleeve with ASTM D 1056, Type 2, Class A, Grade 2 gasket material that mates with pipe and fittings.

C. Corrugated HDPE Pipe and Fittings NPS 56 and NPS 60 (DN 1400 and DN 1524): AASHTO MP7, Type S, with smooth waterway for coupling joints.

1. Silttight Couplings: HDPE sleeve with ASTM D 1056, Type 2, Class A, Grade 2 gasket material that mates with pipe and fittings.

2.2 NONPRESSURE-TYPE PIPE COUPLINGS

A. Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition coupling, for joining underground nonpressure piping. Include ends of same sizes as piping to be joined, and corrosion-resistant-metal tension band and tightening mechanism on each end.

B. Sleeve Materials:
1. For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
2. For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.

2.3 PIPE INSULATION

A. Extruded-Polystyrene Board Insulation: ASTM C 578, of type and density indicated below, with maximum flame-spread and smoke-developed indexes of 75 and 450, respectively:

1. Available Manufacturers:

a. DiversiFoam Products.
b. Dow Chemical Company.
c. Owens Corning.
d. Pactiv Building Products Division.

2. Type IV, 1.60 lb/cu. ft. (26 kg/cu. m), unless otherwise indicated.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavation, trenching, and backfilling are specified in Division 31 Section "Earth Moving."

3.2 PIPING INSTALLATION

A. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground storm drainage piping. Location and arrangement of piping layout take design considerations into account. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.

B. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.

C. Install gravity-flow, nonpressure drainage piping according to the following:

1. Install piping pitched down in direction of flow, at minimum slope of 2 percent, unless otherwise indicated.
2. Install piping NPS 6 (DN 150) and larger with restrained joints at tee fittings and at changes in direction. Use cast-in-place concrete supports or anchors.
3. Install piping below frost line, unless noted otherwise.
4. Install PE pipe according to ASTM D 2774 and ASTM F 645.

D. No pipe installed will be allowed to begin at any point other than a manhole or other appurtenance without the expressed consent of the Owner's Representative. The interior of each length of pipe will be swabbed and wiped clean before installing the next length. No length of pipe shall be installed until the previous length has had sufficient fine material placed and tamped about it to secure it firmly in place to prevent any disturbance. Bell ends shall be installed uphill. Whenever the work is stopped temporarily, or for any reason whatsoever, the end of the pipe shall be carefully protected against dirt, water, or other extraneous material. Bedding shall be as shown on the drawings.

E. The pipe shall be bedded in a compacted granular or stone pipe bedding placed on a flat trench bottom. The bedding material shall be as indicated on the drawings and compacted to at least 90%. The remainder of the cover to a minimum of 6 inches over the top of the pipe shall be filled as indicated on the drawings and compacted to at least 90%.

F. The pipe shall be cut as necessary for appurtenances. Sufficient short lengths of pipe shall be furnished so that pipe entering and leaving appurtenances shall not be more than 2 feet in length measured from the inside face of the manhole.

G. Pipe Cutting: The cutting of the pipe shall be done in accordance with the pipe manufacturer's recommendations. The pipe material shall be cut by using a saw or milling process, approved by the pipe manufacturer and not by using any impact device, such as a hammer and chisel, to break the pipe. The pipe shall be cut, not broken. The cut end of the pipe shall be square to the axis of the pipe and any rough edges ground smooth.

3.3 PIPE JOINT CONSTRUCTION

A. Join gravity-flow, nonpressure drainage piping according to the following:
   1. Join corrugated HDPE piping according to CPPA 100 and the following:
      a. Use silttight couplings for Type 2, silttight joints.
   2. Join reinforced-concrete sewer piping according to ACPA's "Concrete Pipe Installation Manual" for rubber-gasket joints.
   3. Join dissimilar pipe materials with nonpressure-type flexible couplings.

3.4 PIPE INSULATION

A. Install 2-in. thick x 4-ft. wide insulation between pipe and culvert or over pipe when noted on plans or as directed by the Owner's Representative.

B. Install 6 in. above the pipe unless otherwise shown on Drawings.

3.5 FIELD QUALITY CONTROL

A. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches (610 mm) of backfill is in place, and again at completion of Project.

   1. Submit separate reports for each system inspection.
   2. Defects requiring correction include the following:

      a. Alignment: Less than full diameter of inside of pipe is visible between structures.
      b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
      c. Crushed, broken, cracked, or otherwise damaged piping.
      d. Infiltration: Water leakage into piping.
      e. Exfiltration: Water leakage from or around piping.

   3. Replace defective piping using new materials, and repeat inspections until defects are within allowances specified.
   4. Reinspect and repeat procedure until results are satisfactory.

B. Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.

   1. Do not enclose, cover, or put into service before inspection and approval.
   2. Test completed piping systems according to authorities having jurisdiction.
   3. Schedule tests and inspections by authorities having jurisdiction with at least 24 hours' advance notice.
   4. Submit separate report for each test.

C. Air Tests: Test piping according to requirements of authorities having jurisdiction, UNI-B-6, and the following:

1. Equipment Requirements:

   a. Pneumatic Plugs: Sealing length equal to or greater than the diameter of the pipe to be tested.
   b. Pneumatic Plugs: Size and type to resist internal test pressures without requiring external bracing or blocking.
   c. All air used shall pass through a single control panel.
   d. Use three individual hoses for the following connections:

      1) From control panel to pneumatic plugs for inflation.
      2) From control panel to sealed line for introducing the low pressure air.
      3) From sealed line to control panel for continually monitoring the air pressure rise in the sealed line.

2. Procedures:

   a. Pneumatic Plug Seal Testing:

      1) Before being used in the actual test installation, lay one length of pipe on the ground and seal at both ends with the pneumatic plugs to be checked.
      2) Introduce air into the plugs to 25 psig.
      3) Sealed pipe shall be pressurized to 5 psig.
      4) The plugs shall hold against this pressure without bracing and without movement of the plugs out of the pipe.

   b. Pipe:

      1) Place plugs in the line and inflate to 25 psig.
      2) Introduce low pressure air into sealed line until the internal air pressure reaches 4 psig greater than the average back pressure of groundwater over the pipe.
      3) Wait at least two minutes for the air pressure to stabilize.
      4) After the stabilization (3.5 psig minimum pressure in the pipe), disconnect the air hose from the control panel to the air supply. The portion of line being tested shall be termed "acceptable" if the time required in minutes for the pressure to decrease from 3.5 to 2.5 psig (greater than the average back pressure of any groundwater that may be over the pipe) is greater than 4 minutes.

   c. Where Groundwater is Known to Exist:

      1) Install a one-half inch diameter capped pipe nipple, approximately 10' long, through the manhole wall on top of one of the pipes entering the manhole, at the time the pipe is installed.
      2) Immediately prior to the performance of the Line Acceptance Test, determine the groundwater by removing the pipe cap, blowing air through the pipe nipple into the ground so as to clear it, and then connect a clear plastic tube to the nipple.

3) The hose shall be held vertically and a measurement of the height in feet shall be divided by 2.3 to establish the pounds of pressure that will be added to all readings. (For example, if the height of water is 11-1/2 feet, then the added pressure will be 5 psig, add the 2.5 psig to 7.5 psig. The allowable drop of one pound and the timing remain the same).

d. Should the pipe, as laid, fail to meet these requirements, perform the necessary work to meet these requirements, without additional cost to the Owner.

D. Leaks and loss in test pressure constitute defects that must be repaired.

E. Replace leaking piping using new materials, and repeat testing until leakage is within allowances specified.

3.6 CLEANING

A. Clean interior of piping of dirt and superfluous materials. Flush with potable water.

END OF SECTION

FINAL REPORT ON GEOTECHNICAL INVESTIGATION AND FOUNDATION DESIGN RECOMMENDATIONS PROPOSED COLLEGE OF PHARMACY UNIVERSITY OF NEW ENGLAND PORTLAND, MAINE

by

Haley & Aldrich, Inc.
Portland, Maine

for

University of New England
Biddeford, Maine

File No. 34718-000
Revised 16 January 2008
2 November 2007

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Revised 16 January 2008
2 November 2007
File No. 34718-000

University of New England
11 Hills Road
Biddeford, Maine 04005

Attention: Mr. Alan Thibeault

Subject: Geotechnical Investigation and Foundation Design Recommendations
Proposed College of Pharmacy
University of New England
Portland, Maine

Ladies and Gentlemen:

This report presents the results of our subsurface explorations, engineering evaluations, and design recommendations for the proposed College of Pharmacy (COP) to be constructed at the University of New England (UNE), Westbrook Campus, in Portland, Maine. This work was undertaken at your request in accordance with our proposal originally dated 28 August 2007, revised 7 September 2007, and your subsequent authorization, and our Agreement Amendment 1 dated 2 November 2007.

This report was originally issued on 2 November 2007, but it has been updated to reflect changes to the proposed project during design development, specifically raising of the basement slab from El. 113 to El. 115.

SUMMARY

We recommend that the proposed COP building be supported on spread and continuous wall footing foundations bearing on undisturbed glacial outwash deposits, glacial marine deposits or glacial till. The footings should be designed based on an allowable bearing pressure, in pounds per square foot (psf), equal to 2,000 multiplied by the least lateral dimension of the footing in feet, up to a maximum of 8,000 psf. We recommend that the lowest floor slab be designed as an earth-supported, concrete slab-on-grade.

Specific recommendations for foundation design, drainage, pavement and construction for the COP building and the adjacent improvements are presented herein.

ELEVATION DATUM

Elevations referenced herein are in feet and are assumed to reference the National Geodetic Vertical Datum of 1929 (NGVD 1929).

EXISTING SITE CONDITIONS

The Westbrook Campus of UNE is located on Stevens Avenue, as shown on Figure 1, Project Locus. The current study area includes the eastern portion of the campus, for which the existing site conditions are described below.

The easternmost portion of the campus is currently occupied by several buildings, grassed/landscaped common areas, and bituminous paved parking lots and sidewalks. The buildings that occupy the eastern portion of campus include Goddard Hall, Coleman Dental Hygiene Building and Ludcke Auditorium, the locations of which are shown on Figure 2. Existing site grades are relatively flat in the eastern portion of campus, with ground surface elevations ranging from about El. 125 to El. 130.

The northern portion of the campus is occupied by a gravel access road that extends west from the terminus of College Street and an existing athletic field, as shown on Figure 3. It is our understanding that this area is no longer planned for development as a part of this project.

PROPOSED DEVELOPMENT

Our understanding of the proposed site development is based on the Design Development (DD) document set issued by Port City Architecture (PCA) dated 7 December 2007. Additional modifications have been made to the proposed development, which were discussed during several project team meetings in December 2007 and January 2008.

Proposed College of Pharmacy

We understand that the proposed COP building will consist of a three-story structure with a plan footprint area of approximately 12,000 square feet (sf), the location of which is shown on Figure 2. The footprint of the COP is within the current parking lot area adjacent to Stevens Avenue, approximately 30 to 35 ft south of Ludcke Auditorium. The level of the first floor slab is proposed to be constructed at El. 130. The COP will be constructed with a full level of below grade space. We understand that the level of the basement floor slab will be constructed 15 ft below the first floor slab, corresponding to El. 115 (11 to 12.5 ft below existing site grades). Proposed site grades surrounding the building will vary from approximately El. 127 to El. 129, 0 to 2 ft above existing grades.

A vivarium is planned to be located in the basement level of the COP building. Based on discussion with the design team, we understand that the vivarium is very sensitive to moisture. As a result, the design team has chosen to install Grace Preprufe 300 positive-side waterproofing enveloping the entire basement area. It is our understanding that the waterproofing membrane will extend around the exterior side of all basement walls, below foundations, the slab and elevator pit and stairway slabs. All penetrations through the basement floor slab and foundation wall will also require waterproofing.

A 14-ft wide paved access road will be constructed along the west side of the COP building, between Coleman Dental Hygiene Building and the COP building. A 12-ft wide service drive will be constructed along the north side of the building, between the COP and Ludcke Auditorium. An entryway courtyard area will be constructed at the main entrance of the building, which is on the west side of the building as shown on Figure 2.

SUBSURFACE EXPLORATIONS

A subsurface exploration program was conducted to provide data on soil and groundwater conditions within the areas of the building and parking lot and access roadways. The program consisted of 22 test borings, designated HA07-1 through HA07-22. The subsurface explorations were drilled by Maine Test Borings, Inc. of Brewer, Maine between 13 and 19 September 2007 and 2 and 3 October 2007. All explorations were monitored by Haley & Aldrich personnel. The borings were drilled at the approximate locations shown on Figures 2 and 3.

Test borings were advanced to depths ranging from 4.0 to 37.0 ft below ground surface (BGS). All borings were terminated in naturally deposited soils or bedrock. The boreholes were backfilled with drill spoils at the completion of the exploration program. Soil samples were typically obtained either continuously or at 5-ft intervals by driving a 1 3/8-in. I.D. split-spoon sampler with a 140-lb weight dropped 30 in. as indicated on the test boring logs. The number of hammer blows required to advance the sampler for each 6-in. interval was recorded and is provided on the test boring logs. The SPT N-value is the total number of the hammer blows required to advance the sampler through the middle 12 in. of the 24-in. sampling interval. The soils samples were collected and preserved in glass jars.

Bedrock was cored in test borings HA07-20 and HA07-22 using an NQ-size core barrel. Total bedrock core lengths ranged from 4.6 to 5.0 ft. The recovered rock core was collected and stored in a wooden box and is available for review.

Test boring and core boring logs are provided in Appendix A. The locations of the test borings shown on Figures 2 and 3 are approximate and were estimated in the field by taping/pacing from existing improvements. Please note that ground surface elevations at test boring locations shown on the logs in Appendix A are approximate and were estimated using site topographic information provided by SYTDesign.

Groundwater observation wells were installed in completed boreholes HA07-3, HA07-5, HA07-13 and HA07-21. The well installation and monitoring reports are included in Appendix B.

SUBSURFACE CONDITIONS

Soil/Bedrock Conditions

Five principal soil units were encountered beneath a surficial layer of topsoil or bituminous concrete during the recent subsurface explorations conducted at the site: fill, organic deposit, glacial outwash deposit, glacial marine deposit and glacial till. The topsoil thickness varied from 0.3 to 2.4 ft, and the bituminous concrete thickness varied from 0.3 to 0.4 ft. Bedrock was apparently encountered beneath the glacial outwash or glacial till at five test boring locations (3 of 5 were determined by practicable drilling/sampling refusal). The soil and bedrock units encountered beneath the topsoil and bituminous concrete are described below.

Fill – Fill material was encountered at all of the test boring locations except for HA07-3 through HA07-5. The encountered fill thickness in the borings varies from 0.2 to 14.2 ft, typically ranging between 1.5 and 3.5 ft within the footprint of the COP building. The fill typically consists of loose to very dense, poorly graded to well-graded sand and silty sand, generally consisting of recompacted glacial outwash or glacial marine soils. The thickest fill (14.2 ft thick) was encountered near the southern end of the existing gravel road at the terminus of College Street (HA07-7). At this location, the fill material between 6 and 12 ft BGS consisted of 25 to 75 percent coal slag and ash. Coal slag and ash were also encountered in the fill in boring HA07-8 within 3.5 ft of existing ground surface. This indicates that the northern portion of the existing gravel road was partially filled using ash-laden and/or slag-laden soils. SPT N-values in the borings ranged from 3 to 57 blows per foot (bpf).

Organic Deposit – Soils containing organic matter were encountered below the in-situ fill material beneath the north and west perimeter of the proposed parking area (i.e., HA07-13, HA07-16, HA07-17 and HA07-18). In all of the borings except HA07-17, the organic deposit was only 0.1 to 0.2 ft thick and consisted of sandy silt to silty sand with varying amounts of organic matter. This material likely consists of topsoil that was not stripped prior to construction of the existing athletic field. In boring HA07-17, the organic deposit consisted of 1.9 ft of soft, brown sandy peat. The SPT N-value for the peat was 4 bpf.

Glacial Outwash Deposit – A glacial outwash deposit was encountered beneath the topsoil or fill at ten of the boring locations, including 3 of the 4 borings drilled within the footprint of the COP building. The thickness of the glacial outwash deposit was not determined in 7 of the 10 locations where it was encountered. Where the deposit was penetrated (within the footprint of the COP), the encountered thickness varied from approximately 2 to 21 ft. This deposit generally consists of dense to very dense poorly to well-graded sand with gravel and silt. SPT N-values ranged from 10 to greater than 100 bpf, but were typically greater than 30 bpf.

Glacial Marine Deposit – A glacial marine deposit was encountered beneath the topsoil, fill or organic deposit at the 12 boring locations where glacial outwash soils were not encountered and beneath the glacial outwash deposit in borings HA07-19 and HA07-21. The thickness of the glacial outwash deposit was not determined in 9 of the 14 locations where it was encountered. Where the deposit was penetrated, the encountered thickness varied from approximately 2 to 35 ft. Within the footprint of the COP building, the deposit varied from approximately 13 to 20 ft thick. This deposit generally consists of loose to very dense poorly-graded sand with silt. SPT N-values for the glacial marine sand ranged from 3 to greater than 100 bpf. The loose soils were only encountered beneath the existing athletic field. Approximately 1 to 3 ft of glacial marine clay was encountered beneath the north and west portions of the athletic field (in test borings HA07-13, HA07-17 and HA07-18), consisting of soft to hard lean clay with varying amounts of sand. The clay was encountered below the glacial marine sand, and the top of the clay varies from 7 to 10.5 ft BGS.

Glacial Till – Glacial till was encountered beneath the glacial marine deposit at five test boring locations, including three of the borings drilled within the COP footprint (i.e., HA07-19, HA07-21 and HA07-22. The thickness of the deposit was not determined at HA07-10, where it was greater than 2.4 ft in thickness. At other locations, the encountered thickness varied from 0.6 to 3.2 ft. This deposit typically consists of medium dense to very dense well-graded sand and silty sand with varying amounts of silt and gravel. SPT N-values ranged from 25 to greater than 100 bpf.

Bedrock – Bedrock was encountered (based on practicable drilling refusal or coring) in all of the borings drilled within the COP footprint (i.e., HA07-19 through HA07-22). The measured depth to bedrock ranged from 19.9 to 25.3 ft BGS within the COP footprint. The top of rock surface is relatively flat within the COP footprint but slopes down slightly from east (approximate El. 104.5 to El. 106.5) to west (approximate El. 101 to El. 102.5). Rock core samples were collected in test borings HA07-20 and HA07-22. The cored rock is described as hard to very hard, fresh to slightly weathered schist. Rock quality designation (RQD) values for the core specimens were relatively high, varying from 64 to 88 percent.

Groundwater Conditions

The depth to groundwater was measured in several of the completed boreholes immediately after drilling. The measured groundwater depths are provided on the boring logs in Appendix A. However, these measurements were influenced by the drilling operation and may not represent static water levels.

Several water level measurements were taken in the completed observation wells in between September 2007 and January 2008. The groundwater measurements in the observation wells are summarized below:

HA07-3(OW)	El. 102.8 to El. 103.2 (23.3 to 23.7 ft BGS)
HA07-5(OW)	El. 105.4 to El. 106.3 (18.7 to 19.6 ft BGS)
HA07-13(OW)	El. 93.3 to El. 93.9 (0.1 to 0.7 ft BGS)
HA07-21(OW)	El. 107.9 to El. 108.2 (18.3 to 18.6 ft BGS)

The measured groundwater depths indicate that the water levels vary by several feet over a relatively short distance within the area of the proposed COP building, considering that observation wells HA07-3(OW), HA07-5(OW) and HA07-21(OW) are all within approximately 250 ft of each other. This variance is likely a result of differences in the permeability of the subsurface soils and/or depth to top of bedrock surface. However, the measured groundwater depth has remained relatively constant in HA07-21(OW), located within the COP building footprint, over the three-month period that measurements have been taken.

It should be noted that the groundwater measurements recorded to-date are not likely to be representative of seasonal high groundwater levels because they were taken in the summer and early fall. We anticipate that seasonal high groundwater may be as much as 4 to 6 ft higher than the levels recorded in September and October 2007 in observation wells HA07-3(OW), HA07-5(OW) and HA07-21(OW).

Groundwater levels can be expected to fluctuate, subject to seasonal variation, local soil conditions, topography and precipitation. Groundwater levels encountered during construction may differ from those observed in the test borings or observation wells. Observation well installation and monitoring reports are included in Appendix B.

LABORATORY TEST RESULTS

Laboratory tests were conducted on representative soil samples from the test borings to quantify physical characteristics of the soils. Laboratory tests were performed to determine the water content and particle size distribution of representative samples from the borings. A summary of laboratory test results is provided in the table below, and the laboratory test reports are provided in Appendix C.

Test Boring	Sample Depth BGS (ft)	Material Type	USCS Classification	Particle Size Distribution			Natural Water Content (%)
				Percent Gravel	Percent Sand (coarse/med./fine)	Percent Fines[1]	
HA07-7	2-6	Fill	SM	14	9/30/28	18	6.8
HA07-10	0-2	Fill	SM	5	8/37/33	17	15.4
HA07-13	0.7-2	Fill	SP-SM	0	3/22/69	6	8.1
HA07-19	9.5-11.5	Glacial Marine	SP	0	0/26/71	3	6.5
HA07-20	9.5-11.5	Glacial Outwash	SP	1	5/58/34	2	2.0
HA07-22	0-2	Fill	SP-SM	30	9/29/21	10	2.8

[1] – Refers to the percentage of soil particles finer than the No. 200 (0.075 mm) sieve.

Organic content testing and moisture content testing was also performed on the sample of peat retrieved from boring HA07-17 at a depth of 4 to 6 ft BGS. The results of the laboratory tests on the peat sample are summarized below, and the laboratory reports are provided in Appendix C.

Peat

- <u>Natural Water Content</u> – 245.0 percent
- <u>Organic Content</u> – 32.6 percent

FINLEY HALL INVESTIGATIONS

On 7 and 14 December 2007, a Haley & Aldrich engineer visited Finley Hall to observe the basement and elevator pit to check for indications of past groundwater infiltration and other conditions that could be relevant to the foundation drainage and waterproofing details for the proposed College of Pharmacy (COP) building. Our observations and conclusions were summarized in a memorandum dated 17 December 2007 and is provided in Appendix D for information.

GEOTECHNICAL RECOMMENDATIONS

Structural Loading Information

Dan Burne of Becker Structural Engineers (Becker) provided us with typical column bay spacing and structural load information for the COP building by electronic mail on 10 October 2007. We used this information for our foundation evaluations. The structural information is summarized below:

- Typical column bay spacing of 21 ft by 20 to 34 ft.

- Typical dead plus live column loads (axial compression) of 375 kips (1 kip = 1,000 lb) for interior columns, 190 kips for perimeter columns and 100 kips for corner columns.
- Typical floor live loading of 100 psf (not including dead weight of proposed 6-in. thick slab).

Based on our discussions with Becker, we understand that the axial uplift loads for the COP are sufficiently small that they can be resisted by the dead load of the foundations and/or walls.

Foundation Support

We recommend that the COP building be supported on spread and continuous wall footing foundations bearing on undisturbed glacial outwash deposits, glacial marine deposits or glacial till. The footings should be designed based on an allowable bearing pressure, in pounds per square foot (psf), equal to 2,000 multiplied by the least lateral dimension of the footing in feet, up to a maximum of 8,000 psf. We recommend that all footings be at least 2 ft wide.

At the recommended allowable bearing pressure, we anticipate that the maximum post construction settlement of individual interior footings under static loading conditions, constructed as recommended herein, will not exceed ¾ in., with up to ½ in. of differential settlement between interior columns and adjacent perimeter or corner columns. If ½ in. of differential settlement over the proposed bay spacing is not structurally acceptable, we recommend that flexible construction joints be considered to accommodate the anticipated differential movement. Most of the settlement should occur during construction shortly after structure dead loads are placed on the foundations and during the initial snow loading of the roof.

Frost Protection

Soils at the site are considered to be moderately frost-susceptible. Bottoms of exterior footings should be founded a minimum of 4.5 ft below the lowest adjacent ground surface exposed to freezing. Bottoms of interior footings in heated areas should be founded a minimum of 1.5 ft below the top of the adjacent floor slab. However, if exposure to freezing is anticipated either during or following construction, these footings should be lowered in accordance with the recommendations for exterior footings, or the subgrades and foundations should be insulated to prevent freezing.

Ground Floor Slab

We recommend that the lowest-level floor slab be designed as a soil-supported concrete slab-on-grade. The floor slab should bear on a minimum 12-in. thick layer of crushed stone, overlain by waterproofing as discussed previously and underlain by separation filter fabric as outlined below in the foundation drainage section.

Resistance of Lateral Design Building Loads

Lateral loads can be resisted by a combination of friction along the base of the footings and passive pressure on the vertical faces of footings. Frictional resistance should be computed using an ultimate base friction coefficient (tan δ) between the footing concrete and the naturally deposited soils or granular fill equal to 0.30.

The net passive resistance (passive minus active) provided by the fill surrounding footings and foundation walls can be calculated using an equivalent fluid weight (triangular distribution) of 150 pounds per cubic foot (pcf). The soil within 1 ft of ground surface should be ignored unless it is confined by a slab or bituminous concrete. If the horizontal distance between adjacent footings or walls is less than twice the height of the subject structural element (measured from bottom of element to bottom of slab/ground surface), the passive pressure must be discounted proportionately to the distance (full pressure at twice the height away) to accommodate for interaction of the elements.

The frictional and passive resistance values may be used in combination without reduction. If a combination of these two resistance forces is not enough to provide adequate lateral resistance, we will consider the problem in more detail. A minimum factor of safety for sliding equal to 2.0 should be achieved for resistance of permanent lateral loads.

Foundation Drainage System

As mentioned previously, we anticipate that seasonal high groundwater levels will be several feet above the current levels. We anticipate that typical, sustained seasonal high groundwater levels may rise as much as 4 to 6 ft above current levels (El. 112 to El. 114), but it will generally stay below the level of the bottom of the basement floor slab. However, the groundwater level in the vicinity of the COP building may rise to or slightly above the level of the basement floor slab (El. 115) following a major storm event (e.g., 10-year storm) causing a sudden, short-term rise of the groundwater level. Therefore, we recommend that a permanent foundation drainage system be installed for the building to protect the slab from hydrostatic pressures.

The system should include an underslab drain system installed below the basement floor slab. This system should consist of separation filter fabric placed on the prepared, approved soil subgrade, a minimum 12 in. thickness of ¾-in. crushed stone placed above the fabric, and a network of 4 in. diameter perforated PVC or corrugated HDPE drain pipes (laid flat) embedded mid-height in the crushed stone layer. We recommend that one section of pipe be installed in each column bay (in the north-south and east-west directions). We estimate that the invert of the pipes would be approximately 12 in. below the finish floor elevation (i.e., El. 114).

The system should also include perimeter drains installed along the exterior side of the below-grade building foundation walls adjacent to the ground floor slab. We recommend that the system consist of a 4-in. diameter continuous perforated PVC or HDPE drain pipe (laid flat), surrounded by a minimum of 6 in. of crushed stone, wrapped in separation filter fabric. The invert level of the drain pipe should be positioned above the top of the wall footings and approximately 12 in. below the bottom of the ground floor slab. Per the requirements of the

IBC Code, the perimeter drain (including the pipe, crushed stone and filter fabric) should extend a minimum of 12 in. beyond the outside edge of the footing. We recommend that free-draining granular backfill (e.g., CGF) be placed within a minimum of 5 ft of below grade portions of the foundation walls.

Perimeter and underslab drain pipes should be installed at roughly the same invert elevation and should be laid flat. The underslab and perimeter drain pipes should be connected by constructing "wall-through" or "box-out" penetrations at discrete locations in the foundation wall. Considering the proposed waterproofing system, it will be necessary to coordinate penetrations through the foundation wall with appropriate waterproofing details. It will not be feasible to discharge the foundation drainage system by gravity into an appropriate receptor (e.g., new or existing storm drain system). Therefore, it will be necessary to install a sump pit with pumps to discharge the effluent from the system. Sump pits should be equipped with dual pumps with alternating cycles. The pumps should be wired into an emergency power source (e.g., generator). Based on groundwater seepage estimates, we recommend that the pumps be capable of pumping 50 gallons per minute (gpm). We understand that the sump pit will be constructed in a manhole located on the outside of the building adjacent to the foundation wall.

Pipe cleanouts should be provided at system corners (for both perimeter and underslab drain piping) to allow for future maintenance. Haley & Aldrich will coordinate the location and invert level of the drains, wall through penetrations and sump location/orientation with the Plumbing Consultant, Site Civil Engineer and Structural Engineer. It will be necessary to coordinate cleanouts located in the basement with appropriate waterproofing details.

As an additional measure of protection, surface runoff should be directed away from the building. In general, the level of the finished ground surface adjacent to the building should be sloped downward away from the structure to divert surface runoff. To limit surface water infiltration into the drainage system, it is recommended that the upper 8 in. of backfill within 10 ft of the building, in unpaved areas, consist of topsoil or other soil having low permeability.

We will provide a foundation drainage plan along with the appropriate drain system details for inclusion in the contract documents once the location and elevations of the below slab utilities are finalized.

Seismic Design Considerations

We understand that the proposed building will be designed in accordance with the seismic requirements of Table 1615.1.1 of the 2006 International Building Code (IBC). We recommend that the site be considered as Site Class "C". We recommend the following values be used to determine the design spectral response acceleration parameters (S_{DS} and S_{D1}) and to calculate the base shear for purposes of seismic design:

- Mapped Spectral Accelerations for Short Periods: $S_S = 0.32g$
- Mapped Spectral Accelerations for 1-Second Periods: $S_1 = 0.078g$
- Site Coefficient for Short Periods:, $F_a = 1.2$
- Site Coefficient for 1-Second Periods: $F_v = 1.7$

Please note that "g" refers to acceleration due to gravity.

The foundation soils are not considered to be susceptible to liquefaction.

Dampproofing/Waterproofing

We understand that the entire basement level will have positive-side waterproofing, located outside of the basement walls and below the slab and footings, to provide extra protection for the vivarium. As discussed with you, it is our opinion that subslab waterproofing is not needed, and humidity/moisture could be controlled by the proper installation of a subslab vapor barrier.

In general, we recommend that insulation be placed on the outside face of foundation walls where the adjacent interior space is below the level of the exterior ground surface, in accordance with the IBC Code.

The plans indicate that the base slab for the elevator pit is located below the invert of the underdrain system (El. 114). Therefore, the base slab should be designed to resist hydrostatic uplift loads based on a groundwater level at El. 116. We recommend that the walls and slab for the elevator pit be waterproofed.

Evaluations for the need to control humidity to prevent the formation of mold or other organisms within the building were not within the scope of work of this evaluation. If vapor barriers are used, the floor slab design and construction must be coordinated with the vapor barrier installation, as the barriers may impact concrete curing and curling.

Lateral Earth Pressures on Foundation Walls

We recommend that any exterior below-grade foundation walls retaining soil on one side and restrained at the top should be designed for static lateral earth pressures using an equivalent fluid unit weight of 60 lbs per cubic foot (pcf). Cantilever walls (i.e., walls that are free to rotate at the top) should be designed using an equivalent fluid unit weight of 40 pcf. These fluid weights assume that a free-draining granular backfill is placed within a minimum of 5 ft of the wall (with moist unit weight equal to 120 pcf) and that no unbalanced hydrostatic pressures exist (i.e., "drained condition"). Walls that are subjected to a surcharge due to floor slab live loading should be designed for an additional uniform lateral pressure equal to one-half the vertical design surcharge load, acting over the full height of the wall.

If the elevator pit is not drained, the walls should be designed for static lateral earth pressures using an equivalent fluid weight of 90 pcf.

Pavement Section

Recommendations for bituminous pavement section for auto traffic for the paved areas surrounding the COP building are provided below based upon the Maine Department of Transportation (MaineDOT) Standard Specification, Highways and Bridges (December 2002):

Standard-Duty Flexible Pavement (auto traffic/parking areas):

- 3 in. bituminous concrete, placed in two 1½ in. thick layers.
- 4 in. screened or crushed gravel base course.
- 12 in. sand or gravel subbase course.

Base and subbase course materials should conform to the following gradations:

Screened or Crushed Gravel - MaineDOT Standard Specification, Highways and Bridges; Section 703.06a, Type A.

Sand or Gravel Subbase - MaineDOT Standard Specification, Highways and Bridges; Section 703.06b, Type D. Type D aggregate should be modified to a maximum 4 in. size.

Subbase course material should be placed and compacted in separate 8 in. (maximum) thick loose lifts and compacted at approximately optimum moisture content to a minimum dry density of at least 95 percent of the maximum dry density as determined by ASTM D1557. Base course material should be placed in one loose lift and compacted with a minimum of two passes with self-propelled vibratory compaction equipment.

Prior to placement of pavement base and subbase course materials, all topsoil, organic matter and fill materials containing debris should be removed from within the limits of the proposed roadway/parking areas. The pavement recommendations are based on the assumption that a stable, firm subgrade is prepared beneath the base and subbase courses, as discussed in the Construction Considerations section of this report.

Pavement design recommendations can be provided for the access road and parking area in the northern portion of the site when design grading is available for our review.

Sidewalks

Concrete sidewalks should be supported on a minimum of 1.5 ft of CGF or subbase gravel. The soils at the site are considered to be moderately frost-susceptible and the purpose of placing free-draining granular soil below the sidewalks is to help control the potential for post-construction differential heaving and cracking. Prior to placement of CGF or subbase gravel, all topsoil, organic matter and fill materials containing debris should be removed from within the limits of the proposed roadway/parking area.

CONSTRUCTION CONSIDERATIONS

General

The primary purpose of this section of the report is to comment on items related to excavation, earthwork, and other related geotechnical concerns regarding the proposed construction. This will aid individuals responsible for preparation of plans and specifications, as well as personnel appointed to monitor construction activities. The contractor must evaluate construction problems on the basis of knowledge and experience in the Portland area as well as their experience on similar projects in other localities, taking into account proposed construction procedures, methods, equipment, and personnel.

Excavation

Excavation will be required for general site grading, and for construction of building foundations, the elevator pit, underground utilities, and sidewalks. We anticipate that excavation as deep as 14 ft BGS will be required to construct the COP footings and install the foundation drainage system. We anticipate that an additional 5 ft of excavation will be required to allow construction of the elevator pit.

All topsoil, debris and organic matter encountered within the limits of the proposed sidewalk and paved areas should be stripped and removed from the site, prior to placing site fills.

We expect that excavation of the in-situ soils can typically be accomplished using normal earth-moving equipment. Considering the age of the Westbrook Campus, we anticipate that areas of uncontrolled fill or obstructions associated with previous site uses may be encountered during excavation. At the location of boring HA07-2/2A, three different boring locations met refusal on buried debris within 5 ft of the ground surface prior to advancing boring HA07-2A. We recommend that the contract documents require the contractor to include provisions for obstruction removal in their earthwork bid.

The shallowest bedrock was encountered at approximately El. 106.5 (boring HA07-22) in the southeast corner of the proposed COP building footprint, with top of rock elevations ranging from about El. 101 to El. 104.5 in the other borings drilled in the building footprint. Therefore, the available information indicates that bedrock will likely be at least 8 ft below the level of the basement slab and at least 3 ft below the bottom of the excavation for the elevator pit. If shallower rock is encountered or the bedrock surface is locally higher than the levels encountered in the test borings, the use of drilling and blasting or other excavation techniques may be required for rock removal.

If blasting is required, the excavation contractor should be made responsible for the design and implementation of a blasting plan that meets applicable local, state and federal agency requirements, is safe and does not adversely impact adjacent structures, property or the general public.

Excavations will typically be made into sand with little or no fine-grained soil. Temporary cut earth slopes should, typically, be stable if constructed no steeper than about 1.5H:1V. Some sloughing and raveling should be anticipated in temporary earth slopes, especially during and after rainfall. All temporary excavations should be made in accordance with all OSHA and other applicable regulatory agency requirements. The contractor should be responsible for the design, stability and safety of all temporary and permanent excavations.

Temporary Excavation Support System

Based on the anticipated elevation of the bottom of footings in the basement area (approximately El. 112), existing site grades adjacent to the proposed basement excavation (El. 126 to El. 127) and the proximity of the property lines and Ludcke Hall relative to the location of the proposed basement area, it is likely that an excavation support system will be required to construct the basement level of the proposed building. Based on subsurface soil, rock and groundwater conditions at the site, we anticipate that the most cost effective excavation support system will consist of a soldier pile and lagging wall. It may be necessary to socket the soldier piles into bedrock in some areas (e.g., where soldier piles extend below El. 106 to El. 101). A "benched" excavation support system may be appropriate and should be considered.

We anticipate that support of excavation systems retaining greater than 15 ft of soil will require lateral support in the form of tiebacks or internal bracing. The excavation support system will be designed by the Contractor's engineer as part of the submittal process based on the design requirements outlined in the project specifications. Soil and groundwater properties and other design parameters will be provided in the specifications.

Construction Dewatering

Groundwater has generally been measured at elevations ranging from El. 103 to El. 108 in the vicinity of the proposed COP building footprint. We anticipate that groundwater will be encountered in excavations that extend deeper than these elevations. Groundwater will likely be encountered at shallower depths if excavation is performed in the spring or early summer. We expect that dewatering in these areas may be accomplished by pumping from open sumps and temporary ditches located at the base of the excavations. Sumps should be provided with filters suitable to prevent pumping of fine grained soil particles. Rainwater or snowmelt should be directed away from exposed soil bearing surfaces.

Dewatering and discharge of dewatering effluent should be performed in accordance with all applicable local, state and federal regulations. Due to the size of the site and the non permeable nature of the near surface soils, we anticipate that on-site recharge will not be feasible and that dewatering effluent will need to be discharged to a local storm drain. Sedimentation tanks or other treatment methods may be required for legal disposal of the effluent.

The contractor should be responsible for controlling all surface runoff, infiltration and water from other sources at all times during excavation. Rainwater or snowmelt should be directed away from exposed soil bearing surfaces. Dewatering should be performed as required to maintain the undisturbed nature of the soil bearing surfaces and enable all final excavation, foundation construction and backfilling to be completed "in-the-dry."

Dewatering should be performed in accordance with all applicable regulations. Dewatering should be conducted in a manner that avoids disturbance or undermining of existing foundations, backfill, prepared foundation subgrades, and that limits pumping of fines.

Subgrade Preparation

The following guidelines are recommended to protect subgrade soils beneath the new slab and footings:

- Make final excavations into bearing soils using smooth-bladed equipment to minimize disturbance.
- All work should be performed in the dry. Prevent water from accumulating on

bearing surfaces to reduce the possibility of softening. Surfaces that become disturbed due to softening should be excavated and stabilized with placement of crushed stone and filter fabric, as necessary, with approval of a geotechnical engineer.

- Exposed bearing surfaces should be examined in the field by an experienced geotechnical engineer or technician to verify strength and bearing capacity. Excavation may be necessary to remove weak, disturbed or otherwise unacceptable soils.
- Limit equipment and worker traffic on the finished bearing surfaces.

Footings

We recommend that the excavation work be conducted in a manner that minimizes disturbance to the subgrade soils when excavating for footing bearing surfaces. After final excavation to the design bearing levels, the exposed subgrade should be observed in the field by the Owner's on-site representative to confirm the assumed foundation bearing conditions. It may be necessary to over-excavate and replace locally weak, disturbed or otherwise unacceptable foundation bearing soils. Following excavation to the bearing stratum, exposed granular soil surfaces should be proofrolled with a minimum of two passes of a self-propelled vibratory roller or heavy hand-guided vibratory compactor, until firm, if the bearing soils are loosened by the excavation process as judged by the Owner's on-site representative. Saturated bearing soils should not be proofrolled.

Soil bearing surfaces below completed foundations and slabs must be protected against freezing, before and after foundation construction. If construction is performed during freezing weather, footings should be backfilled to a sufficient depth (up to 4.5 ft) as soon as possible after they are constructed. Alternatively, insulating blankets or other means may be used for protection against freezing.

Slab-on-Grade

Any debris and/or disturbed material should be removed from beneath the ground floor slab and should be replaced with CGF, lean concrete or crushed stone. Existing soil should be removed to a depth of 1 ft below the bottom of the floor slab for placement of the filter fabric and crushed stone for the foundation drainage system. We recommend that floor slab subgrade surface be inspected by a geotechnical engineer prior to placement of fill or construction of the floor slab.

Pavement Areas/Sidewalks

All topsoil, debris and organic matter should be removed within the limits of the sidewalk and pavement areas. Prior to placing any additional fill or base course material within these areas, the soil subgrade should be proofrolled with a minimum of four passes of a self-propelled vibratory roller. Any soft areas revealed by proofrolling should be removed and replaced by CGF. The surface should then be compacted with additional passes of the vibratory roller as deemed appropriate by the Owner's on-site representative.

Filling and Backfilling

Filling will be required to raise grades in some areas during general site grading. All topsoil, debris and organic matter should be removed as stated above prior to placement of fill material.

Placement of compacted fills should not be conducted when air temperatures are low enough (approximately 30 degrees F., or below) to cause freezing of the moisture in the fill during or before placement. Fill materials should not be placed on snow, ice or uncompacted frozen soil. Compacted fill should not be placed on frozen soil. No fill should be allowed to freeze prior to compaction. At the end of each day's operations, the last lift of fill, after compaction, should be rolled by a smooth-wheeled roller to eliminate ridges of uncompacted soil.

Fill Materials

Compacted Granular Fill

Compacted granular fill (CGF) placed within the ZOI of footings, beneath building slabs, and adjacent to foundation walls should consist of mineral, bank-run sand and gravel, free of organic material, snow, ice, or other unsuitable materials and should be well-graded within the following limits:

Sieve Size	Percent Finer by Weight
6 in. (1)	100
No. 4	30 – 80
No. 40	10 – 50
No. 200	0 – 8

(1) Cobbles or boulders having a size exceeding 2/3 of the loose lift thickness should be removed prior to compaction.

CGF should be placed in lifts not exceeding 12 in. in loose measure and compacted using self-propelled vibratory equipment. The soil should be placed near its approximate optimum moisture content to achieve a dry density of at least 95 percent of the maximum dry density, as determined in accordance with ASTM D1557. In confined areas, maximum particle size should be reduced to 3 in., maximum loose layer reduced to 6 in., and compaction performed by hand-guided equipment. A minimum of four systematic passes of the compaction equipment should be used to compact each lift. Cobbles or boulders having a size exceeding 2/3 of the loose lift thickness should be removed prior to compaction.

CGF placed on the outside of the perimeter foundation walls should extend laterally a minimum of 5 ft beyond the walls. Backfill beyond this limit may consist of common fill. The top 8 in. of fill around the exterior of the building should consist of low permeability material used to minimize water infiltration adjacent to the structure. Grading should be designed to promote drainage of surface water away from the structure.

Excavated glacial outwash soils and glacial marine soils are not considered acceptable for reuse as CGF within 5 ft of the basement walls due to the fine-grained nature and relatively low permeability of these soils. In-situ fill soils within the footprint of the COP may be suitable for reuse as CGF. If the contractor wishes to reuse this material, the fill should be stripped, stockpiled and tested to confirm that the gradation requirements are met.

Common Fill

The in-situ fill (excluding any debris-laden material) and naturally deposited glacial outwash and glacial marine soils are acceptable for use as common fill if they meet the requirements summarized below.

Common fill should consist of mineral sandy soil, free from organic matter, plastic, metal, wood, ice, snow or other deleterious material and should have the characteristic that it can be readily placed and compacted. Common fill imported to the site should have a maximum of 80 percent passing the No. 40 sieve and a maximum of 30 percent finer than the No. 200 sieve. The largest particle size for common fill should not exceed 2/3 of the loose lift thickness. Silty common fill soils may require moisture control during placement and compaction. Common fill should be placed in maximum 12 in. thick loose lifts using compaction equipment as described above for CGF.

Where common fill is used to raise grades beneath sidewalks and paved areas and as backfill more than 5 ft from the basement walls, it is recommended that either glacial outwash soils or sandy glacial marine soils be used to promote proper compaction.

Compaction Requirements

A summary of recommended compaction requirements is as follows:

Location	Minimum Compaction Requirements
Beneath footings and building slabs	95 percent
Parking, roadways and sidewalks	92 percent up to 3 ft below finished grade 95 percent in the upper 3 ft
Basement wall backfill (within 5 ft of wall)	95 percent
Landscaped areas	90 percent nominal compaction

Minimum compaction requirements refer to percentages of the maximum dry density determined in accordance with ASTM D1557.

Preparation of Contract Documents and Submittal Reviews

The contract drawings and specifications should be written so that the requirements of the documents are consistent with the design intent of the geotechnical recommendations outlined herein. Therefore, we recommend that Haley & Aldrich either be retained to prepare or provide technical review of the specifications and contract drawings related to the following topics:

- Earthwork
- Foundation Drainage
- Construction Dewatering
- Temporary Excavation Support System

We recommend that Haley & Aldrich be retained to provide foundation drainage plans and details for the COP building.

The contract specifications will require the Contractor and the Contractor's engineer to perform analyses and submit results to the designers for review. We recommend that Haley & Aldrich be allowed to review the geotechnical-related submittals to ensure that the Contractor's analyses/submittals are in accordance with the intent of the design. Haley & Aldrich should also respond to geotechnical-related RFIs from the Contractor, as needed.

Construction Monitoring

The foundation recommendations contained herein are based on the predictable behavior of a properly engineered and constructed foundation. Monitoring of the foundation construction is required to enable the geotechnical engineer to keep in contact with procedures and techniques used in construction, and to comply with Section 1808.2.10 of the IBC Code. Therefore, it is recommended that a geotechnical engineer or experienced technician be present during construction to monitor the following activities.

- Installation/testing of temporary excavation support system(s).
- Excavation to subgrade levels and subgrade inspection prior to construction of footings and slabs.
- Installation of the foundation drainage system.
- Placement and compaction testing of site fills.
- Confirming that soils used as backfill are in accordance with the project plans and specifications, and making judgments on suitability of excavated soils for reuse as fill.
- Backfilling adjacent to foundation walls and beneath the building slab.
- Inspection of the slab and pavement subgrade prior to slab construction/pavement installation.

We ask that you consider Haley & Aldrich be allowed to provide these services.

LIMITATIONS

This report is prepared for the exclusive use of the University of New England relative to the proposed College of Pharmacy project in Portland, Maine. There are no intended beneficiaries other than the University of New England. Haley & Aldrich shall owe no duty whatsoever to any other person or entity on account of the Agreement or the report. Use of this report by any person or entity other than the University of New England for any purpose whatsoever is expressly forbidden unless such other person or entity obtains written authorization from the University of New England and from Haley & Aldrich. Use of this report by such other person or entity without the written authorization of the University of New England and Haley & Aldrich shall be at such other person's or entities sole risk, and shall be without legal exposure or liability to Haley & Aldrich.

Use of this Report by any person or entity, including by the University of New England, for a purpose other than the proposed College of Pharmacy project in Portland, Maine is expressly prohibited unless such person or entity obtains written authorization from Haley & Aldrich indicating that the Report is adequate for such other use. Use of this Report by any other person or entity for such other purpose without written authorization by Haley & Aldrich shall be at such person's or entities sole risk, and shall be without legal exposure or liability to Haley & Aldrich.

The analyses and recommendations are based, in part, upon the data obtained from the referenced subsurface explorations. The nature and extent of variations between explorations may not become evident until construction. If variations then appear, it may be necessary to reevaluate the recommendations presented in this report.

We appreciate the opportunity to provide geotechnical engineering services on this project. Please do not hesitate to call if you have any questions or comments.

Sincerely yours,
HALEY & ALDRICH, INC.

STATE OF MAINE
ANDREW R. BLAISDELL
No. 10957
LICENSED
PROFESSIONAL ENGINEER

Andrew R. Blaisdell, P.E.
Senior Engineer

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Wayne A. Chadbourne, P.E.
Vice President

Enclosures:

- Table I – Summary of Subsurface Explorations
- Figure 1 – Project Locus
- Figure 2 – Site and Subsurface Exploration Location Plan (College of Pharmacy)
- Figure 3 – Site and Subsurface Exploration Location Plan (Parking Improvements)
- Appendix A – Test Boring Logs
- Appendix B – Observation Well Installation and Groundwater Monitoring Reports
- Appendix C – Laboratory Test Reports
- Appendix D – 17 December 2007 Memorandum by Haley & Aldrich, Inc. entitled "Summary of Site Visit, Elevator Pit in Finley Hall Athletic Center"

c: Port City Architecture; Attn.: Lita Semrau
SYTDesign Consultants; Attn.: Peter Biegel
Becker Structural Engineers; Attn.: Dan Burne

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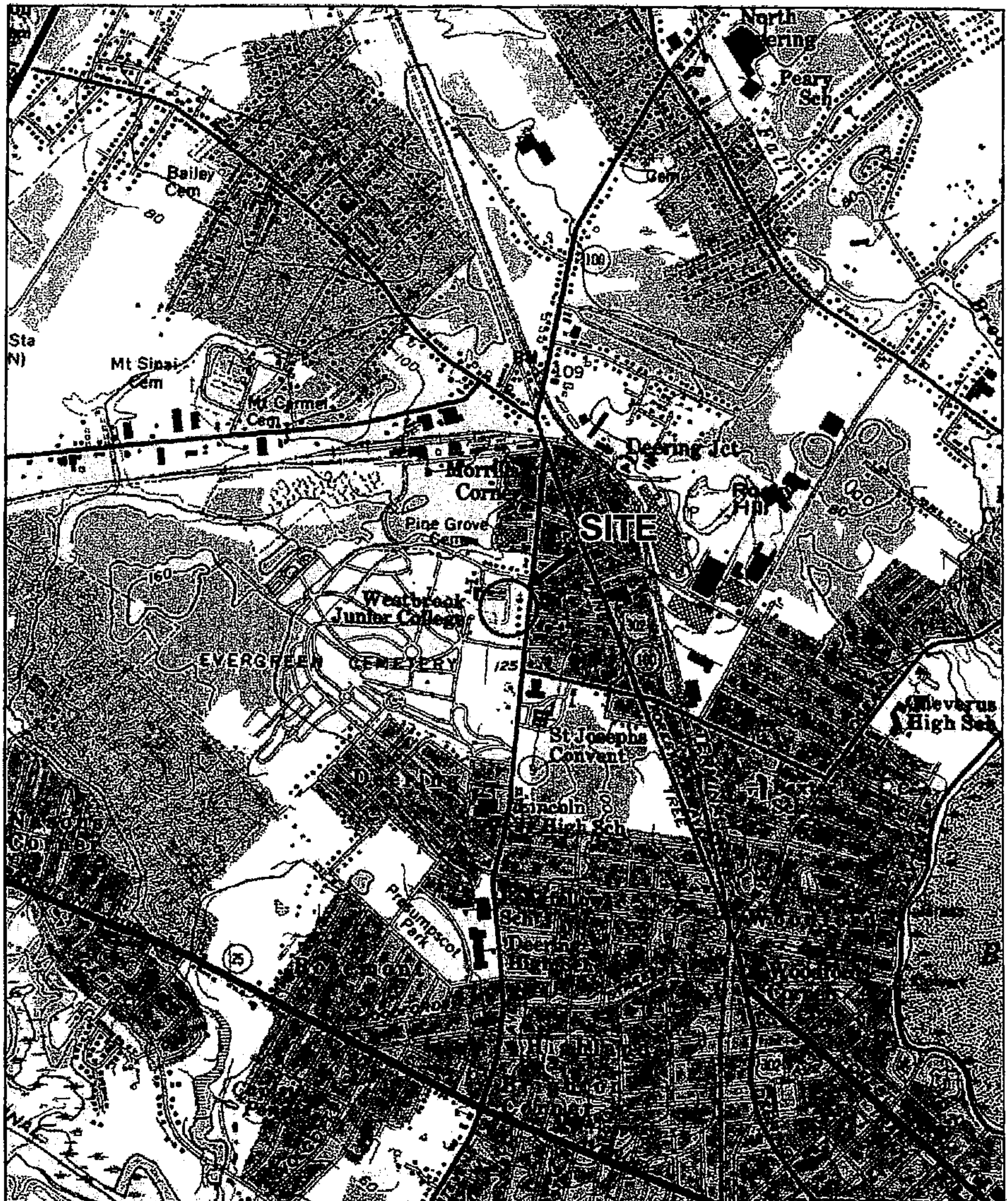
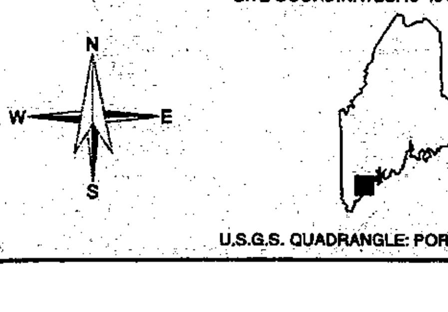
TABLE I
Summary of Subsurface Explorations
Proposed College of Pharmacy and Campus Improvements
University of New England
Portland, Maine

Test Boring No. [1]	Estimated Ground Surface Elevation [2,3]	Thickness of Strata (ft)						Measured Depth to Top of Bedrock [4] (ft)
		Topsoil	Fill	Organic Deposit	Glacial Outwash Deposit	Glacial Marine Deposit	Glacial Till	
HA07-1	127.5	0.7	2.3	NE	> 24.0 (BOE)	--	--	NE
HA07-2/2A	127.5	0.7	4.3	NE	> 22.2 (BOE)	--	--	NE
HA07-3(OW)	126.5	2.4	NE	NE	> 29.6 (BOE)	--	--	NE
HA07-4	127.5	0.6	NE	NE	NE	34.7	1.8	37.1
HA07-5(OW)	125	0.5	NE	NE	NE	> 19.8 (BOE)	--	NE
HA07-6	129	NE	0.9	NE	> 3.8 (BOE)	--	--	NE
HA07-7	118	NE	14.2	NE	> 1.8 (BOE)	--	--	NE
HA07-8	111	NE	3.6	NE	> 2.4 (BOE)	--	--	NE
HA07-9	105	NE	2.0	NE	> 2.0 (BOE)	--	--	NE
HA07-10	98	NE	1.8	NE	NE	1.8	> 2.4 (BOE)	NE
HA07-11	98	1.0	0.2	NE	NE	> 6.8 (BOE)	--	NE
HA07-12	97	0.3	3.7	NE	NE	> 4.0 (BOE)	--	NE
HA07-13(OW)	94	0.7	2.3	0.1	NE	> 13.9 (BOE)	--	NE
HA07-14	96	0.5	4.3	NE	NE	> 1.2 (BOE)	--	NE
HA07-15	98	0.4	3.6	NE	NE	> 2.0 (BOE)	--	NE
HA07-16	95	1.0	2.8	0.2	NE	> 2.0 (BOE)	--	NE
HA07-17	95	0.5	3.5	1.9	NE	> 4.1 (BOE)	--	NE
HA07-18	95	0.3	3.2	0.1	NE	> 28.4 (BOE)	--	NE
HA07-19	126.5	NE	1.6	NE	2.1	20.7	0.6	25.3
HA07-20	127	NE	1.0	NE	21.2	NE	NE	22.6
HA07-21(OW)	126.5	NE	1.7	NE	2.9	17.7	1.4	24.0
HA07-22	126.5	NE	3.2	NE	NE	13.2	3.2	19.9

Notes:
[1] Test boring locations are shown on Figures 2 and 3, Site and Subsurface Exploration Location Plans.
[2] Ground surface elevations at test boring locations are approximate and were estimated by interpolating between elevation contour data provided by SYTDesign (estimated to the nearest 0.5 ft).
[3] Elevations are in feet and reference the National Geodetic Vertical Datum of 1929 (NGVD 29).
[4] Measured bedrock depths were determined by practicable refusal of drilling equipment and/or rock coring ("NE" indicates bedrock not encountered).
[5] "NE" indicates stratum was not encountered in test boring, "BOE" indicates bottom of exploration.



SITE COORDINATES:43°40'57"N 70°17'41"W



U.S.G.S. QUADRANGLE: PORTLAND WEST, ME

HALEY & ALDRICH

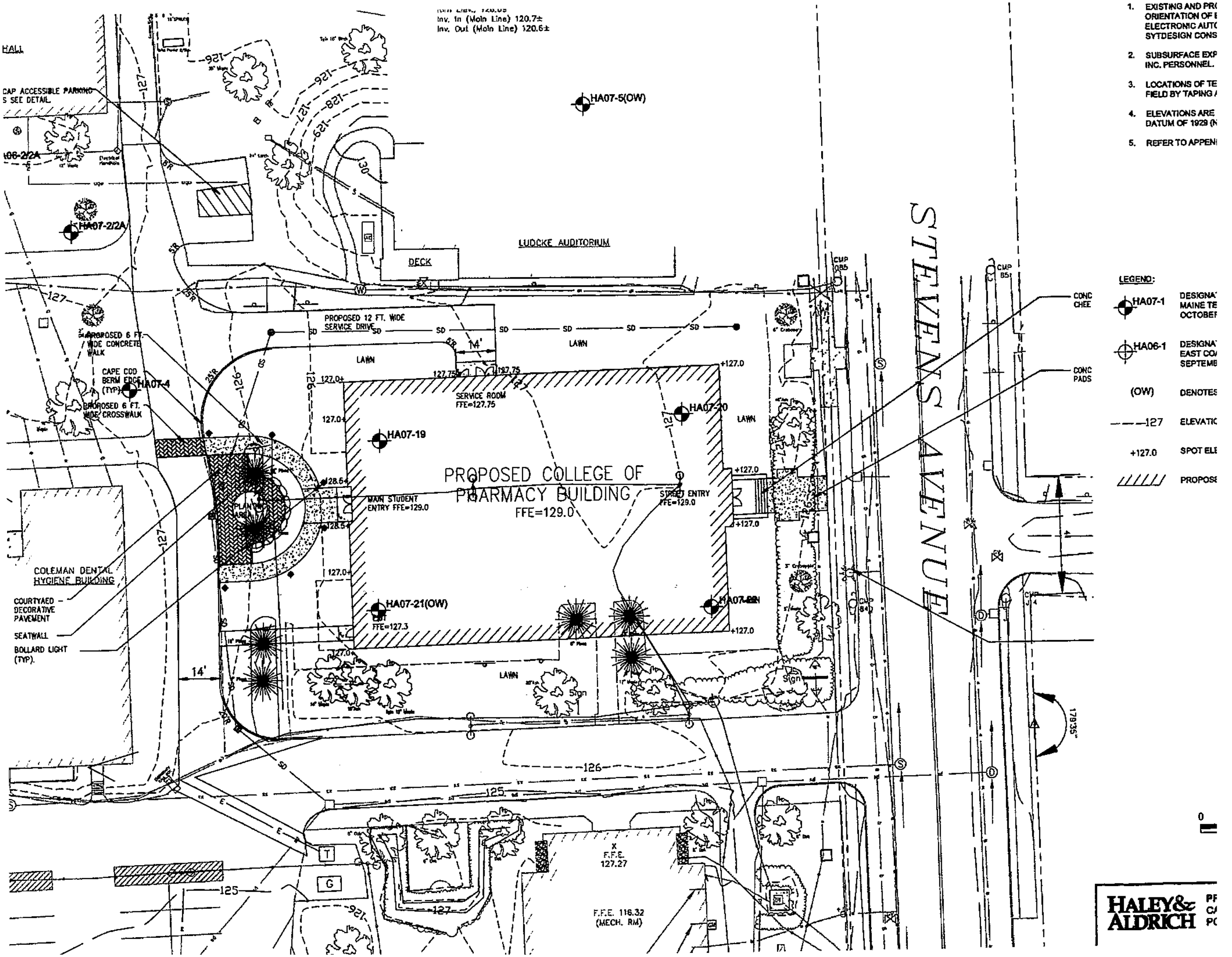
PROPOSED COLLEGE OF PHARMACY AND CAMPUS IMPROVEMENTS
UNIVERSITY OF NEW ENGLAND
PORTLAND, MAINE

PROJECT LOCUS

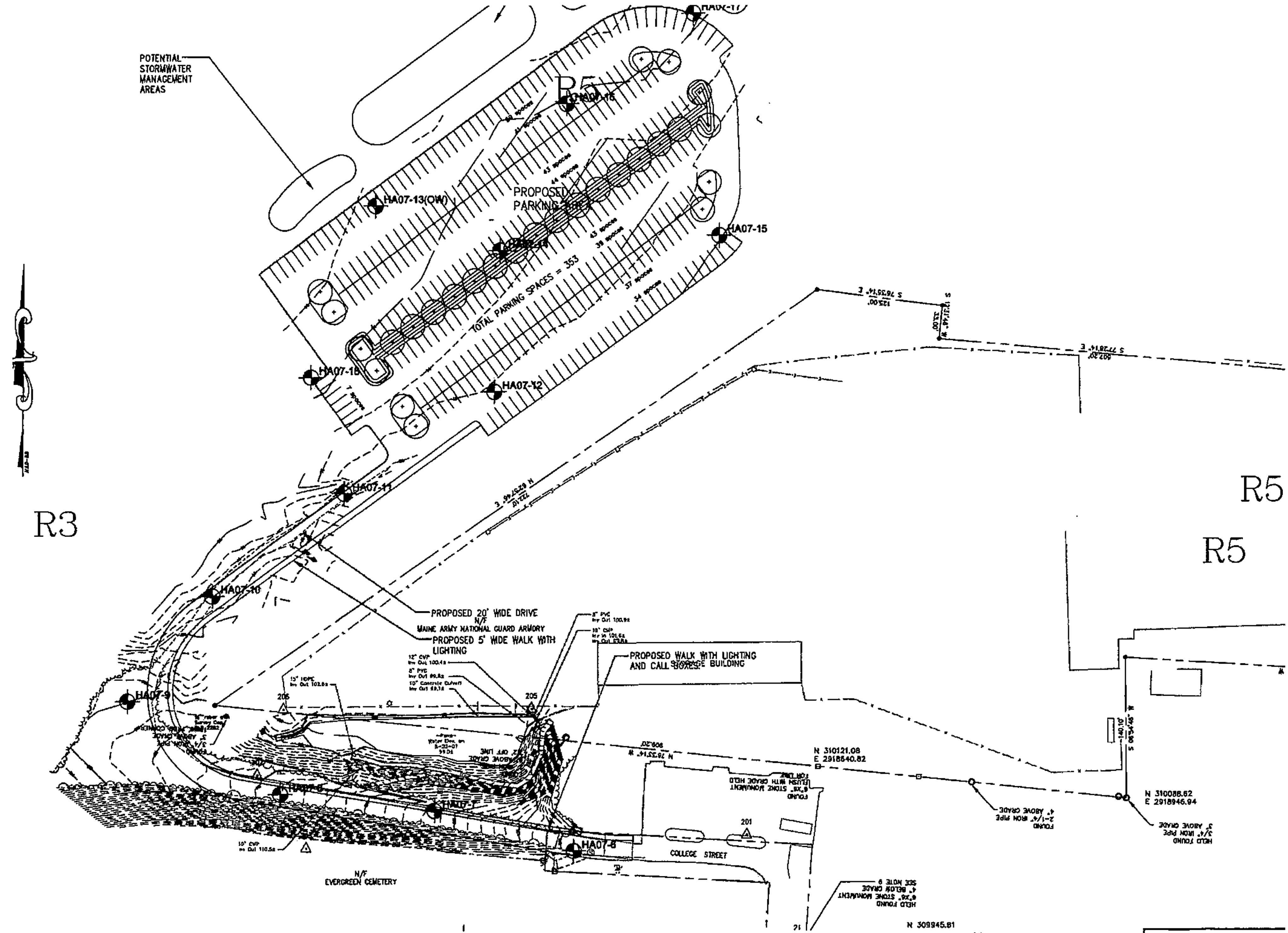
SCALE: 1:24,000
NOVEMBER 2007

FIGURE 1

34718-000 1.PDF



PROPOSED COLLEGE OF PHARMACY BUILDING
FFE=129.0
STEVENS AVENUE
LUDCKE AUDITORIUM
DECK
HALL
CAP ACCESSIBLE PARKING S SEE DETAIL
Inv. In (Main Line) 120.7±
Inv. Out (Main Line) 120.6±
HA07-5(OW)
HA07-2/2A
HA07-4
HA07-19
HA07-20
HA07-21(OW)
PROPOSED 12 FT. WIDE SERVICE DRIVE
PROPOSED 6 FT. WIDE CONCRETE WALK
CAPE COD BERM EDGE (TYP)
PROPOSED 6 FT. WIDE CROSSWALK
SERVICE ROOM FFE=127.75
MAIN STUDENT ENTRY FFE=129.0
STREET ENTRY FFE=129.0
FFE=127.3
LAWN
COLEMAN DENTAL HYGIENE BUILDING
COURTYAED DECORATIVE PAVEMENT
SEATWALL
BOLLARD LIGHT (TYP).
F.F.E. 127.27
F.F.E. 116.32 (MECH. RM)
CONC CHEE
CONC PADS
179°35"
1. EXISTING AND PR ORIENTATION OF ELECTRONIC AUT SYTDESIGN CONS
2. SUBSURFACE EXP INC. PERSONNEL.
3. LOCATIONS OF TE FIELD BY TAPING
4. ELEVATIONS ARE DATUM OF 1929 (N
5. REFER TO APPEN
LEGEND:
HA07-1 DESIGNA MAINE TE OCTOBE
HA06-1 DESIGNA EAST CO SEPTEMB
(OW) DENOTES
127 ELEVATIC
+127.0 SPOT ELE
PROPOSE
HALEY & ALDRICH



HALEY& ALDRICH

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PORT

LEGEND:

HA07-1 DESIGNATION AND APPROXIMATE LOCATION OF TEST BORING DRILLED BY MAINE TEST BORINGS, INC. OF BREWER, MAINE IN SEPTEMBER AND OCTOBER 2007

) ORIENTATION OF EXISTING AND PROPOSED SITE
ILE ENTITLED "0621608 Site Plan Building," PROVIDED

APPENDIX A

Test Boring Logs

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ALDRICH

HALEY & ALDRICH	TEST BORING REPORT	Boring No. HA07-1

Project	Proposed College of Pharmacy and Campus Improvements Portland, Maine
Client	University of New England
Contractor	Maine Test Borings, Inc.

File No.	34718-000
Sheet No.	1 of 2
Start	14 September 2007
Finish	14 September 2007
Driller	M. Porter
H&A Rep.	E. Beirne
Elevation	127.5+/-
Datum	NGVD 1929
Location	See Plan

	Casing	Sampler	Barrel	Drilling Equipment and Procedures
Type	NW	S	--	Rig Make & Model: Mobile B-53 Bombardier
Inside Diameter (in.)	3.0	1 3/8	--	Bit Type: Roller Bit Drill Mud: None
Hammer Weight (lb.)	300	140	-	Casing: NW Drive to 25 ft.
Hammer Fall (in.)	16	30	-	Hoist/Hammer: Winch/ Safety Hammer

Depth (ft.)	SPT[1]	Sample No. & Rec. (in.)	Sample Depth (ft.)	Well Diagram	Elev./Depth (ft.)	USCS Symbol	Visual-Manual Identification and Description (Density/consistency, color, GROUP NAME, max. particle size[2], structure, odor, moisture, optional descriptions, geologic interpretation)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Test Dilatancy	Field Test Toughness	Field Test Plasticity	Field Test Strength
0	2 4 14 7	S1 17	0.0 2.0	NO WELL INSTALLED	0.5	ML	Medium dense, dark brown, sandy SILT (ML), mps <1 mm, no structure, slight organic odor, dry to moist, rootlets throughout -TOPSOIL-				10	40	50				
					0.7	SP-SM	Medium dense, brown, poorly-graded SAND with silt (SP-SM), mps=2mm, no structure, no odor, moist				15	75	10				
					3.0	SW-SM	Medium dense, brown to black, well graded SAND with silt (SW-SM), mps=0.5 in., no structure, slight organic odor, moist, glass and tar fragments -FILL-		15	20	25	25	15				
5	17 22 19 24	S2 15	5.0 7.0			SW	Note: Driller noted change to brown sand and gravel at 3.0 ft. Dense, brown to white, well-graded SAND with gravel (SW), mps=2 in., no structure, no odor, dry -GLACIAL OUTWASH DEPOSIT-	20	10	15	35	20					
10	45 64 63 49	S3 16	10.0 12.0			SW	Very dense, brown, well-graded SAND with gravel (SW), mps=1.5 in., no structure, no odor, moist -GLACIAL OUTWASH DEPOSIT-	20	10	15	30	20	5				
15	18 26 28 29	S4 11	15.0 17.0			SW	Very dense, brown, well-graded SAND (SW), mps=.25 in., no structure, no odor, wet -GLACIAL OUTWASH DEPOSIT-		5	15	45	30	5				
20	16 28 24 24	S5 10	20.0 22.0			SW	Very dense, brown, well-graded SAND (SW), mps=.50 in., no structure, no odor, wet -GLACIAL OUTWASH DEPOSIT-		5	15	45	30	5				
25																	

Water Level Data

Date	Time	Elapsed Time (hr.)	Depth (ft.) to: Bottom of Casing	Bottom of Hole	Water
9/14/07	12:40	0.1	20.0	24.0	--

Sample Identification

- O Open End Rod
- T Thin Wall Tube
- U Undisturbed Sample
- S Split Spoon
- G Geoprobe

Well Diagram

Riser Pipe, Screen, Filter Sand, Cuttings, Grout, Concrete, Bentonite Seal

Summary

Overburden (lin. ft.)	27.0
Rock Cored (lin. ft.)	--
Samples	6S

Boring No. HA07-1

Field Tests: Dilatancy: R-Rapid, S-Slow, N-None; Toughness: L-Low, M-Medium, H-High; Plasticity: N-Nonplastic, L-Low, M-Medium, H-High; Dry Strength: N-None, L-Low, M-Medium, H-High, V-Very High

[1] SPT = Sampler blows per 6 in. [2] Maximum particle size is determined by direct observation within the limitations of sampler size.

Note: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

USCS_TB4 USCSLIB4.GLB USCSTB+CORE4.GDT G:\PROJECTS\34718\000\DRILLING\34718-000TB.GPJ 11 Oct 07

TEST BORING REPORT

Depth (ft.)	SPT[1]	Sample No. & Rec. (in.)	Sample Depth (ft.)	Well Diagram	Elev./Depth (ft.)	USCS Symbol	Visual-Manual Identification and Description (Density/consistency, color, GROUP NAME, max. particle size[2], structure, odor, moisture, optional descriptions, geologic interpretation)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Test Dilatancy	Field Test Toughness	Field Test Plasticity	Field Test Strength
25	23 20 20 29	S6 12	25.0 27.0			SW-SM	Dense, well-graded SAND with silt (SW-SM), mps=.75 in., no structure, no odor, wet, two poorly-graded fine sand layers -GLACIAL OUTWASH DEPOSIT-	10	10	40	30	10					
					27.0		-BOTTOM OF EXPLORATION AT 27.0 FT.-										

[1]SPT = Sampler blows per 6 in. [2]Maximum particle size is determined by direct observation within the limitations of sampler size.

NOTE: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

HALEY & ALDRICH — TEST BORING REPORT

Boring No. HA07-2

Project: Proposed College of Pharmacy and Campus Improvements Portland, Maine
Client: University of New England
Contractor: Maine Test Borings, Inc.

File No. 34718-000
Sheet No. 1 of 1
Start: 17 September 2007
Finish: 17 September 2007
Driller: B. Enos
H&A Rep.: E. Beirne
Elevation: 127.5+/-
Datum: NGVD 1929
Location: See Plan

	Casing	Sampler	Barrel
Type	NW	S	--
Inside Diameter (in.)	3.0	1 3/8	--
Hammer Weight (lb.)	300	140	-
Hammer Fall (in.)	16	30	-

Drilling Equipment and Procedures
Rig Make & Model: Mobile Drill B-47
Bit Type: Roller Bit
Drill Mud: None
Casing: NW Drive to 5 ft.
Hoist/Hammer: Winch/ Doughnut Hammer

Depth (ft.)	SPT[1]	Sample No. & Rec. (in.)	Sample Depth (ft.)	Well Diagram	Elev./Depth (ft.)	USCS Symbol	Visual-Manual Identification and Description (Density/consistency, color, GROUP NAME, max. particle size[2], structure, odor, moisture, optional descriptions, geologic interpretation)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Dilatancy	Toughness	Plasticity	Strength
0	3 12 6 5	S1 21	0.0 2.0	NO WELL INSTALLED		SM	Medium dense, brown, silty SAND (SM), mps=2 mm, no structure, organic odor, moist, rootlets throughout -TOPSOIL-				5	60	35				
					0.7	SW-SM	Medium dense, dark brown, well-graded SAND with silt (SW-SM), mps=1.25 in., no structure, odor, moist, pavement fragments -FILL-	5	15	20	20	30	15				
5	1 50/2	S2 6	5.0 5.7		5.5	SW-SM	Medium dense, dark brown, well-graded SAND with silt (SW-SM), mps=1.25 in., no structure, no odor, moist, pavement fragments -FILL-		25	10	20	35	10				
					5.7		Concrete										
							-BOTTOM OF EXPLORATION AT 5.7 FT.- Moved location ahead 5 ft., see HA07-2A.										

Water Level Data

Date	Time	Elapsed Time (hr.)	Depth (ft.) to: Bottom of Casing	Bottom of Hole	Water

Sample Identification
O Open End Rod
T Thin Wall Tube
U Undisturbed Sample
S Split Spoon
G Geoprobe

Well Diagram
Riser Pipe
Screen
Filter Sand
Cuttings
Grout
Concrete
Bentonite Seal

Summary
Overburden (lin. ft.) 5.7
Rock Cored (lin. ft.) --
Samples 2S

Boring No. HA07-2

Field Tests: Dilatancy: R-Rapid, S-Slow, N-None; Toughness: L-Low, M-Medium, H-High; Plasticity: N-Nonplastic, L-Low, M-Medium, H-High; Dry Strength: N-None, L-Low, M-Medium, H-High, V-Very High

[1] SPT = Sampler blows per 6 in. [2] Maximum particle size is determined by direct observation within the limitations of sampler size.

Note: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

HALEY & ALDRICH — TEST BORING REPORT

Boring No. HA07-2A

Project: Proposed College of Pharmacy and Campus Improvements Portland, Maine
Client: University of New England
Contractor: Maine Test Borings, Inc.

File No. 34718-000
Sheet No. 1 of 2
Start: 17 September 2007
Finish: 17 September 2007
Driller: B. Enos
H&A Rep.: E. Beirne
Elevation: 127.5+/-
Datum: NGVD 1929
Location: See Plan

	Casing	Sampler	Barrel
Type	NW	S	–
Inside Diameter (in.)	3.0	1 3/8	–
Hammer Weight (lb.)	300	140	-
Hammer Fall (in.)	16	30	-

Drilling Equipment and Procedures
Rig Make & Model: Mobile Drill B-47
Bit Type: Roller Bit
Drill Mud: None
Casing: NW Drive to 20.0 ft.
Hoist/Hammer: Winch/ Doughnut Hammer

Depth (ft.)	SPT[1]	Sample No. & Rec. (in.)	Sample Depth (ft.)	Well Diagram	Elev./Depth (ft.)	USCS Symbol	Visual-Manual Identification and Description (Density/consistency, color, GROUP NAME, max. particle size[2], structure, odor, moisture, optional descriptions, geologic interpretation)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Dilatancy	Toughness	Plasticity	Strength
0				NO WELL INSTALLED			See HA07-2 for 0-5 ft.. Fourth attempted location for 5-7 ft. sample										
5	24 44 55 54	S1 19	5.0 7.0			SW	Very dense, brown to white, well-graded SAND with gravel (SW), mps=1.75 in., no structure, no odor, dry to moist -GLACIAL OUTWASH DEPOSIT-	15	15	20	30	20					
10	42 53 62 66	S2 14	10.0 12.0			SW	Very dense, light brown, well-graded SAND (SW), mps=3/4 in., no structure, no odor, moist to wet -GLACIAL OUTWASH DEPOSIT-		5	25	35	30	5				
15	42 47 44 54	S3 15	15.0 17.0			SW-SM	Very dense, brown, well-graded SAND with silt and gravel (SW-SM), mps=2.0 in., no structure, no odor, wet -GLACIAL OUTWASH DEPOSIT-	15	10	20	25	20	10				
20	47 72 55 47	S4 15	20.0 22.0			SW-SM	Very dense, brown, well-graded SAND with silt (SW-SM), mps=1.0 in., no structure, no odor, wet		10	20	25	35	10				
25																	

Water Level Data

Date	Time	Elapsed Time (hr.)	Depth (ft.) to: Bottom of Casing	Bottom of Hole	Water
9/17/07	14:51	0.1	–	23.2	22.5

Sample Identification
O Open End Rod
T Thin Wall Tube
U Undisturbed Sample
S Split Spoon
G Geoprobe

Well Diagram
Riser Pipe
Screen
Filter Sand
Cuttings
Grout
Concrete
Bentonite Seal

Summary
Overburden (lin. ft.) 27
Rock Cored (lin. ft.) –
Samples 5S

Boring No. HA07-2A

Field Tests: Dilatancy: R-Rapid, S-Slow, N-None; Toughness: L-Low, M-Medium, H-High; Plasticity: N-Nonplastic, L-Low, M-Medium, H-High; Dry Strength: N-None, L-Low, M-Medium, H-High, V-Very High

[1]SPT = Sampler blows per 6 in. [2]Maximum particle size is determined by direct observation within the limitations of sampler size.

Note: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

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Depth (ft.)	SPT[1]	Sample No. & Rec. (in.)	Sample Depth (ft.)	Well Diagram	Elev./Depth (ft.)	USCS Symbol	Visual-Manual Identification and Description (Density/consistency, color, GROUP NAME, max. particle size[2], structure, odor, moisture, optional descriptions, geologic interpretation)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Test Dilatancy	Field Test Toughness	Field Test Plasticity	Field Test Strength
25	63 53 43 50	S5 12	25.0 27.0			SM	Very dense, gray-brown, silty SAND with gravel (SM), mps=2.0 in., no structure, no odor, wet -GLACIAL OUTWASH DEPOSIT-	20	15	10	20	20	15				
					27.0		-BOTTOM OF EXPLORATION AT 27.0 FT.-										

[1]SPT = Sampler blows per 6 in. [2]Maximum particle size is determined by direct observation within the limitations of sampler size.

NOTE: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

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HALEY & ALDRICH — TEST BORING REPORT

Boring No. HA07-3(OW)

Project	Proposed College of Pharmacy and Campus Improvements Portland, Maine
Client	University of New England
Contractor	Maine Test Borings, Inc.

File No. 34718-000
Sheet No. 1 of 2
Start 13 September 2007
Finish 13 September 2007
Driller M. Porter
H&A Rep. E. Beirne
Elevation 126.5+/-
Datum NGVD 1929
Location See Plan

	Casing	Sampler	Barrel	Drilling Equipment and Procedures
Type	NW	S	--	Rig Make & Model: Mobile B-53 Bombardier
Inside Diameter (in.)	3.0	1 3/8	--	Bit Type: Roller Bit; Drill Mud: None
Hammer Weight (lb.)	300	140	-	Casing: NW Drive to 30.0 ft.
Hammer Fall (in.)	16	30	-	Hoist/Hammer: Winch/ Safety Hammer

Depth (ft.)	SPT[1]	Sample No. & Rec. (in.)	Sample Depth (ft.)	Elev./Depth (ft.)	USCS Symbol	Visual-Manual Identification and Description (Density/consistency, color, GROUP NAME, max. particle size[2], structure, odor, moisture, optional descriptions, geologic interpretation)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Dilatancy	Toughness	Plasticity	Strength
0	2 3 3 5	S1 14	0.0 2.0	0.3	ML	Medium stiff, brown, SILT with sand (ML), mps=2 mm, no structure, no odor, moist, roots throughout -TOPSOIL-				5	20	75				
					SM	Loose, dark brown, silty SAND (SM), mps=3/4 in., no structure, no odor, moist			15	35	30	20				
				2.4		Note: Driller noted change in density at 2.4 ft.										
5	15 30 37 57	S2 16	5.0 7.0		SW	Very dense, brown, well-graded SAND (SW), mps=1/2 in., no structure, no odor, moist -GLACIAL OUTWASH DEPOSIT-		10	15	45	25	5				
10	23 45 46 43	S3 14	10.0 12.0		SW-SM	Very dense, gray-brown, well-graded SAND with silt (SW-SM), mps=1/4 in., no structure, no odor, moist -GLACIAL OUTWASH DEPOSIT-			20	45	25	10				
15	19 27 41 78	S4 15	15.0 17.0		SW-SM	Very dense, gray-brown, well-graded SAND with silt and gravel (SW-SM), mps=1.0 in., no structure no odor, moist	5	10	25	35	15	10				
20	28 28 36 45	S5 12	20.0 22.0		SW	Very dense, gray-brown, well-graded SAND with gravel (SW), mps=2 in., no structure, no odor, moist	20	15	20	30	10	5				
25																

Water Level Data

Date	Time	Elapsed Time (hr.)	Depth (ft.) to: Bottom of Casing	Bottom of Hole	Water
9/13/07	17:34	0.25	30	29.3	23.2
9/13/07	06:15	11.25	30	28.5	23.3

Sample Identification
O Open End Rod
T Thin Wall Tube
U Undisturbed Sample
S Split Spoon
G Geoprobe

Well Diagram
Riser Pipe
Screen
Filter Sand
Cuttings
Grout
Concrete
Bentonite Seal

Summary
Overburden (lin. ft.) 32
Rock Cored (lin. ft.) --
Samples 7S

Boring No. HA07-3(OW)

Field Tests: Dilatancy: R-Rapid, S-Slow, N-None; Plasticity: N-Nonplastic, L-Low, M-Medium, H-High
Toughness: L-Low, M-Medium, H-High; Dry Strength: N-None, L-Low, M-Medium, H-High, V-Very High

[1]SPT = Sampler blows per 6 in. [2]Maximum particle size is determined by direct observation within the limitations of sampler size.

Note: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

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HALEY & ALDRICH

TEST BORING REPORT

Boring No. HA07-3(OW)
File No. 34718-000
Sheet No. 2 of 2

Depth (ft.)	SPT[1]	Sample No. & Rec. (in.)	Sample Depth (ft.)	Well Diagram	Elev./Depth (ft.)	USCS Symbol	Visual-Manual Identification and Description (Density/consistency, color, GROUP NAME, max. particle size[2], structure, odor, moisture, optional descriptions, geologic interpretation)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Test Dilatancy	Field Test Toughness	Field Test Plasticity	Field Test Strength
25	19 22 15 16	S6 10	25.0 27.0			SW	Very dense, gray-brown, well graded SAND (SW), mps=3/4 in., no structure, no odor, moist to wet, finer with depth -GLACIAL OUTWASH DEPOSIT-		10	25	35	25	5				
30	9 13 19 23	S7 13	30.0 32.0			SW	Medium dense, gray-brown, well-graded SAND (SW), mps=1/2 in., no structure, no odor, wet -GLACIAL OUTWASH DEPOSIT-		10	30	45	15					
					32.0		-BOTTOM OF EXPLORATION AT 32.0 FT.-										

[1]SPT = Sampler blows per 6 in. [2]Maximum particle size is determined by direct observation within the limitations of sampler size.

NOTE: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

HALEY & ALDRICH — TEST BORING REPORT

Boring No. HA07-4

Project	Proposed College of Pharmacy and Campus Improvements Portland, Maine
Client	University of New England
Contractor	Maine Test Borings, Inc.

File No. 34718-000
Sheet No. 1 of 2
Start 13 September 2007
Finish 13 September 2007
Driller M. Porter
H&A Rep. E. Beirne
Elevation 127.5+/-
Datum NGVD 1929
Location See Plan

	Casing	Sampler	Barrel	Drilling Equipment and Procedures
Type	NW	S	–	Rig Make & Model: Mobile B-53 Bombardier
Inside Diameter (in.)	3.0	1 3/8	–	Bit Type: Roller Bit; Drill Mud: None
Hammer Weight (lb.)	300	140	-	Casing: NW Drive to 35.0 ft.
Hammer Fall (in.)	16	30	-	Hoist/Hammer: Winch/ Safety Hammer

Depth (ft.)	SPT[1]	Sample No. & Rec. (in.)	Sample Depth (ft.)	Well Diagram	Elev./Depth (ft.)	USCS Symbol	Visual-Manual Identification and Description (Density/consistency, color, GROUP NAME, max. particle size[2], structure, odor, moisture, optional descriptions, geologic interpretation)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Dilatancy	Toughness	Plasticity	Strength
0	6 10 7 5	S1 15	0.0 2.0	NO WELL INSTALLED		SP	Medium dense, dark brown, poorly-graded SAND (SP), mps=4mm, no			5	25	65	5				
					0.6	SM	structure, slight organic odor, moist, organics throughout -TOPSOIL-										
							Medium dense, brown, silty SAND (SM), mps=1/2 in., no structure, no odor		5	10	20	50	15				
					2.4		Gravel layer (driller noted)										
					3.5												
5	25 20 25 40	S2 15	5.0 7.0			SP	Dense, light brown, poorly-graded SAND (SP), mps=4 mm, no structure, no odor, dry to moist -GLACIAL MARINE DEPOSIT-			10	15	75					
					6.5		Driller noted change in density at 6.5 ft.										
10	54 112	S3 6	10.0 11.0			SP	Very dense, light brown, poorly-graded SAND (SP), mps=2 mm, no structure, no odor, moist, much coarser for last 2 in. -GLACIAL MARINE DEPOSIT-			5	30	60	5				
15	30 43 62 87	S4 15	15.0 17.0			SP	Very dense, light brown, poorly-graded SAND (SP), mps=4 mm, no structure, no odor, moist -GLACIAL MARINE DEPOSIT-			15	40	40	5				
20	27 29 53 66	S5 11	20.0 22.0			SP	Very dense, light brown, poorly-graded SAND (SP), mps=4 mm, no structure, no odor, moist -GLACIAL MARINE DEPOSIT-			15	40	40	5				
25																	

Water Level Data

Date	Time	Elapsed Time (hr.)	Depth (ft.) to: Bottom of Casing	Bottom of Hole	Water
9/13/07	12:25	0.25	–	21.4	20.6

Sample Identification
O Open End Rod
T Thin Wall Tube
U Undisturbed Sample
S Split Spoon
G Geoprobe

Well Diagram
Riser Pipe
Screen
Filter Sand
Cuttings
Grout
Concrete
Bentonite Seal

Summary
Overburden (lin. ft.) 37
Rock Cored (lin. ft.) –
Samples 8S

Boring No. HA07-4

Field Tests: Dilatancy: R-Rapid, S-Slow, N-None; Plasticity: N-Nonplastic, L-Low, M-Medium, H-High; Toughness: L-Low, M-Medium, H-High; Dry Strength: N-None, L-Low, M-Medium, H-High, V-Very High

[1]SPT = Sampler blows per 6 in. [2]Maximum particle size is determined by direct observation within the limitations of sampler size.

Note: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

HALEY & ALDRICH	TEST BORING REPORT	Boring No. HA07-4 File No. 34718-000 Sheet No. 2 of 2

Depth (ft.)	SPT[1]	Sample No. & Rec. (in.)	Sample Depth (ft.)	Well Diagram	Elev./Depth (ft.)	USCS Symbol	Visual-Manual Identification and Description (Density/consistency, color, GROUP NAME, max. particle size[2], structure, odor, moisture, optional descriptions, geologic interpretation)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Test Dilatancy	Field Test Toughness	Field Test Plasticity	Field Test Strength
25	6 16 19 23	S6 13	25.0 27.0			SM	Dense, olive-brown, silty SAND (SM), mps=2 mm, no structure, no odor, moist			15	55	30					
					25.3	SP	Dense, light brown, poorly-graded SAND (SP), mps=4mm, no structure, no odor, moist to wet, finer with depth, oxidized iron layer from 25.9-26.1 ft.		10	25	60	5					
30	3 10 11 13	S7 NR	30.0 32.0			SW	Medium dense, brown, well-graded SAND (SW), mps=4mm, no structure, no odor, mottled, wet -GLACIAL MARINE DEPOSIT-			10	40	45	5				
35	15 23 39 109	S8 14	35.0 37.0			SW	Very dense, gray-brown, well-graded SAND with gravel (SW), mps=1.5 in., no structure, no odor wet	15	20	15	30	20	0				
					35.3	SW	Very dense, brown, well-graded SAND with gravel (SW), mps=1.5 in., bonded, no odor, moist to wet -GLACIAL TILL-	10	10	10	35	30	5				
					37.1		Refusal on Probable Bedrock Advanced roller cone to 37.1 ft. -BOTTOM OF EXPLORATION AT 37.1 FT.-										

[1]SPT = Sampler blows per 6 in. [2]Maximum particle size is determined by direct observation within the limitations of sampler size.

NOTE: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

Boring No. HA07-4

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HALEY & ALDRICH — TEST BORING REPORT

Boring No. HA07-5(OW)

Project: Proposed College of Pharmacy and Campus Improvements Portland, Maine
Client: University of New England
Contractor: Maine Test Borings, Inc.

File No. 34718-000
Sheet No. 1 of 1
Start: 17 September 2007
Finish: 18 September 2007
Driller: B. Enos
H&A Rep.: E. Beirne
Elevation: 125.0+/-
Datum: NGVD 1929
Location: See Plan

	Casing	Sampler	Barrel	Drilling Equipment and Procedures
Type	HW	S	--	Rig Make & Model: Mobile Drill B-47
Inside Diameter (in.)	4.0	1 3/8	--	Bit Type: Roller Bit Drill Mud: None
Hammer Weight (lb.)	300	140	-	Casing: HW Driven to 20.0 ft.
Hammer Fall (in.)	16	30	-	Hoist/Hammer: Winch/ Doughnut Hammer

Depth (ft.)	SPT[1]	Sample No. & Rec. (in.)	Sample Depth (ft.)	Well Diagram	Elev./Depth (ft.)	USCS Symbol	Visual-Manual Identification and Description (Density/consistency, color, GROUP NAME, max. particle size[2], structure, odor, moisture, optional descriptions, geologic interpretation)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Dilatancy	Toughness	Plasticity	Strength
0	4 4 7 5	S1 10	0.0 2.0			ML	Stiff, brown, sandy SILT (ML), mps=2 mm, no structure, organic odor, dry to moist				10	25	65				
					0.5	SP	-TOPSOIL-				25	70	5				
					1.2	SM	Medium dense, light brown, poorly-graded SAND (SP), mps=2 mm no structure, slight organic odor, dry to moist Medium dense, dark brown, silty SAND (SM), mps=2mm, no structure, organic odor, moist				5	70	25				
5	7 17 22 31	S2 14	5.0 7.0		5.0	SP	Dense, light brown, poorly-graded SAND (SP), mps=1 mm, no structure, no odor, moist					95	5				
	38 80 50/0.2	S3 11	8.0 9.7														
10						SP	Very dense, light brown, poorly-graded SAND (SP), mps=4 mm, no structure, no odor, moist -GLACIAL MARINE DEPOSIT-			10	15	70	5				
15	43 63 55/0.3	S4 12	15.0 16.3			SP	Very dense, light brown, poorly-graded SAND (SP), mps=1/2 in., no structure, no odor, moist		5	10	20	65					
					19.3	GP-GM	Very dense, brown, poorly-graded GRAVEL with sand and silt (GP-GM), mps=1/2 in., wet	15	40	20	10	5	10				
20	100/0.3	S5 3	20.0 20.3		20.3		-GLACIAL MARINE DEPOSIT- -BOTTOM OF EXPLORATION AT 20.3 FT.- Observation well installed in completed borehole. See Observation Well Installation Report for details.										

Water Level Data

Date	Time	Elapsed Time (hr.)	Depth (ft.) to: Bottom of Casing	Bottom of Hole	Water
9/18/07	6:10	12.0	15	17.0	14.5

Sample Identification
O Open End Rod
T Thin Wall Tube
U Undisturbed Sample
S Split Spoon
G Geoprobe

Well Diagram
Riser Pipe
Screen
Filter Sand
Cuttings
Grout
Concrete
Bentonite Seal

Summary
Overburden (lin. ft.) 20.3
Rock Cored (lin. ft.) –
Samples 5S

Boring No. HA07-5(OW)

Field Tests: Dilatancy: R-Rapid, S-Slow, N-None; Plasticity: N-Nonplastic, L-Low, M-Medium, H-High; Toughness: L-Low, M-Medium, H-High; Dry Strength: N-None, L-Low, M-Medium, H-High, V-Very High

[1]SPT = Sampler blows per 6 in. [2]Maximum particle size is determined by direct observation within the limitations of sampler size.

Note: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

HALEY & ALDRICH — TEST BORING REPORT

Boring No. HA07-6

Project	Proposed College of Pharmacy and Campus Improvements Portland, Maine
Client	University of New England
Contractor	Maine Test Borings, Inc.

File No.	34718-000
Sheet No.	1 of 1
Start	18 September 2007
Finish	18 September 2007
Driller	B. Enos
H&A Rep.	A. Blaisdell
Elevation	129.0+/-
Datum	NGVD 1929
Location	See Plan

	Casing	Sampler	Barrel	Drilling Equipment and Procedures
Type	--	S	--	Rig Make & Model: Mobile Drill B-47
Inside Diameter (in.)	--	2.5	--	Bit Type: Roller Bit; Drill Mud: None
Hammer Weight (lb.)	--	140	-	Casing: None
Hammer Fall (in.)	--	30	-	Hoist/Hammer: Winch/ Doughnut Hammer

Depth (ft.)	SPT[1]	Sample No. & Rec. (in.)	Sample Depth (ft.)	Well Diagram	Elev./Depth (ft.)	USCS Symbol	Visual-Manual Identification and Description (Density/consistency, color, GROUP NAME, max. particle size[2], structure, odor, moisture, optional descriptions, geologic interpretation)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Test Dilatancy	Toughness	Plasticity	Strength
0				NO WELL INSTALLED			-BITUMINOUS CONCRETE-										
	50 70 76 81	S1 18	0.0 2.4		0.3	SW-SM	Dense, dark brown, well-graded SAND with silt and gravel (SW-SM), mps=1 in., moist	5	20	30	20	10	15				
					1.2	SP	-FILL- (Existing Subbase)										
	57 80 110 50/0.3	S2 24	2.4 4.2			SP	Dense, light brown, poorly graded SAND (SP), mps=1/4 in., no structure, moist -GLACIAL OUTWASH DEPOSIT-		10	15	50	20	5				
					5.0		-BOTTOM OF EXPLORATION AT 4.2 FT.-										

Water Level Data

Date	Time	Elapsed Time (hr.)	Depth (ft.) to: Bottom of Casing	Bottom of Hole	Water

Sample Identification

- O Open End Rod
- T Thin Wall Tube
- U Undisturbed Sample
- S Split Spoon
- G Geoprobe

Well Diagram

- Riser Pipe
- Screen
- Filter Sand
- Cuttings
- Grout
- Concrete
- Bentonite Seal

Summary

- Overburden (lin. ft.) 4.2
- Rock Cored (lin. ft.) --
- Samples 2S

Boring No. HA07-6

Field Tests: Dilatancy: R-Rapid, S-Slow, N-None — Plasticity: N-Nonplastic, L-Low, M-Medium, H-High
Toughness: L-Low, M-Medium, H-High — Dry Strength: N-None, L-Low, M-Medium, H-High, V-Very High

[1]SPT = Sampler blows per 6 in. [2]Maximum particle size is determined by direct observation within the limitations of sampler size.

Note: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

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HALEY & ALDRICH — TEST BORING REPORT

Boring No. HA07-7

Project: Proposed College of Pharmacy and Campus Improvements Portland, Maine
Client: University of New England
Contractor: Maine Test Borings, Inc.

File No. 34718-000
Sheet No. 1 of 1
Start: 18 September 2007
Finish: 18 September 2007
Driller: B. Enos
H&A Rep.: M. Snow
Elevation: 118.0+/-
Datum: NGVD 1929
Location: See Plan

	Casing	Sampler	Barrel
Type	HSA	S	--
Inside Diameter (in.)	2.5	1 3/8	--
Hammer Weight (lb.)	--	140	-
Hammer Fall (in.)	--	30	-

Drilling Equipment and Procedures
Rig Make & Model: Mobile Drill B-47
Bit Type: Roller Bit
Drill Mud: None
Casing: HSA
Hoist/Hammer: Winch/ Doughnut Hammer

Depth (ft.)	SPT[1]	Sample No. & Rec. (in.)	Sample Depth (ft.)	Well Diagram	Elev./Depth (ft.)	USCS Symbol	Visual-Manual Identification and Description (Density/consistency, color, GROUP NAME, max. particle size[2], structure, odor, moisture, optional descriptions, geologic interpretation)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Test Dilatancy	Field Test Toughness	Field Test Plasticity	Field Test Strength
0	5 8 12 11	S1 7	0.0 2.0	NO WELL INSTALLED		SW	Medium dense, dark brown, well-graded SAND with gravel (SW), mps=1.0 in., dry -FILL-	5	10	20	40	25					
	12 8 4 4	S2 10	2.0 4.0			SM	Medium dense, dark brown, silty SAND (SM), mps=1/2 in., dry		5	10	30	40	15				
5	4 3 3 4	S3 3	4.0 6.0			SM	Loose, dark brown, silty SAND (SM) 1-in. piece clayey SILT (ML), mps=1.0 in., damp to dry		5	10	30	40	15				
	3 3 15 17	S4 12	6.0 8.0		6.0	SP	30% coal slag and ash. Medium dense, with dark brown, poorly-graded SAND (SP) mps=1/2 in., damp -COAL SLAG- -FILL-		5	15	30	30	20				
	12 12 13 14	S5 6	8.0 10.0			SP	(cave-in from above) 25% coal slag, little ash. Medium dense, dark brown, poorly-graded SAND (SP), mps=1/2 in., damp -COAL SLAG- -FILL-		5	15	30	35	15				
10	10 5 6 7	S6 12	10.0 12.0			SP	75% coal slag with ash and coal pieces. Medium dense, dark brown, poorly-graded SAND, mps=1.0 in., moist		5	15	25	40	15				
	3 1 2 5	S7 8	12.0 14.0		11.9	SP	Loose, dark brown to brown, poorly-graded SAND with silt and gravel (SP). mps=1.0 in., moist -FILL-		15	5	25	35	20				
15	8 5 5 3	S8 12	14.0 16.0		14.2	SP	Light brown to brown, poorly-graded SAND (SP), mps=3.0 mm, moist -GLACIAL OUTWASH DEPOSIT-			15	40	40	5				
					16.0		-BOTTOM OF EXPLORATION AT16.0 FT.-										

Water Level Data

Date	Time	Elapsed Time (hr.)	Depth (ft.) to: Bottom of Casing	Depth (ft.) to: Bottom of Hole	Water

Sample Identification
O Open End Rod
T Thin Wall Tube
U Undisturbed Sample
S Split Spoon
G Geoprobe

Well Diagram
Riser Pipe
Screen
Filter Sand
Cuttings
Grout
Concrete
Bentonite Seal

Summary
Overburden (lin. ft.) 16
Rock Cored (lin. ft.) --
Samples 8S

Boring No. HA07-7

Field Tests: Dilatancy: R-Rapid, S-Slow, N-None; Plasticity: N-Nonplastic, L-Low, M-Medium, H-High; Toughness: L-Low, M-Medium, H-High; Dry Strength: N-None, L-Low, M-Medium, H-High, V-Very High

[1] SPT = Sampler blows per 6 in. [2] Maximum particle size is determined by direct observation within the limitations of sampler size.

Note: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

HALEY & ALDRICH — TEST BORING REPORT

Boring No. HA07-8

Project: Proposed College of Pharmacy and Campus Improvements Portland, Maine
Client: University of New England
Contractor: Maine Test Borings, Inc.

File No. 34718-000
Sheet No. 1 of 1
Start: 18 September 2007
Finish: 18 September 2007
Driller: B. Enos
H&A Rep.: M. Snow
Elevation: 111.0+/-
Datum: NGVD 1929
Location: See Plan

	Casing	Sampler	Barrel
Type	HSA	S	--
Inside Diameter (in.)	2.5	1 3/8	--
Hammer Weight (lb.)	--	140	-
Hammer Fall (in.)	--	30	-

Drilling Equipment and Procedures
Rig Make & Model: Mobile Drill B-47
Bit Type: Roller Bit
Drill Mud: None
Casing: HSA
Hoist/Hammer: Winch/ Doughnut Hammer

Depth (ft.)	SPT[1]	Sample No. & Rec. (in.)	Sample Depth (ft.)	Well Diagram	Elev./Depth (ft.)	USCS Symbol	Visual-Manual Identification and Description (Density/consistency, color, GROUP NAME, max. particle size[2], structure, odor, moisture, optional descriptions, geologic interpretation)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Dilatancy	Toughness	Plasticity	Strength
0	8 16 25 14	S1 16	0.0 2.0	NO WELL INSTALLED		SP	50% coal slag, ash, coal pieces. Dense, brown to dark brown, poorly-graded SAND (SP), mps=1.0 in., damp		20	10	25	35	10				
	6 5 13 20	S2A 14	2.0 3.6			SP	(S2A) 35% coal slag. Medium dense, dark brown, poorly-graded SAND (SP), mps=4.75 mm, damp -FILL-			10	40	40	10				
		S2B	3.6 4.0		3.6	SP	Medium dense, light brown to brown, poorly- graded SAND (SP), mps=4.75 mm, dry -GLACIAL OUTWASH DEPOSIT-			20	20	55	5				
5	10 14 24 20	S3 16	4.0 6.0			SP	Dense, light brown, poorly-graded SAND (SP), mps=3/4 in., dry		5	20	30	40	5				
					6.0		-BOTTOM OF EXPLORATION AT 6.0 FT.-										

Water Level Data

Date	Time	Elapsed Time (hr.)	Depth (ft.) to: Bottom of Casing	Bottom of Hole	Water

Sample Identification
O Open End Rod
T Thin Wall Tube
U Undisturbed Sample
S Split Spoon
G Geoprobe

Well Diagram
Riser Pipe
Screen
Filter Sand
Cuttings
Grout
Concrete
Bentonite Seal

Summary
Overburden (lin. ft.) 6
Rock Cored (lin. ft.) --
Samples 3S

Boring No. HA07-8

Field Tests: Dilatancy: R-Rapid, S-Slow, N-None; Toughness: L-Low, M-Medium, H-High; Plasticity: N-Nonplastic, L-Low, M-Medium, H-High; Dry Strength: N-None, L-Low, M-Medium, H-High, V-Very High

[1]SPT = Sampler blows per 6 in. [2]Maximum particle size is determined by direct observation within the limitations of sampler size.

Note: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

HALEY & ALDRICH

TEST BORING REPORT

Boring No. HA07-9

Project: Proposed College of Pharmacy and Campus Improvements Portland, Maine
Client: University of New England
Contractor: Maine Test Borings, Inc.

File No. 34718-000
Sheet No. 1 of 1
Start: 18 September 2007
Finish: 18 September 2007
Driller: B. Enos
H&A Rep.: M. Snow
Elevation: 105.0+/-
Datum: NGVD 1929
Location: See Plan

	Casing	Sampler	Barrel	Drilling Equipment and Procedures
Type	HSA	S	--	Rig Make & Model: Mobile Drill B-47
Inside Diameter (in.)	2.5	1 3/8	--	Bit Type: Roller Bit; Drill Mud: None
Hammer Weight (lb.)	--	140	-	Casing: HSA
Hammer Fall (in.)	--	30	-	Hoist/Hammer: Winch/ Doughnut Hammer

Depth (ft.)	SPT[1]	Sample No. & Rec. (in.)	Sample Depth (ft.)	Well Diagram	Elev./Depth (ft.)	USCS Symbol	Visual-Manual Identification and Description (Density/consistency, color, GROUP NAME, max. particle size[2], structure, odor, moisture, optional descriptions, geologic interpretation)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Dilatancy	Toughness	Plasticity	Strength
0	7 21 36 47	S1 14	0.0 2.0	NO WELL INSTALLED		SW	Very dense, brown, well-graded SAND (SW), mps=1.0 in., moist 1/2-in. asphalt layer -FILL-		10	25	30	25	10				
	8 6 5 4	S2 14	2.0 4.0		2.0	SP	Medium dense, brown, poorly-graded SAND (SP), mps=4.75 mm, moist -GLACIAL OUTWASH DEPOSIT-			15	40	40	5				
					4.0		-BOTTOM OF EXPLORATION AT 4.0 FT.-										

Water Level Data

Date	Time	Elapsed Time (hr.)	Depth (ft.) to: Bottom of Casing	Bottom of Hole	Water

Sample Identification
O Open End Rod
T Thin Wall Tube
U Undisturbed Sample
S Split Spoon
G Geoprobe

Well Diagram
Riser Pipe
Screen
Filter Sand
Cuttings
Grout
Concrete
Bentonite Seal

Summary
Overburden (lin. ft.) 4
Rock Cored (lin. ft.) --
Samples 2S

Boring No. HA07-9

Field Tests: Dilatancy: R-Rapid, S-Slow, N-None; Toughness: L-Low, M-Medium, H-High; Plasticity: N-Nonplastic, L-Low, M-Medium, H-High; Dry Strength: N-None, L-Low, M-Medium, H-High, V-Very High

[1]SPT = Sampler blows per 6 in. [2]Maximum particle size is determined by direct observation within the limitations of sampler size.

Note: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

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HALEY& ALDRICH

TEST BORING REPORT

Boring No. HA07-10

Project: Proposed College of Pharmacy and Campus Improvements Portland, Maine
Client: University of New England
Contractor: Maine Test Borings, Inc.

File No. 34718-000
Sheet No. 1 of 1
Start: 18 September 2007
Finish: 18 September 2007
Driller: B. Enos
H&A Rep.: M. Snow
Elevation: 98.0+/-
Datum: NGVD 1929
Location: See Plan

	Casing	Sampler	Barrel	Drilling Equipment and Procedures
Type	HSA	S	--	Rig Make & Model: Mobile Drill B-47
Inside Diameter (in.)	2.5	1 3/8	--	Bit Type: Roller Bit; Drill Mud: None
Hammer Weight (lb.)	--	140	-	Casing: HSA
Hammer Fall (in.)	--	30	-	Hoist/Hammer: Winch/ Doughnut Hammer

Depth (ft.)	SPT[1]	Sample No. & Rec. (in.)	Sample Depth (ft.)	Well Diagram	Elev./Depth (ft.)	USCS Symbol	Visual-Manual Identification and Description (Density/consistency, color, GROUP NAME, max. particle size[2], structure, odor, moisture, optional descriptions, geologic interpretation)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Test Dilatancy	Toughness	Plasticity	Strength
0	5 6 5 7	S1 14	0.0 2.0	NO WELL INSTALLED		SM	Medium dense, brown, silty SAND (SM), mps=1.0 in., wet -FILL-		5	15	30	30	20				
	10 27 20 26	S2 14	2.0 4.0		1.8	SM-ML	Dense, brown-gray, silty SAND to sandy SILT (SM-ML), mottled, wet, mps=0.43 mm -GLACIAL MARINE DEPOSIT-					50	50				
5	4 11 14 14	S3 14	4.0 6.0		3.6	SW-SM	Dense, brown-gray, well-graded SAND with silt and gravel (SW-SM), mps=1.0 in., wet -GLACIAL TILL-		15	20	20	20	25				
						SW-SM	Medium dense, brown-gray, well-graded SAND with silt (SW-SM), mps=1.0 in., wet		10	25	25	20	20				
					6.0		-BOTTOM OF EXPLORATION AT 6.0 FT.-										

Water Level Data

Date	Time	Elapsed Time (hr.)	Depth (ft.) to: Bottom of Casing	Bottom of Hole	Water
9/18/07	12:00				2.8

Sample Identification
O Open End Rod
T Thin Wall Tube
U Undisturbed Sample
S Split Spoon
G Geoprobe

Well Diagram
Riser Pipe
Screen
Filter Sand
Cuttings
Grout
Concrete
Bentonite Seal

Summary
Overburden (lin. ft.) 6
Rock Cored (lin. ft.) --
Samples 3S

Boring No. HA07-10

Field Tests: Dilatancy: R-Rapid, S-Slow, N-None; Toughness: L-Low, M-Medium, H-High; Plasticity: N-Nonplastic, L-Low, M-Medium, H-High; Dry Strength: N-None, L-Low, M-Medium, H-High, V-Very High

[1]SPT = Sampler blows per 6 in. [2]Maximum particle size is determined by direct observation within the limitations of sampler size.

Note: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

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HALEY & ALDRICH — TEST BORING REPORT

Boring No. HA07-11

Project: Proposed College of Pharmacy and Campus Improvements Portland, Maine
Client: University of New England
Contractor: Maine Test Borings, Inc.

File No. 34718-000
Sheet No. 1 of 1
Start: 18 September 2007
Finish: 18 September 2007
Driller: B. Enos
H&A Rep.: M. Snow
Elevation: 98.0+/-
Datum: NGVD 1929
Location: See Plan

	Casing	Sampler	Barrel	Drilling Equipment and Procedures
Type	HSA	S	–	Rig Make & Model: Mobile Drill B-47
Inside Diameter (in.)	2.5	1 3/8	–	Bit Type: Roller Bit; Drill Mud: None
Hammer Weight (lb.)	--	140	-	Casing: HSA
Hammer Fall (in.)	--	30	-	Hoist/Hammer: Winch/ Doughnut Hammer

Depth (ft.)	SPT[1]	Sample No. & Rec. (in.)	Sample Depth (ft.)	Well Diagram	Elev./Depth (ft.)	USCS Symbol	Visual-Manual Identification and Description (Density/consistency, color, GROUP NAME, max. particle size[2], structure, odor, moisture, optional descriptions, geologic interpretation)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Dilatancy	Toughness	Plasticity	Strength
0	5 7 13 11	S1 18	0.0 2.0	NO WELL INSTALLED	0.2	SM-ML	Roadway SAND				10	45	45				
							Medium dense, dark brown, sandy SILT (SM-ML) to silty SAND, mps=0.42 mm, wet -TOPSOIL-					70	30				
	16 21 27 37	S2 12	2.0 4.0		1.2	SP	Medium dense, brown, silty SAND (SM), mps=0.42 mm, wet -GLACIAL MARINE DEPOSIT- Dense, brown, poorly-graded SAND (SP), mps=1.0 in., wet		5	10	25	50	10				
5	13 15 18 17	S3 17	4.0 6.0			SP-SM	Dense, brown, poorly-graded SAND with silt (SP-SM) with occasional gray lean clay layers (1/2 in.), mps=0.42 mm, wet -GLACIAL MARINE DEPOSIT-				35	55	10				
	8 11 20 23	S4	6.0 8.0			SP-SM	Dense, brown, poorly-graded SAND with silt (SP-SM) with occasional sandy silt lenses, mps=0.42 mm, wet				35	55	10				
					7.7	SW	Dense, brown, well-graded SAND (SW), mps=4.75 mm, wet -GLACIAL MARINE DEPOSIT-			25	35	35	5				
					8.0		-BOTTOM OF EXPLORATION AT 8.0 FT.-										

Water Level Data

Date	Time	Elapsed Time (hr.)	Depth (ft.) to: Bottom of Casing	Bottom of Hole	Water
9/18/07					2.9

Sample Identification
O Open End Rod
T Thin Wall Tube
U Undisturbed Sample
S Split Spoon
G Geoprobe

Well Diagram
Riser Pipe
Screen
Filter Sand
Cuttings
Grout
Concrete
Bentonite Seal

Summary
Overburden (lin. ft.) 8
Rock Cored (lin. ft.) --
Samples 4S

Boring No. HA07-11

Field Tests: Dilatancy: R-Rapid, S-Slow, N-None; Plasticity: N-Nonplastic, L-Low, M-Medium, H-High; Toughness: L-Low, M-Medium, H-High; Dry Strength: N-None, L-Low, M-Medium, H-High, V-Very High

[1] SPT = Sampler blows per 6 in. [2] Maximum particle size is determined by direct observation within the limitations of sampler size.

Note: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

HALEY & ALDRICH

TEST BORING REPORT

Boring No. HA07-12

Project	Proposed College of Pharmacy and Campus Improvements Portland, Maine
Client	University of New England
Contractor	Maine Test Borings, Inc.

File No.	34718-000
Sheet No.	1 of 1
Start	18 September 2007
Finish	18 September 2007
Driller	B. Enos
H&A Rep.	M. Snow
Elevation	97.0+/-
Datum	NGVD 1929
Location	See Plan

	Casing	Sampler	Barrel
Type	HSA	S	--
Inside Diameter (in.)	2.5	1 3/8	–
Hammer Weight (lb.)	–	140	-
Hammer Fall (in.)	–	30	-

Drilling Equipment and Procedures

- Rig Make & Model: Mobile Drill B-47
- Bit Type: Roller Bit
- Drill Mud: None
- Casing: HSA
- Hoist/Hammer: Winch/ Doughnut Hammer

Depth (ft.)	SPT[1]	Sample No. & Rec. (in.)	Sample Depth (ft.)	Well Diagram	Elev./Depth (ft.)	USCS Symbol	Visual-Manual Identification and Description (Density/consistency, color, GROUP NAME, max. particle size[2], structure, odor, moisture, optional descriptions, geologic interpretation)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Test Dilatancy	Toughness	Plasticity	Strength
0	4 10 11 9	S1 10	0.0 2.0	NO WELL INSTALLED	0.3	OL/ OH	Medium dense, brown, SAND with silt, mps=0.25 in., dry -TOPSOIL-				35	45	20				
						SW	Medium dense, brown, gravelly SAND (SW), mps=2.0 in., dry		20	30	25	20	5				
	5 4 2 3	S2 12	2.0 4.0			SP	Loose, brown, poorly-graded SAND (SP), mps=3/4 in., dry -FILL-		10	20	30	35	5				
5	2 2 1 3	S3 1	4.0 6.0		4.0	SM	Loose, brown, silty SAND (SM), mps=0.42 mm, moist -GLACIAL MARINE DEPOSIT-			10	40	35	15				
	9 11 6 3	S4 8	6.0 8.0			SM	Medium dense, brown, silty SAND (SM), mps=1.5 in., wet				40	40	20				
					8.0		-BOTTOM OF EXPLORATION AT 8.0 FT.-										

Water Level Data

Date	Time	Elapsed Time (hr.)	Depth (ft.) to: Bottom of Casing	Bottom of Hole	Water

Sample Identification

- O Open End Rod
- T Thin Wall Tube
- U Undisturbed Sample
- S Split Spoon
- G Geoprobe

Well Diagram

- Riser Pipe
- Screen
- Filter Sand
- Cuttings
- Grout
- Concrete
- Bentonite Seal

Summary

Overburden (lin. ft.)	8
Rock Cored (lin. ft.)	–
Samples	4S

Boring No. HA07-12

Field Tests: Dilatancy: R-Rapid, S-Slow, N-None Plasticity: N-Nonplastic, L-Low, M-Medium, H-High
Toughness: L-Low, M-Medium, H-High Dry Strength: N-None, L-Low, M-Medium, H-High, V-Very High

[1] SPT = Sampler blows per 6 in. [2] Maximum particle size is determined by direct observation within the limitations of sampler size.

Note: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

HALEY & ALDRICH

TEST BORING REPORT

Boring No. HA07-13(OW)

Project: Proposed College of Pharmacy and Campus Improvements Portland, Maine
Client: University of New England
Contractor: Maine Test Borings, Inc.

File No. 34718-000
Sheet No. 1 of 1
Start: 18 September 2007
Finish: 18 September 2007
Driller: B. Enos
H&A Rep.: M. Snow
Elevation: 94.0+/-
Datum: NGVD 1929
Location: See Plan

	Casing	Sampler	Barrel	Drilling Equipment and Procedures
Type	NW	S	--	Rig Make & Model: Mobile Drill B-47
Inside Diameter (in.)	3.0	1 3/8	--	Bit Type: Roller Bit; Drill Mud: None
Hammer Weight (lb.)	300	140	-	Casing: NW Drive to 17.0
Hammer Fall (in.)	30	30	-	Hoist/Hammer: Winch/ Doughnut Hammer

Depth (ft.)	SPT[1]	Sample No. & Rec. (in.)	Sample Depth (ft.)	Elev./Depth (ft.)	USCS Symbol	Visual-Manual Identification and Description (Density/consistency, color, GROUP NAME, max. particle size[2], structure, odor, moisture, optional descriptions, geologic interpretation)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Dilatancy	Toughness	Plasticity	Strength
0	5 9 14 14	S1 20	0.0 2.0		SM	Loose to medium, dense, dark brown, silty SAND (SM), mps=4.75			5	10	70	15				
				0.7	SP-SM	mm, no structure, organic odor, moist, rootlets throughout -TOPSOIL-			5	15	70	10				
					SP-SM	Medium dense, yellow brown, poorly graded SAND with silt (SP-SM), mps=4.75 mm, no structure, no odor, moist -FILL-			5	15	70	10				
	2 7 20 26	S2 12	3.0 5.0	3.0	OL/OH	Loose, yellow brown, poorly graded SAND with silt (SP-SM), mps=4.75 mm, no structure, no odor, moist -FILL-										
				3.1												
5	14 18 18 22	S3 16	5.0 7.0		SP-SM	Very soft, black, sandy ORGANIC SOIL (OL/OH), mps=2 mm, no structure, organic odor, moist -ORGANIC DEPOSIT-				5	85	10				
						Dense, tan, poorly-graded SAND with silt (SP-SM), mps=2 mm, no structure, no odor, moist				5	85	10				
						-GLACIAL MARINE DEPOSIT-				5	85	10				
				9.0	CL	Medium stiff, gray lean CLAY (CL), mps=0.42 mm, no odor, wet -GLACIAL MARINE DEPOSIT-					10	90				
10	1 2 2 3	S4 24	10.0 12.0		CL	Medium stiff, gray, sandy lean CLAY (CL), mps=0.42 mm, no odor, wet -GLACIAL MARINE DEPOSIT-					30	70				
				12.0												
15	5 8 9 14	S5 6	15.0 17.0		SP	Medium dense, gray, poorly-graded SAND (SP), mps=4.75 mm, no structure, no odor, wet -GLACIAL MARINE DEPOSIT-			15	70	10	5				
				17.0		-BOTTOM OF EXPLORATION AT 17.0 FT.-										
						NOTE: Observation well installed in completed borehole. See Well Installation Report for details.										

Water Level Data					
Date	Time	Elapsed Time (hr.)	Depth (ft.) to: Bottom of Casing	Bottom of Hole	Water

Sample Identification
O Open End Rod
T Thin Wall Tube
U Undisturbed Sample
S Split Spoon
G Geoprobe

Well Diagram
Riser Pipe
Screen
Filter Sand
Cuttings
Grout
Concrete
Bentonite Seal

Summary
Overburden (lin. ft.) 17
Rock Cored (lin. ft.) --
Samples 5S

Boring No. HA07-13(OW)

Field Tests: Dilatancy: R-Rapid, S-Slow, N-None; Plasticity: N-Nonplastic, L-Low, M-Medium, H-High; Toughness: L-Low, M-Medium, H-High; Dry Strength: N-None, L-Low, M-Medium, H-High, V-Very High

[1]SPT = Sampler blows per 6 in. [2]Maximum particle size is determined by direct observation within the limitations of sampler size.

Note: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

HALEY & ALDRICH

TEST BORING REPORT

Boring No. HA07-14

Project	Proposed College of Pharmacy and Campus Improvements Portland, Maine
Client	University of New England
Contractor	Maine Test Borings, Inc.

File No.	34718-000
Sheet No.	1 of 1
Start	18 September 2007
Finish	18 September 2007
Driller	B. Enos
H&A Rep.	B. Steinert
Elevation	96.0+/-
Datum	NGVD 1929
Location	See Plan

	Casing	Sampler	Barrel	Drilling Equipment and Procedures
Type	HSA	S	–	Rig Make & Model: Mobile Drill B-47
Inside Diameter (in.)	2.5	1 3/8	–	Bit Type: Roller Bit Drill Mud: None
Hammer Weight (lb.)	-	140	-	Casing: HSA
Hammer Fall (in.)	-	30	-	Hoist/Hammer: Winch/ Doughnut Hammer

Depth (ft.)	SPT[1]	Sample No. & Rec. (in.)	Sample Depth (ft.)	Well Diagram	Elev./Depth (ft.)	USCS Symbol	Visual-Manual Identification and Description (Density/consistency, color, GROUP NAME, max. particle size[2], structure, odor, moisture, optional descriptions, geologic interpretation)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Test Dilatancy	Field Test Toughness	Field Test Plasticity	Field Test Strength
0	4 9 18 19	S1 12	0.0 2.0	NO WELL INSTALLED	0.5	OL/OH	Medium dense; dark brown, silty SAND with organics(OL/OH), mps=0.075 mm, moist			.	10	65	25				
							-TOPSOIL-										
						SP	Medium dense, brown, poorly graded SAND (SP), mps=1/2 in., moist		5	15	35	40	5				
	17 17 18 21	S2 14	2.0 4.0			SP	Dense, brown, poorly-graded SAND with gravel (SP), mps=1.0 in., moist	5	15	10	25	35	5				
							-FILL-										
5	14 22 24 21	S3 16	4.0 6.0		4.8	SP-SM	Dense, brown, poorly-graded SAND with silt (SP-SM), mps=4.75 mm, wet			5	30	40	25				
					6.0	SP	Dense, brown, poorly-graded SAND (SP), occasional silt/clay bands, mps=1/2 in., wet		5	10	35	40	10				
							-GLACIAL MARINE DEPOSIT-										
							-BOTTOM OF EXPLORATION AT 6.0 FT.-										

Water Level Data

Date	Time	Elapsed Time (hr.)	Depth (ft.) to: Bottom of Casing	Bottom of Hole	Water
					4.4

Sample Identification

- O Open End Rod
- T Thin Wall Tube
- U Undisturbed Sample
- S Split Spoon
- G Geoprobe

Well Diagram

- Riser Pipe
- Screen
- Filter Sand
- Cuttings
- Grout
- Concrete
- Bentonite Seal

Summary

Overburden (lin. ft.)	6
Rock Cored (lin. ft.)	--
Samples	3S

Boring No. HA07-14

Field Tests: Dilatancy: R-Rapid, S-Slow, N-None Plasticity: N-Nonplastic, L-Low, M-Medium, H-High

Toughness: L-Low, M-Medium, H-High Dry Strength: N-None, L-Low, M-Medium, H-High, V-Very High

[1]SPT = Sampler blows per 6 in. [2]Maximum particle size is determined by direct observation within the limitations of sampler size.

Note: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

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HALEY & ALDRICH

TEST BORING REPORT

Boring No. HA07-15

Project: Proposed College of Pharmacy and Campus Improvements Portland, Maine
Client: University of New England
Contractor: Maine Test Borings, Inc.

File No. 34718-000
Sheet No. 1 of 1
Start: 18 September 2007
Finish: 18 September 2007
Driller: B. Enos
H&A Rep.: M. Snow
Elevation: 98.0+/-
Datum: NGVD 1929
Location: See Plan

	Casing	Sampler	Barrel	Drilling Equipment and Procedures
Type	HSA	S	--	Rig Make & Model: Mobile Drill B-47
Inside Diameter (in.)	2.5	1 3/8	--	Bit Type: Roller Bit; Drill Mud: None
Hammer Weight (lb.)	--	140	-	Casing: HSA
Hammer Fall (in.)	--	30	-	Hoist/Hammer: Winch/ Doughnut Hammer

Depth (ft.)	SPT[1]	Sample No. & Rec. (in.)	Sample Depth (ft.)	Well Diagram	Elev./Depth (ft.)	USCS Symbol	Visual-Manual Identification and Description (Density/consistency, color, GROUP NAME, max. particle size[2], structure, odor, moisture, optional descriptions, geologic interpretation)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Test Dilatancy	Field Test Toughness	Field Test Plasticity	Field Test Strength
0	4 10 11 14	S1 14	0.0 2.0	NO WELL INSTALLED	0.4	OL/OH	Medium dense, dark brown, silty SAND (OL/OH), mps=0.075 mm, moist -TOPSOIL-					75	25				
						SP	Medium dense, light brown, poorly-graded SAND (SP), mps=4.75 mm, dry			20	40	35	5				
	15 18 19 16	S2 14	2.0 4.0			SW	-FILL- Dense, light brown, well-graded SAND (SW), mps=1.5 in., dry		15	25	30	25	5				
5	6 7 14 14	S3 14	4.0 6.0		4.0	SM	Dense, brown, silty SAND with gravel (SM), mps=2.0 in., wet -GLACIAL MARINE DEPOSIT-	5	20	20	15	20	20				
					6.0		-BOTTOM OF EXPLORATION AT 6.0 FT.-										

Water Level Data

Date	Time	Elapsed Time (hr.)	Depth (ft.) to: Bottom of Casing	Bottom of Hole	Water
9/18/07	3:15	0	6.8	5.5	

Sample Identification
O Open End Rod
T Thin Wall Tube
U Undisturbed Sample
S Split Spoon
G Geoprobe

Well Diagram
Riser Pipe
Screen
Filter Sand
Cuttings
Grout
Concrete
Bentonite Seal

Summary
Overburden (lin. ft.) 6
Rock Cored (lin. ft.) --
Samples 3S

Boring No. HA07-15

Field Tests: Dilatancy: R-Rapid, S-Slow, N-None; Plasticity: N-Nonplastic, L-Low, M-Medium, H-High; Toughness: L-Low, M-Medium, H-High; Dry Strength: N-None, L-Low, M-Medium, H-High, V-Very High

[1]SPT = Sampler blows per 6 in. [2]Maximum particle size is determined by direct observation within the limitations of sampler size.

Note: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

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HALEY & ALDRICH

TEST BORING REPORT

Boring No. HA07-16

Project: Proposed College of Pharmacy and Campus Improvements Portland, Maine
Client: University of New England
Contractor: Maine Test Borings, Inc.

File No. 34718-000
Sheet No. 1 of 1
Start: 18 September 2007
Finish: 18 September 2007
Driller: B. Enos
H&A Rep.: M. Snow
Elevation: 95.0+/-
Datum: NGVD 1929
Location: See Plan

	Casing	Sampler	Barrel
Type	HSA	S	--
Inside Diameter (in.)	2.5	1 3/8	--
Hammer Weight (lb.)	--	140	-
Hammer Fall (in.)	--	30	-

Drilling Equipment and Procedures
Rig Make & Model: Mobile Drill B-47
Bit Type: Roller Bit
Drill Mud: None
Casing: HSA
Hoist/Hammer: Winch/ Doughnut Hammer

Depth (ft.)	SPT[1]	Sample No. & Rec. (in.)	Sample Depth (ft.)	Well Diagram	Elev./Depth (ft.)	USCS Symbol	Visual-Manual Identification and Description (Density/consistency, color, GROUP NAME, max. particle size[2], structure, odor, moisture, optional descriptions, geologic interpretation)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Test Dilatancy	Field Test Toughness	Field Test Plasticity	Field Test Strength
0	2 3 4 6	S1 14	0.0 2.0	NO WELL INSTALLED		OL/OH	Loose, brown SAND with silt (OH/OH) -TOPSOIL-				30	55	15				
					1.0	SP	Loose, brown to rust-brown, poorly-graded SAND (SP), mps=1/2 in., moist -FILL-			25	35	30	10				
	8 2 2 3	S2 10	2.0 4.0			SP	Loose, rust-brown, poorly-graded SAND (SP), mps=1/2 in., moist			25	35	30	10				
	2 8 14 14	S3 16	4.0 6.0		3.8	SM-ML	Dark brown, sandy SILT (ML) to silty SAND with organics (SM), mps=0.42 mm, wet -ORGANIC DEPOSIT-					50	50				
5					4.0	SW	Medium dense, gray, well-graded SAND (SW), mps=4.75 mm, wet -GLACIAL MARINE DEPOSIT-			35	30	30	5				
					6.0		-BOTTOM OF EXPLORATION AT 6.0 FT.-										

Water Level Data

Date	Time	Elapsed Time (hr.)	Depth (ft.) to: Bottom of Casing	Bottom of Hole	Water
9/18/07	1:15	0	--	6.0	4.8

Sample Identification
O Open End Rod
T Thin Wall Tube
U Undisturbed Sample
S Split Spoon
G Geoprobe

Well Diagram
Riser Pipe
Screen
Filter Sand
Cuttings
Grout
Concrete
Bentonite Seal

Summary
Overburden (lin. ft.) 6
Rock Cored (lin. ft.) --
Samples 3S

Boring No. HA07-16

Field Tests: Dilatancy: R-Rapid, S-Slow, N-None; Toughness: L-Low, M-Medium, H-High; Plasticity: N-Nonplastic, L-Low, M-Medium, H-High; Dry Strength: N-None, L-Low, M-Medium, H-High, V-Very High

[1]SPT = Sampler blows per 6 in. [2]Maximum particle size is determined by direct observation within the limitations of sampler size.

Note: Soil identification based on visual-manual methods of the USCS as practiced ...

HALEY & ALDRICH

TEST BORING REPORT

Boring No. HA07-17

Project	Proposed College of Pharmacy and Campus Improvements Portland, Maine
Client	University of New England
Contractor	Maine Test Borings, Inc.

File No.	34718-000
Sheet No.	1 of 1
Start	18 September 2007
Finish	18 September 2007
Driller	B. Enos
H&A Rep.	M. Snow
Elevation	95.0+/-
Datum	NGVD 1929
Location	See Plan

	Casing	Sampler	Barrel
Type	HSA	S	--
Inside Diameter (in.)	2.5	1 3/8	--
Hammer Weight (lb.)	--	140	-
Hammer Fall (in.)	--	30	-

Drilling Equipment and Procedures

Rig Make & Model: Mobile Drill B-47
Bit Type: Roller Bit
Drill Mud: None
Casing: HSA
Hoist/Hammer: Winch/ Doughnut Hammer

Depth (ft.)	SPT[1]	Sample No. & Rec. (in.)	Sample Depth (ft.)	Well Diagram	Elev./Depth (ft.)	USCS Symbol	Visual-Manual Identification and Description (Density/consistency, color, GROUP NAME, max. particle size[2], structure, odor, moisture, optional descriptions, geologic interpretation)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Test Dilatancy	Field Test Toughness	Field Test Plasticity	Field Test Strength
0	4 7 15 18	S1 6	0.0 2.0	NO WELL INSTALLED	0.5	SM	Medium dense, brown, poorly-graded SAND with silt (SM), mps=1.0 in., dry -TOPSOIL-		5	10	25	40	20				
	8 6 5 2	S2 12	2.0 4.0			SP	Medium dense, rust-brown, poorly-graded SAND (SP), mps=1.5 in., moist -FILL-			15	40	35	10				
					3.8	SP	Dark brown, silty SAND lense at 3.8 ft.				15	50	25				
5	2 2 2 4	S3 10	4.0 6.0			SP-SM	Gray, poorly-graded SAND with silt (SP-SM), mps=0.43 mm, wet										
					4.0	PT	Brown sandy PEAT (PT), wet -ORGANIC DEPOSIT-										
	1 1 WOH 2	S4 16	6.0 8.0		5.9	SM	Gray, medium to fine SAND layer 5.9-6.0 ft. Loose, gray, silty SAND (SM), mps=0.43 mm, wet				35	50	15				
	WOH 1 4 3	S5 18	8.0 10.0		7.0	CL	Soft to medium stiff, gray, lean CLAY (CL), with shells mps=0.075 mm, wet -GLACIAL MARINE DEPOSIT-						100				
10					10.0		Gray, silty fine SAND layer at 9.9 ft. -BOTTOM OF EXPLORATION AT 10.0 FT.-										

Water Level Data

Date	Time	Elapsed Time (hr.)	Depth (ft.) to: Bottom of Casing	Bottom of Hole	Water
9/18/07	2:55				6.0

Sample Identification

O Open End Rod
T Thin Wall Tube
U Undisturbed Sample
S Split Spoon
G Geoprobe

Well Diagram

Riser Pipe
Screen
Filter Sand
Cuttings
Grout
Concrete
Bentonite Seal

Summary

Overburden (lin. ft.) 10
Rock Cored (lin. ft.) --
Samples 5S

Boring No. HA07-17

Field Tests: Dilatancy: R-Rapid, S-Slow, N-None; Toughness: L-Low, M-Medium, H-High; Plasticity: N-Nonplastic, L-Low, M-Medium, H-High; Dry Strength: N-None, L-Low, M-Medium, H-High, V-Very High

[1] SPT = Sampler blows per 6 in. [2] Maximum particle size is determined by direct observation within the limitations of sampler size.

Note: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

HALEY & ALDRICH

TEST BORING REPORT

Boring No. HA07-18

Project	Proposed College of Pharmacy and Campus Improvements Portland, Maine
Client	University of New England
Contractor	Maine Test Borings, Inc.

File No.	34718-000
Sheet No.	1 of 2
Start	18 September 2007
Finish	18 September 2007
Driller	B. Enos
H&A Rep.	M. Snow
Elevation	95.0+/-
Datum	NGVD 1929
Location	See Plan

	Casing	Sampler	Barrel
Type	HSA	S	--
Inside Diameter (in.)	3.0	1 3/8	--
Hammer Weight (lb.)	--	140	-
Hammer Fall (in.)	--	30	-

Drilling Equipment and Procedures

- Rig Make & Model: Mobile Drill B-47
- Bit Type: Roller Bit
- Drill Mud: None
- Casing: HSA
- Hoist/Hammer: Winch/ Doughnut Hammer

Depth (ft.)	SPT[1]	Sample No. & Rec. (in.)	Sample Depth (ft.)	Well Diagram	Elev./Depth (ft.)	USCS Symbol	Visual-Manual Identification and Description (Density/consistency, color, GROUP NAME, max. particle size[2], structure, odor, moisture, optional descriptions, geologic interpretation)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Test Dilatancy	Field Test Toughness	Field Test Plasticity	Field Test Strength
0	5 6 8 6	S1 8	0.0 2.0	NO WELL INSTALLED	0.3	OL/OH	Medium dense, dark brown, sandy SILT (OL/OH) -TOPSOIL-										
						SP	Medium dense, brown, poorly-graded SAND (SP), mps=1.0 in., dry -FILL-		5	20	30	25	10				
	3 2 6 15	S2 10	2.0 4.0			SP	Loose, brown, poorly-graded SAND (SP), mps=1.0 in., wet		5	20	30	25	10				
					3.5	SM-ML	Dark brown, sandy SILT (SM-ML) layer with organics at 3.5-3.6 ft. -ORGANIC DEPOSIT-		5	25	25	30	15				
5	11 16 16 16	S3 14	4.0 6.0		3.6	SP	Medium dense, gray-brown, poorly-graded SAND (SP), mps=1.0 in., wet -GLACIAL MARINE DEPOSIT-				30	50	20				
						SP	Medium dense, brown, poorly-graded SAND (SP), mps=0.42 mm, wet										
10	1 1 8 10	S4 20	10.0 12.0		10.5	SC	Medium stiff, brown, sandy CLAY (SC), mps=0.75 mm, wet					35	65				
					11.5	SP	Medium dense, brown, poorly-graded SAND (SP), mps=1.0 in., wet -GLACIAL MARINE DEPOSIT-		5	20	35	30	10				
15	3 5 8 12	S5 6	15.0 17.0			SP	Medium dense, brown, poorly-graded SAND (SP), mps=0.43 mm, wet -GLACIAL MARINE DEPOSIT-			5	50	40	5				
20	12 13 15 13	S6 18	20.0 22.0			SP	Medium dense, brown, poorly-graded SAND (SP), occasional sandy SILT lenses (SM-ML), mps=1/2 in., wet			15	50	30	5				
25																	

Water Level Data

Date	Time	Elapsed Time (hr.)	Depth (ft.) to: Bottom of Casing	Bottom of Hole	Water

Sample Identification

- O Open End Rod
- T Thin Wall Tube
- U Undisturbed Sample
- S Split Spoon
- G Geoprobe

Well Diagram

- Riser Pipe
- Screen
- Filter Sand
- Cuttings
- Grout
- Concrete
- Bentonite Seal

Summary

- Overburden (lin. ft.) 32?
- Rock Cored (lin. ft.) --
- Samples 8S

Boring No. HA07-18

Field Tests: Dilatancy: R-Rapid, S-Slow, N-None; Toughness: L-Low, M-Medium, H-High; Plasticity: N-Nonplastic, L-Low, M-Medium, H-High; Dry Strength: N-None, L-Low, M-Medium, H-High, V-Very High

[1] SPT = Sampler blows per 6 in. [2] Maximum particle size is determined by direct observation within the limitations of sampler size.

Note: [illegible]

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TEST BORING REPORT

Depth (ft.)	SPT[1]	Sample No. & Rec. (in.)	Sample Depth (ft.)	Well Diagram	Elev./Depth (ft.)	USCS Symbol	Visual-Manual Identification and Description (Density/consistency, color, GROUP NAME, max. particle size[2], structure, odor, moisture, optional descriptions, geologic interpretation)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Test Dilatancy	Field Test Toughness	Field Test Plasticity	Field Test Strength
25	12 17 22 41	S7 12	25.0 27.0			SP	Dense, brown, poorly-graded SAND (SP), mps=1/2 in., wet			15	50	30	5				
30	7 11 19 28	S8 24	30.0 32.0			CL	Hard, gray sandy CLAY (CL) with sand layers			5	10	10	75				
							-GLACIAL MARINE DEPOSIT-										
					32.0		-BOTTOM OF EXPLORATION AT 32.0 FT.-										

[1]SPT = Sampler blows per 6 in. [2]Maximum particle size is determined by direct observation within the limitations of sampler size.

NOTE: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

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TEST BORING REPORT

Boring No. HA07-19

Project	Proposed College of Pharmacy and Campus Improvements Portland, Maine
Client	University of New England
Contractor	Maine Test Borings, Inc.

File No.	34718-000
Sheet No.	1 of 2
Start	3 October 2007
Finish	3 October 2007
Driller	M. Porter
H&A Rep.	E. Beirne
Elevation	126.5+/-
Datum	NGVD 1929
Location	See Plan

	Casing	Sampler	Barrel	Drilling Equipment and Procedures
Type	NW	S	-	Rig Make & Model: Mobile B-53 Bombardier
Inside Diameter (in.)	3.0	1 3/8	-	Bit Type: Roller Bit Drill Mud: None
Hammer Weight (lb.)	300	140	-	Casing: NW Driven to 20 ft.
Hammer Fall (in.)	16	30	-	Hoist/Hammer: Winch/ Doughnut Hammer

Depth (ft.)	SPT[1]	Sample No. & Rec. (in.)	Sample Depth (ft.)	Well Diagram	Elev./Depth (ft.)	USCS Symbol	Visual-Manual Identification and Description (Density/consistency, color, GROUP NAME, max. particle size[2], structure, odor, moisture, optional descriptions, geologic interpretation)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Test Dilatancy	Field Test Toughness	Field Test Plasticity	Field Test Strength
0				NO WELL INSTALLED			-BITUMINOUS CONCRETE-										
	5 6 5 9	S1 9	0.3 2.3		0.3	SW-SM	Medium dense, gray, well graded SAND with silt (SW-SM), mps = .25 in., no structure, no odor, moist -FILL-		5	5	35	45	10				
					1.2	GW-GM	Medium dense, black, well graded GRAVEL with silt and sand (GW-GM), mps = 2.0 in., no structure, no odor, moist -FILL-	25	25	5	15	20	10				
					1.9	SW	Medium dense, brown well graded SAND (SW), mps = .50 in., no structure, no odor, moist -GLACIAL OUTWASH DEPOSIT-		5	10	45	40					
5	7 12 23 32	S2 19	4.5 6.5		4.0	SP	Dense, light brown poorly graded SAND (SP), mps = .25 in., no structure, no odor, moist, zones of brown sand			5	35	60					
10	18 32 43 60	S3 19	9.5 11.5			SP	Very dense, light brown, poorly graded SAND (SP), mps = 4mm., no structure, no odor, moist -GLACIAL MARINE DEPOSIT-				30	70					
15	14 26 33 43	S4 16	15.0 17.0			SP	Very dense, light brown, poorly graded SAND (SP), occasional silt layers, mps = 4mm., no structure, no odor, moist -GLACIAL MARINE DEPOSIT-				45	50	5				
20	9 19 23 28	S5 15	20.0 22.0			SP	Dense, brown, poorly graded SAND (SP), mps = 2mm., no structure, no odor, wet -GLACIAL MARINE DEPOSIT-				25	70	5				
25																	

Water Level Data

Date	Time	Elapsed Time (hr.)	Depth (ft.) to: Bottom of Casing	Bottom of Hole	Water
10/03/07	11:47	0.1	20.0	25.3	14.0
10/03/07	11:58	0.2	-	25.3	18.0

Sample Identification

- O Open End Rod
- T Thin Wall Tube
- U Undisturbed Sample
- S Split Spoon
- G Geoprobe

Well Diagram

- Riser Pipe
- Screen
- Filter Sand
- Cuttings
- Grout
- Concrete
- Bentonite Seal

Summary

Overburden (lin. ft.)	25.3
Rock Cored (lin. ft.)	-
Samples	6S

Boring No. HA07-19

Field Tests: Dilatancy: R-Rapid, S-Slow, N-None Plasticity: N-Nonplastic, L-Low, M-Medium, H-High
Toughness: L-Low, M-Medium, H-High Dry Strength: N-None, L-Low, M-Medium, H-High, V-Very High

[1] SPT = Sampler blows per 6 in. [2] Maximum particle size is determined by direct observation within the limitations of sampler size.

Note: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich

TEST BORING REPORT

Depth (ft.)	SPT[1]	Sample No. & Rec. (in.)	Sample Depth (ft.)	Well Diagram	Elev./Depth (ft.)	USCS Symbol	Visual-Manual Identification and Description (Density/consistency, color, GROUP NAME, max. particle size[2], structure, odor, moisture, optional descriptions, geologic interpretation)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Test Dilatancy	Field Test Toughness	Field Test Plasticity	Field Test Strength
25	50/0.3	S6 2	25.0 25.3		24.7 25.3	SM	Note: Driller noted change in material at 24.7 ft. Very dense, gray-brown silty SAND (SM), mps = .50 in., bonded, no odor, moist -GLACIAL TILL- Split spoon refusal at 25.3 ft.				25	45	30				
							-BOTTOM OF EXPLORATION AT 25.3 FT.-										

[1]SPT = Sampler blows per 6 in. [2]Maximum particle size is determined by direct observation within the limitations of sampler size.

NOTE: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

HALEY & ALDRICH — TEST BORING REPORT

Boring No. HA07-20

Project	Proposed College of Pharmacy and Campus Improvements Portland, Maine
Client	University of New England
Contractor	Maine Test Borings, Inc.

File No.	34718-000
Sheet No.	1 of 2
Start	3 October 2007
Finish	3 October 2007
Driller	M. Porter
H&A Rep.	E. Beirne
Elevation	127.0+/-
Datum	NGVD 1929
Location	See Plan

	Casing	Sampler	Barrel
Type	NW	S	-
Inside Diameter (in.)	3.0	1 3/8	-
Hammer Weight (lb.)	300	140	-
Hammer Fall (in.)	16	30	-

Drilling Equipment and Procedures

- Rig Make & Model: Mobile B-53 Bombardier
- Bit Type: Roller Bit
- Drill Mud: None
- Casing: NW Driven to 20.0 ft.
- Hoist/Hammer: Winch/ Doughnut Hammer

Depth (ft.)	SPT[1]	Sample No. & Rec. (in.)	Sample Depth (ft.)	Well Diagram	Elev./Depth (ft.)	USCS Symbol	Visual-Manual Identification and Description (Density/consistency, color, GROUP NAME, max. particle size[2], structure, odor, moisture, optional descriptions, geologic interpretation)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Dilatancy	Toughness	Plasticity	Strength
0							-BITUMINOUS CONCRETE-										
	4 3 3 4	S1 23	0.4 2.4		0.4	SM	-SUBBASE- Loose, dark brown, silty SAND with gravel (SM), mps = .50 in., no structure, no odor, moist, organics throughout		15	10	25	30	20				
					0.6	SP	-FILL-				40	55	5				
					1.4		Loose, brown, poorly graded SAND (SP), mps = .25 in., no structure, no odor, moist, trace organics										
5	10 17 17 28	S2 19	4.5 6.5			SP	Dense, light brown, poorly graded SAND (SP), mps = 2mm., no structure, no odor, moist -GLACIAL OUTWASH DEPOSIT-				15	85					
10	27 45 46 80	S3 24	9.5 11.5	NO WELL INSTALLED		SP	Very dense, brown to gray-brown, poorly graded SAND (SP), mps = .25 in., no structure, no odor, moist			5	60	35					
15	26 49 85	S4 12	15.0 16.5			SW-SM	Very dense, brown well graded SAND with silt (SW-SM), mps = .50 in., no structure, no odor, wet -GLACIAL OUTWASH DEPOSIT-		10	10	40	30	10				
20	13 21 23 31	S5 12	20.0 22.0			SP	Dense, gray-brown, poorly graded SAND (SP), mps = 4mm., no structure, no odor, wet			5	55	40					
					22.6		Top of Bedrock at 22. 6 ft. Advanced roller bit to 22.7 ft. Begin NQ rock core at 22.7 ft. See Core Boring Report for bedrock details.										
25																	

Water Level Data

Date	Time	Elapsed Time (hr.)	Depth (ft.) to: Bottom of Casing	Bottom of Hole	Water

Sample Identification

- O Open End Rod
- T Thin Wall Tube
- U Undisturbed Sample
- S Split Spoon
- G Geoprobe

Well Diagram

- Riser Pipe
- Screen
- Filter Sand
- Cuttings
- Grout
- Concrete
- Bentonite Seal

Summary

Overburden (lin. ft.)	22.6
Rock Cored (lin. ft.)	4.5
Samples	5S, 1C

Boring No. HA07-20

Field Tests: Dilatancy: R-Rapid, S-Slow, N-None; Toughness: L-Low, M-Medium, H-High; Plasticity: N-Nonplastic, L-Low, M-Medium, H-High; Dry Strength: N-None, L-Low, M-Medium, H-High, V-Very High

[1]SPT = Sampler blows per 6 in. [2]Maximum particle size is determined by direct observation within the limitations of sampler size.

Note: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

Depth (ft)	Drilling Rate Min./ft	Run No.	Depth (ft)	Recovery/RQD in.	Recovery/RQD %	Weathering	Well Diagram	Elev./Depth (ft)	Visual Description and Remarks
									SEE TEST BORING REPORT FOR OVERBURDEN DETAILS
20									
									Top of Bedrock at 22.6 ft. Advanced roller bit to 22.7 ft.
		C1	22.7 27.3	50/35	93/64	Fr.-SL.	NO WELL INSTALLED	22.6	Begin NQ rock core at 22.7 ft. Very hard, fresh to slightly weathered, light gray fine grained to aphanitic SCHIST. Joints are high angle to horizontal, very close to moderately spaced, planar, stepped and undulating, rough, tight to open, some calcite infilling. Quartz, calcite veins throughout. Chlorite mineralization coincident with quartz-rich zones.
25									
								27.3	-BOTTOM OF EXPLORATION AT 27.3 FT.-

HALEY & ALDRICH

TEST BORING REPORT

Boring No. HA07-21(OW)

Project	Proposed College of Pharmacy and Campus Improvements Portland, Maine	File No.	34718-000
Client	University of New England	Sheet No.	1 of 2
Contractor	Maine Test Borings, Inc.	Start	2 October 2007
		Finish	3 October 2007
		Driller	M. Porter
		H&A Rep.	E. Beirne
		Elevation	126.5+/-
		Datum	NGVD 1929
		Location	See Plan

	Casing	Sampler	Barrel	Drilling Equipment and Procedures
Type	NW	S	-	Rig Make & Model: Mobile B-53 Bombardier
Inside Diameter (in.)	3.0	1 3/8	-	Bit Type: Roller Bit; Drill Mud: None
Hammer Weight (lb.)	300	140	-	Casing: NW Driven to 20.0 ft.
Hammer Fall (in.)	16	30	-	Hoist/Hammer: Winch/ Doughnut Hammer

Depth (ft.)	SPT[1]	Sample No. & Rec. (in.)	Sample Depth (ft.)	Well Diagram	Elev./Depth (ft.)	USCS Symbol	Visual-Manual Identification and Description (Density/consistency, color, GROUP NAME, max. particle size[2], structure, odor, moisture, optional descriptions, geologic interpretation)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Test Dilatancy	Toughness	Plasticity	Strength
0							-BITUMINOUS CONCRETE-										
	12 25 14 13	S1 17	0.3 2.3		0.3	SW-SM	Dense, dark brown to brown, well graded SAND with silt and gravel (SW-SM), mps = 2.0 in., no structure, no odor, dry to moist -FILL-	10	15	5	25	35	10				
					2.0	SW											
5	17 29 33 37	S2 20	4.5 6.5			SW	Very dense, brown to light brown, well graded SAND (SW), mps = 1.0 in., no structure, no odor, moist -GLACIAL OUTWASH DEPOSIT-		10	5	30	55					
					4.9	SP	Very dense, light brown, poorly graded SAND (SP), mps = 4mm., no structure, no odor, moist				25	75					
10	18 32 36 52	S3 24	9.5 11.5			SP	Very dense, light brown, poorly graded SAND (SP) with oxidized iron spots, mps = 4mm., no structure, no odor, moist -GLACIAL MARINE DEPOSIT-				25	75					
15	8 19 22 24	S4 14	15.0 17.0			SP	Dense, light brown, poorly graded SAND (SP), mps = 4mm., no structure, no odor, moist to wet, somewhat mottled. Silt and fine sand layer in tip -GLACIAL MARINE DEPOSIT-				55	45					
20	10 26 33 41	S5 13	20.0 22.0			SP	Very dense, gray-brown poorly graded SAND (SP), mps = 4 mm., no structure, no odor, wet				60	40					
					22.6	SW	Note: Driller detected gravel layer at 22.6ft. -PROBABLE GLACIAL TILL-										
					24.0		Bedrock encountered at 24.0 ft. Advanced roller bit to 24.2 ft.										

Water Level Data

Date	Time	Elapsed Time (hr.)	Depth (ft.) to: Bottom of Casing	Bottom of Hole	Water

Sample Identification

- O Open End Rod
- T Thin Wall Tube
- U Undisturbed Sample
- S Split Spoon
- G Geoprobe

Well Diagram

- Riser Pipe
- Screen
- Filter Sand
- Cuttings
- Grout
- Concrete
- Bentonite Seal

Summary

Overburden (lin. ft.) 24.0
Rock Cored (lin. ft.) -
Samples 5S

Boring No. HA07-21(OW)

Field Tests: Dilatancy: R-Rapid, S-Slow, N-None; Toughness: L-Low, M-Medium, H-High; Plasticity: N-Nonplastic, L-Low, M-Medium, H-High; Dry Strength: N-None, L-Low, M-Medium, H-High, V-Very High

[1] SPT = Sampler blows per 6 in. [2] Maximum particle size is determined by direct observation within the limitations of sampler size.

Note: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

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TEST BORING REPORT

Depth (ft.)	SPT[1]	Sample No. & Rec. (in.)	Sample Depth (ft.)	Well Diagram	Elev./Depth (ft.)	USCS Symbol	Visual-Manual Identification and Description (Density/consistency, color, GROUP NAME, max. particle size[2], structure, odor, moisture, optional descriptions, geologic interpretation)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Test Dilatancy	Field Test Toughness	Field Test Plasticity	Field Test Strength
					24.2		-BOTTOM OF EXPLORATION AT 24.2 FT.- Installed observation well. See Observation Well Report HA07-21(OW) for details.										

[1]SPT = Sampler blows per 6 in. [2]Maximum particle size is determined by direct observation within the limitations of sampler size.

NOTE: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

USCS_TB4 USCSLIB4.GLB USCSTB+CORE4.GDT G:\PROJECTS\34718\000\DRILLING\34718-000TB.GPJ 11 Oct 07

HALEY & ALDRICH — TEST BORING REPORT

Boring No. HA07-22

Project	Proposed College of Pharmacy and Campus Improvements Portland, Maine
Client	University of New England
Contractor	Maine Test Borings, Inc.

File No.	34718-000
Sheet No.	1 of 2
Start	2 October 2007
Finish	2 October 2007
Driller	M. Porter
H&A Rep.	E. Beirne
Elevation	126.5+/-
Datum	NGVD 1929
Location	See Plan

	Casing	Sampler	Barrel	Drilling Equipment and Procedures
Type	NW	S	-	Rig Make & Model: Mobile B-53 Bombardier
Inside Diameter (in.)	3.0	1 3/8	-	Bit Type: Roller Bit; Drill Mud: None
Hammer Weight (lb.)	300	140	-	Casing: NW Driven to 19.9 ft.
Hammer Fall (in.)	16	30	-	Hoist/Hammer: Winch/ Doughnut Hammer

Depth (ft.)	SPT[1]	Sample No. & Rec. (in.)	Sample Depth (ft.)	Well Diagram	Elev./Depth (ft.)	USCS Symbol	Visual-Manual Identification and Description (Density/consistency, color, GROUP NAME, max. particle size[2], structure, odor, moisture, optional descriptions, geologic interpretation)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Test Dilatancy	Field Test Toughness	Field Test Plasticity	Field Test Strength
0				NO WELL INSTALLED			-BITUMINOUS CONCRETE-										
	25 32 19 10	S1 8	0.3 2.3		0.3	SP-SM	Very dense, brown, poorly graded SAND with silt and gravel (SP-SM), mps = 2.0 in., no structure, no odor, moist -FILL-	15	15	10	30	20	10				
					3.5	SM	Note: Driller detected change to dark brown, silty SAND with gravel										
5	6 7 23 67	S2 22	4.5 6.5		4.1	SP	Dense, brown, poorly graded SAND (SP), mps = .25 in., no structure, no odor, moist -GLACIAL MARINE DEPOSIT-			5	35	55	5				
					5.8	SP	Dense, light brown, poorly graded SAND (SP), mps = 4mm., no structure, no odor -GLACIAL MARINE DEPOSIT-				25	75	5				
10	19 40 48 58	S3 14	10.0 12.0			SP	Very dense, light brown, poorly graded SAND (SP), mps = 4mm., no structure, no odor, wet			5	40	55					
15	13 38 45 83	S4 15	15.0 17.0			SP	Very dense, brown, poorly graded SAND (SP), mps = .25 in., no structure, no odor, moist to wet -GLACIAL MARINE DEPOSIT-			5	40	55					
					16.7	SW-SM	Very dense, gray-brown well graded SAND with silt and gravel (SW-SM), mps = .75 in., no structure, no odor, wet -GLACIAL TILL-	5	15	5	25	40	10				
20					19.9		Bedrock encountered at 19.9 ft. Advanced roller bit to 20.4 ft. Begin NQ rock core at 20.4 ft. See Core Boring Report for details.										
25																	

Water Level Data

Date	Time	Elapsed Time (hr.)	Depth (ft.) to: Bottom of Casing	Bottom of Hole	Water
10/02/07	14:35	0.1	20.0	25.4	12.6
10/02/07	14:55	0.3	-	19.4	14.4

Sample Identification

- O Open End Rod
- T Thin Wall Tube
- U Undisturbed Sample
- S Split Spoon
- G Geoprobe

Well Diagram

Riser Pipe; Screen; Filter Sand; Cuttings; Grout; Concrete; Bentonite Seal

Summary

- Overburden (lin. ft.) 19.9
- Rock Cored (lin. ft.) 5.0
- Samples 4S, 1C

Boring No. HA07-22

Field Tests: Dilatancy: R-Rapid, S-Slow, N-None; Toughness: L-Low, M-Medium, H-High; Plasticity: N-Nonplastic, L-Low, M-Medium, H-High; Dry Strength: N-None, L-Low, M-Medium, H-High, V-Very High

[1]SPT = Sampler blows per 6 in. [2]Maximum particle size is determined by direct observation within the limitations of sampler size.

Note: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

USCS_TB4 USCSLIB4.GLB USCSTB+CORE4.GDT G:\PROJECTS\34718\000\DRILLING\34718-000TB.GPJ 1 Nov 07

HALEY & ALDRICH

CORE BORING REPORT

Depth (ft)	Drilling Rate Min./ft	Run No.	Depth (ft)	Recovery/RQD in.	Recovery/RQD %	Weathering	Well Diagram	Elev./Depth (ft)	Visual Description and Remarks
									SEE TEST BORING REPORT FOR OVERBURDEN DETAILS
20							NO WELL INSTALLED	19.9	
		C1	20.4 25.4	60/53	100/88	Fr.-SL.			Very hard to hard, fresh to slightly weathered, fine grained to aphanitic SCHIST. Joints are high angle to horizontal, very close to moderately spaced, planar, stepped and undulating, rough, tight to open, some calcite infilling. Quartz/calcite veins throughout core. Chlorite mineralization coincident with quartz-rich zones.
25									
								25.4	-BOTTOM OF EXPLORATION AT 25.4 FT.-

APPENDIX B

Observation Well Installation and Groundwater Monitoring Reports

OBSERVATION WELL INSTALLATION REPORT

HALEY & ALDRICH

Well No.	HA07-3(OW)
Boring No.	HA07-3

PROJECT	Proposed School of Pharmacy, University of New England	H&A FILE NO.	34718-000
LOCATION	Portland, Maine	PROJECT MGR.	A. Blaisdell
CLIENT	University of New England	FIELD REP.	E. Beirne
CONTRACTOR	Maine Test Borings, Inc.	DATE INSTALLED	9/14/2007
DRILLER	M. Porter	WATER LEVEL	23.33 ft., 12:45

Ground El. 126.5+/- ft — Location: See Plan
El. Datum NGVD 1929

☐ Guard Pipe
☑ Roadway Box

SOIL/ROCK CONDITIONS	BOREHOLE BACKFILL
-TOPSOIL-	
0.3	0.9
Silty SAND -FILL-	Bentonite Chips
2.4	6.0
-GLACIAL OUTWASH DEPOSIT- (Sand)	Filter Sand
	25.0
	Collapsed Native Material
30.0	30.0

(Bottom of Exploration)
(Numbers refer to depth from ground surface in feet)

(Not to Scale)

Type of protective cover/lock	Steel cover w/1/2-in. bolts	
Depth of top of roadway box below ground surface	0.0	ft
Depth of top of riser pipe below ground surface	0.5	ft
Type of protective casing:	Roadway Box	
Length	0.8	ft
Inside Diameter	6.0	in
Depth of bottom of roadway box	0.8	ft

Type of Seals	Top of Seal (ft)	Thickness (ft)
Concrete		
Bentonite Seal	0.9	5.1

Type of riser pipe:	Schedule 40 PVC	
Inside diameter of riser pipe	1.5	in
Type of backfill around riser	Filter Sand/Bentonite Seal	
Diameter of borehole	3.0	in
Depth to top of well screen	8.35	ft
Type of screen	Schedule 40 PVC Slotted	
Screen gauge or size of openings	0.010	in
Diameter of screen	1.5	in
Type of backfill around screen	Filter Sand	
Depth of bottom of well screen	25.15	ft
Bottom of Silt trap	25.35	ft
Depth of bottom of borehole	30.0	ft

7.5 ft (Riser Pay Length (L1)) + 17.0 ft (Length of screen (L2)) + 0.2 ft (Length of silt trap (L3)) = 24.7 ft (Pay length)

COMMENTS:

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HALEY & ALDRICH

GROUNDWATER MONITORING REPORT

OW/PZ NUMBER **HA07-3(OW)**

PROJECT	Proposed School of Pharmacy, University of New England	**H&A FILE NO.**	34718-000
LOCATION	Portland, Maine	**PROJECT MGR.**	A. Blaisdell
CLIENT	University of New England	**FIELD REP.**	E. Beirne
CONTRACTOR	Maine Test Borings, Inc.	**DATE**	9/14/2007
ELEVATION SUBTRAHEND	126.5 ft +/-, NGVD 29		

Date	Time	Elapsed Time (days)	Depth of Water from Ground Surface	Elevation of Water	Remarks	Read By
9/14/2007	12:45	0	23.3	103.2		ARB
9/25/2007	15:42	11	23.5	103.0		ECB
9/27/2007	13:45	13	23.6	102.9	2-hours after large rain event	ECB
9/28/2007	7:50	14	23.5	103.0	1 day after rain event	ECB
10/1/2007	11:15	17	23.7	102.8		ARB
10/12/2007	15:32	28	23.7	102.8	During rain event	ECB

HALEY & ALDRICH

OBSERVATION WELL INSTALLATION REPORT

Well No.	HA07-5(OW)
Boring No.	HA07-5

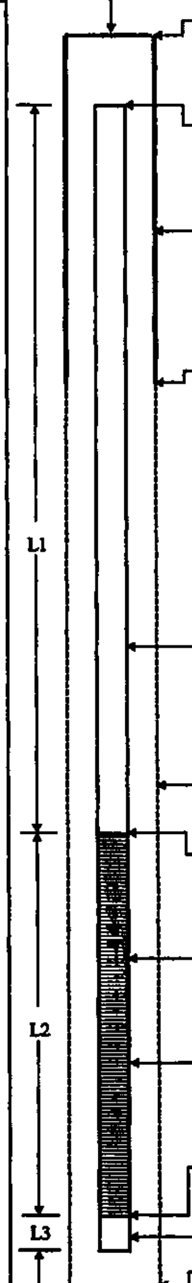
PROJECT	Proposed School of Pharmacy, University of New England	H&A FILE NO.	34718-000
LOCATION	Portland, Maine	PROJECT MGR.	A. Blaisdell
CLIENT	University of New England	FIELD REP.	A. Blaisdell
CONTRACTOR	Maine Test Borings, Inc.	DATE INSTALLED	9/18/2007
DRILLER	B. Enos	WATER LEVEL	18.7 ft., 07:30

Ground El. 125.0+/- ft
El. Datum NGVD 1929
Location See Plan

☐ Guard Pipe
☑ Roadway Box

SOIL/ROCK CONDITIONS	BOREHOLE BACKFILL
0.0	0.0
-TOPSOIL-	Filter Sand
0.5	5.0
-GLACIAL MARINE DEPOSIT- (Sand)	Bentonite Chips
	8.0
	Filter Sand
20.0 (Bottom of Exploration)	20.0

(Numbers refer to depth from ground surface in feet)



Type of protective cover/lock	Steel cover w/1/2-in. bolts
Depth of top of roadway box below ground surface	0.0 ft
Depth of top of riser pipe below ground surface	0.5 ft
Type of protective casing:	Roadway Box
Length	0.8 ft
Inside Diameter	6.0 in
Depth of bottom of roadway box	0.8 ft

Type of Seals	Top of Seal (ft)	Thickness (ft)
Concrete		
Bentonite Seal	5.0	3.0

Type of riser pipe:	Schedule 40 PVC
Inside diameter of riser pipe	2.0 in
Type of backfill around riser	Filter Sand/Bentonite Seal
Diameter of borehole	4.0 in
Depth to top of well screen	10.0 ft
Type of screen	Schedule 40 PVC Slotted
Screen gauge or size of openings	0.010 in
Diameter of screen	2.0 in
Type of backfill around screen	Filter Sand
Depth of bottom of well screen	19.8 ft
Bottom of Silt trap	20.0 ft
Depth of bottom of borehole	30.0 ft

(Not to Scale)

9.8 ft + 10.0 ft + 0.2 ft = 20.0 ft
Riser Pay Length (L1) + Length of screen (L2) + Length of silt trap (L3) = Pay length

COMMENTS:

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HALEY & ALDRICH

GROUNDWATER MONITORING REPORT

OW/PZ NUMBER
HA07-5(OW)

PROJECT	Proposed School of Pharmacy, University of New England	**H&A FILE NO.**	34718-000
LOCATION	Portland, Maine	**PROJECT MGR.**	A. Blaisdell
CLIENT	University of New England	**FIELD REP.**	A. Blaisdell
CONTRACTOR	Maine Test Borings, Inc.	**DATE**	9/17/2007
ELEVATION SUBTRAHEND	125 ft +/-, NGVD 29		

Date	Time	Elapsed Time (days)	Depth of Water from Ground Surface	Elevation of Water	Remarks	Read By
9/18/2007	7:30	1	18.7	106.3		ARB
9/25/2007	15:51	8	19.1	105.9		ECB
9/27/2007	13:52	10	19.3	105.8	2-hours after large rain event	ECB
9/28/2007	8:12	11	19.2	105.8	1 day after rain event	ECB
10/1/2007	11:25	14	19.3	105.7		ARB
10/5/2007	11:06	18	19.3	105.7		ECB
10/12/2007	15:40	25	19.6	105.4	During rain event	ECB

HALEY & ALDRICH

OBSERVATION WELL INSTALLATION REPORT

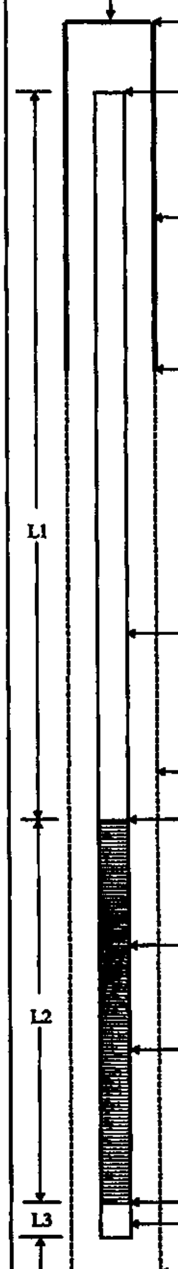
Well No. HA07-13(OW)
Boring No. HA07-13

PROJECT	Proposed School of Pharmacy, University of New England	**H&A FILE NO.**	34718-000
LOCATION	Portland, Maine	**PROJECT MGR.**	A. Blaisdell
CLIENT	University of New England	**FIELD REP.**	B. Steinert
CONTRACTOR	Maine Test Borings, Inc.	**DATE INSTALLED**	9/19/2007
DRILLER	B. Enos	**WATER LEVEL**	

Ground El. 94.0+/- ft **Location** See Plan ☑ **Guard Pipe**
El. Datum NGVD 1929 ☐ **Roadway Box**

SOIL/ROCK CONDITIONS	BOREHOLE BACKFILL
-TOPSOIL-	Bentonite Chips
0.7	
-FILL- (Sand)	
3.0	
-PEAT-	
3.1	4.0
-MARINE DEPOSIT- (Sand)	Filter Sand
9.0	
-MARINE DEPOSIT- (Clay)	
12.0	
-MARINE DEPOSIT- (Sand)	
17.0	15.0

(Bottom of Exploration)
(Numbers refer to depth from ground surface in feet)



Type of protective cover/lock	Steel Guardpipe	
Depth of top of guardpipe above ground surface	2.9	ft
Depth of top of riser pipe above ground surface	2.9	ft
Type of protective casing:	Steel Guardpipe	
Length	5.25	ft
Inside Diameter	3.5	in
Depth of bottom of guardpipe	2.35	ft

Type of Seals	Top of Seal (ft)	Thickness (ft)
Concrete		
Bentonite Seal	0.0	4.0

Type of riser pipe:	Schedule 40 PVC	
Inside diameter of riser pipe	1.5	in
Type of backfill around riser	Filter Sand/Bentonite Seal	
Diameter of borehole	3.0	in
Depth to top of well screen	5.0	ft
Type of screen	Schedule 40 PVC Slotted	
Screen gauge or size of openings	0.010	in
Diameter of screen	1.5	in
Type of backfill around screen	Filter Sand	
Depth of bottom of well screen	15.0	ft
Bottom of Silt trap	15.0	ft
Depth of bottom of borehole	17.0	ft

(Not to Scale)

7.9 ft + 10.0 ft + 0 ft = 17.9 ft
Riser Pay Length (L1) + Length of screen (L2) + Length of silt trap (L3) = Pay length

COMMENTS: Begin Well Installation at 0800, finish @ 0830, 1.5 Bags Sand, 1/2 Bag Bentonite Chips

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HALEY & ALDRICH

GROUNDWATER MONITORING REPORT

OW/PZ NUMBER HA07-13(OW)

PROJECT	Proposed School of Pharmacy, University of New England	H&A FILE NO.	34718-000
LOCATION	Portland, Maine	PROJECT MGR.	A. Blaisdell
CLIENT	University of New England	FIELD REP.	B. Steinert
CONTRACTOR	Maine Test Borings, Inc.	DATE	9/18/2007
ELEVATION SUBTRAHEND	94 ft +/-, NGVD 29		

Date	Time	Elapsed Time (days)	Depth of Water from Ground Surface	Elevation of Water	Remarks	Read By
9/25/2007	16:05	7	0.7	93.3		ECB
9/27/2007	14:07	9	0.6	93.4	2-hours after large rain event	ECB
9/28/2007	8:24	10	0.5	93.6	1 day after rain event	ECB
10/12/2007	15:15	24	0.1	93.9	During rain event	ECB

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OBSERVATION WELL INSTALLATION REPORT

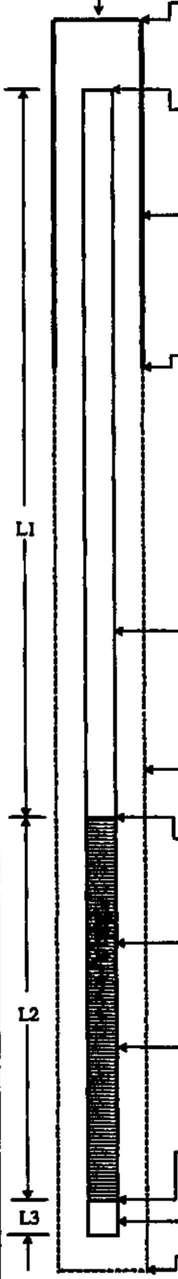
Well No.	HA07-21(OW)
Boring No.	HA07-21(OW)

PROJECT	Proposed School of Pharmacy, University of New England	**H&A FILE NO.**	34718-000
LOCATION	Portland, Maine	**PROJECT MGR.**	A. Blaisdell
CLIENT	University of New England	**FIELD REP.**	E. Beirne
CONTRACTOR	Maine Test Borings, Inc.	**DATE INSTALLED**	10/3/2007
DRILLER	M. Porter	**WATER LEVEL**	18.25 ft., 9:08AM

Ground El. 126.5+/- ft **Location** See Plan ☐ **Guard Pipe**
El. Datum NGVD 1929 ☑ **Roadway Box**

SOIL/ROCK CONDITIONS	BOREHOLE BACKFILL
-BITUMINOUS CONCRETE-	
0.3	
-FILL-	Cuttings (Sand)
3.0	
	5.0
	Bentonite Chips
	9.7
-GLACIAL OUTWASH DEPOSIT- (Sand)	Filter Sand
24.0	
-BEDROCK-	
24.2	24.2

(Bottom of Exploration)
(Numbers refer to depth from ground surface in feet)



(Not to Scale)

Type of protective cover/lock	Steel cover w/1/2-in. bolts
Depth of top of roadway box below ground surface	0.0 ft
Depth of top of riser pipe below ground surface	0.2 ft
Type of protective casing:	Roadway Box
Length	0.8 ft
Inside Diameter	6.0 in
Depth of bottom of roadway box	0.8 ft

Type of Seals	Top of Seal (ft)	Thickness (ft)
Concrete		
Bentonite Seal	5.0	4.7

Type of riser pipe:	Schedule 40 PVC
Inside diameter of riser pipe	1.5 in
Type of backfill around riser	Filter Sand/Bentonite Seal
Diameter of borehole	3.0 in
Depth to top of well screen	13.0 ft
Type of screen	Schedule 40 PVC Slotted
Screen gauge or size of openings	0.010 in
Diameter of screen	1.5 in
Type of backfill around screen	Filter Sand
Depth of bottom of well screen	22.8 ft
Bottom of Silt trap	23.0 ft
Depth of bottom of borehole	24.2 ft

13.0 ft + 9.8 ft + 0.2 ft = 23.0 ft
Riser Pay Length (L1) + Length of screen (L2) + Length of silt trap (L3) = Pay length

COMMENTS:

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HALEY & ALDRICH

GROUNDWATER MONITORING REPORT

OW/PZ NUMBER HA07-21(OW)

Page 1 of 1

PROJECT	Proposed School of Pharmacy, University of New England	**H&A FILE NO.**	34718-000
LOCATION	Portland, Maine	**PROJECT MGR.**	A. Blaisdell
CLIENT	University of New England	**FIELD REP.**	E. Beirne
CONTRACTOR	Maine Test Borings, Inc.	**DATE**	10/3/2007
ELEVATION SUBTRAHEND	126.5 ft +/-, NGVD 29		

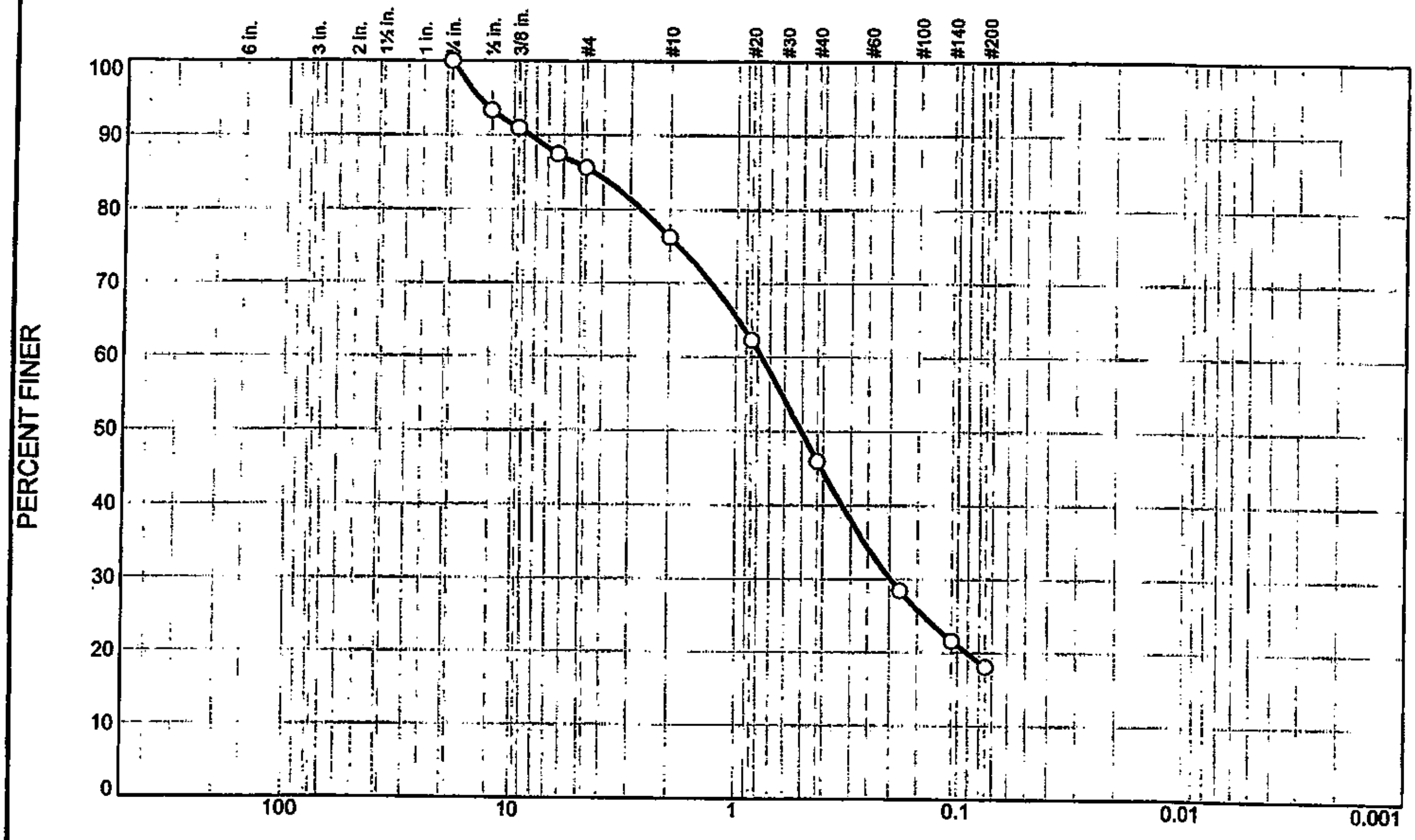
Date	Time	Elapsed Time (days)	Depth of Water from Ground Surface	Elevation of Water	Remarks	Read By
10/5/2007	11:00	2	18.3	108.2		ECB
10/12/2007	15:28	9	18.5	108.0	During rain event	ECB
12/3/2007	8:30	61	18.4	108.1		ARB
1/1/2008	11:45	90	18.6	107.9		DAD
1/9/2008	16:35	98	18.6	107.9		ARB

Form 2021

APPENDIX C

Laboratory Test Reports

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	14.4	9.3	30.4	27.9	18.0	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3/4"	100.0		
1/2"	93.3		
3/8"	91.0		
1/4"	87.5		
#4	85.6		
#10	76.3		
#20	62.3		
#40	45.9		
#80	28.5		
#140	21.6		
#200	18.0		

* (no specification provided)

Soil Description

silty sand

Atterberg Limits

PL= np LL= nv PI=

Coefficients

D_{85}= 4.3716 D_{60}= 0.7652 D_{50}= 0.5025
D_{30}= 0.1978 D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= SM AASHTO= A-1-b

Remarks

Moisture content: 6.8%

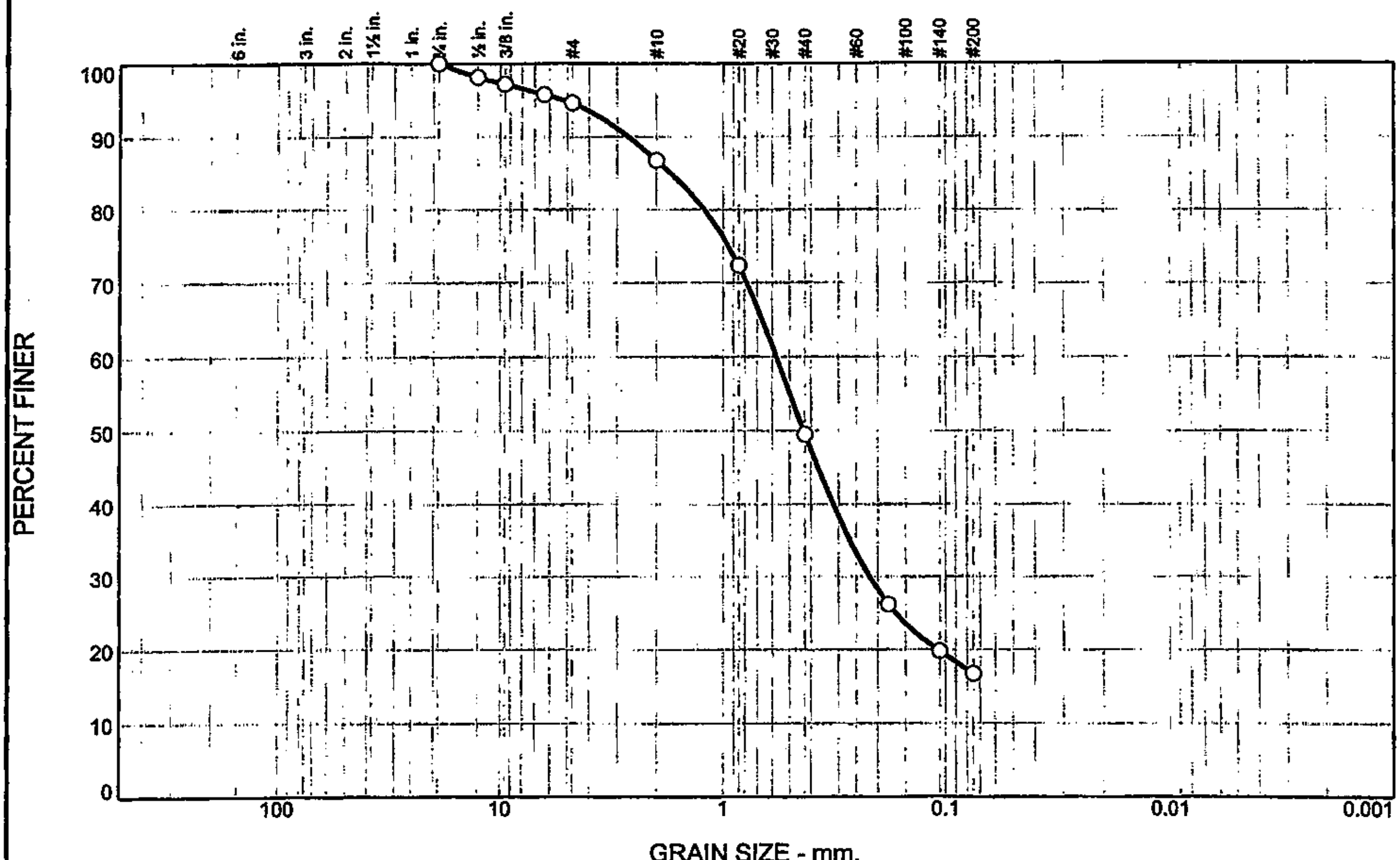
Sample No.: S-2/S-3 **Source of Sample:** University of New England, Portland, Maine **Date:** 10/07/07
Location: HA07-7 **Elev./Depth:** 2'-6'

R.W. Gillespie & Associates, Inc. Saco, Maine

Client: Haley & Aldrich, Inc.
Project: Misc. Testing
Project No: 956-04 **Lab #** 9867a

Tested By: JJH/DCH **Checked By:** MTG MTG

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	5.4	7.8	37.3	32.8	16.7	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3/4"	100.0		
1/2"	98.1		
3/8"	97.2		
1/4"	95.8		
#4	94.6		
#10	86.8		
#20	72.3		
#40	49.5		
#80	26.2		
#140	19.8		
#200	16.7		

* (no specification provided)

Soil Description

silty sand

Atterberg Limits

PL= np   LL= nv   PI=

Coefficients

D_{85}= 1.7230 D_{60}= 0.5738 D_{50}= 0.4312
D_{30}= 0.2181 D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= SM   AASHTO= A-1-b

Remarks

Moisture content: 15.4%

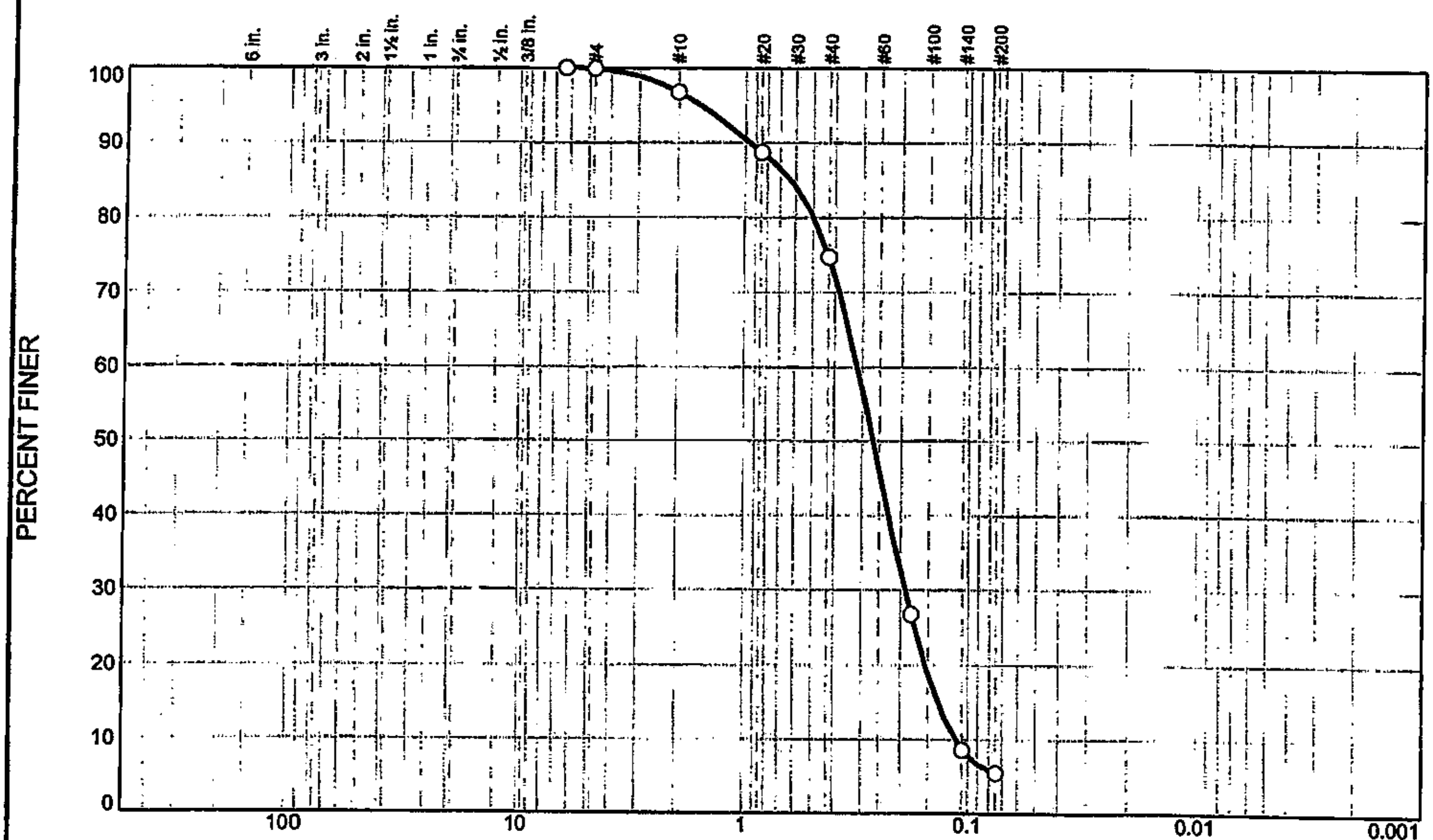
Sample No.: S-1   **Source of Sample:** University of New England, Portland, Maine   **Date:** 10/1/07
Location: HA07-10   **Elev./Depth:** 0-2'

R.W. Gillespie & Associates, Inc. Saco, Maine

Client: Haley & Aldrich, Inc.
Project: Misc. Testing
Project No: 956-04   **Lab #** 9867b

Tested By: JJH/DCH   **Checked By:** MTG MTG

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.1	3.1	22.1	69.2	5.5	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1/4"	100.0		
#4	99.9		
#10	96.8		
#20	88.7		
#40	74.7		
#80	26.7		
#140	8.6		
#200	5.5		

* (no specification provided)

Soil Description

poorly graded sand with silt

Atterberg Limits

PL= np LL= nv PI=

Coefficients

D_{85}= 0.6282 D_{60}= 0.3167 D_{50}= 0.2681
D_{30}= 0.1915 D_{15}= 0.1365 D_{10}= 0.1140
C_u= 2.78 C_c= 1.02

Classification

USCS= SP-SM AASHTO= A-3

Remarks

Moisture content: 8.1%

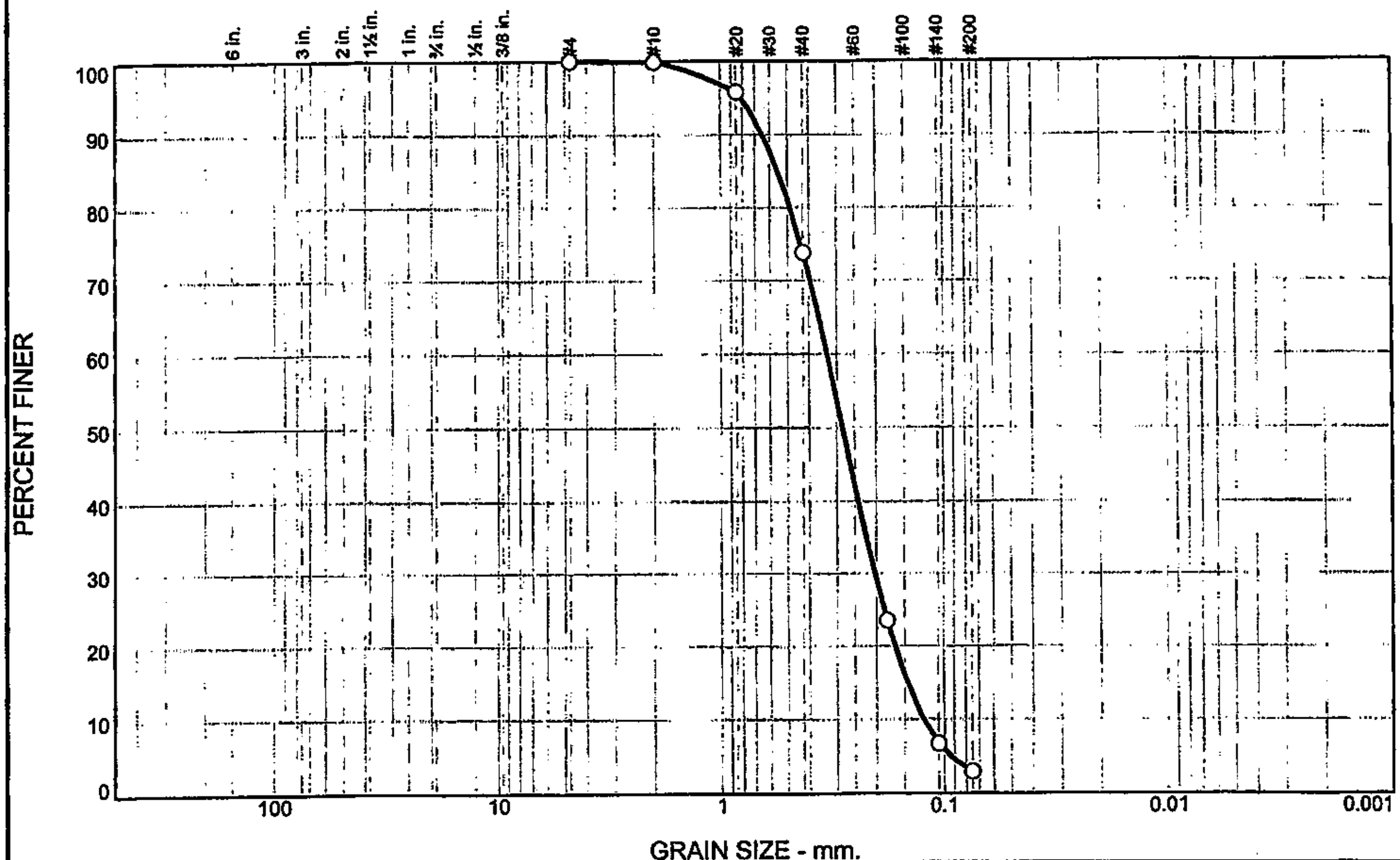
Sample No.: S-1B **Source of Sample:** University of New England, Portland, Maine **Date:** 10/17/07
Location: HA07-13 **Elev./Depth:** 0.7-2'

R.W. Gillespie & Associates, Inc. Saco, Maine

Client: Haley & Aldrich, Inc.
Project: Misc. Testing
Project No: 956-04 **Lab #** 9867c

Tested By: JJH/DCH **Checked By:** MTG MTG

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.1	26.1	70.9	2.9	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#4	100.0		
#10	99.9		
#20	95.8		
#40	73.8		
#80	23.5		
#140	6.7		
#200	2.9		

* (no specification provided)

Soil Description

poorly graded sand

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 0.5518 D_{60}= 0.3328 D_{50}= 0.2836
D_{30}= 0.2040 D_{15}= 0.1466 D_{10}= 0.1241
C_u= 2.68 C_c= 1.01

Classification

USCS= SP AASHTO=

Remarks

Moisture content: 6.5%

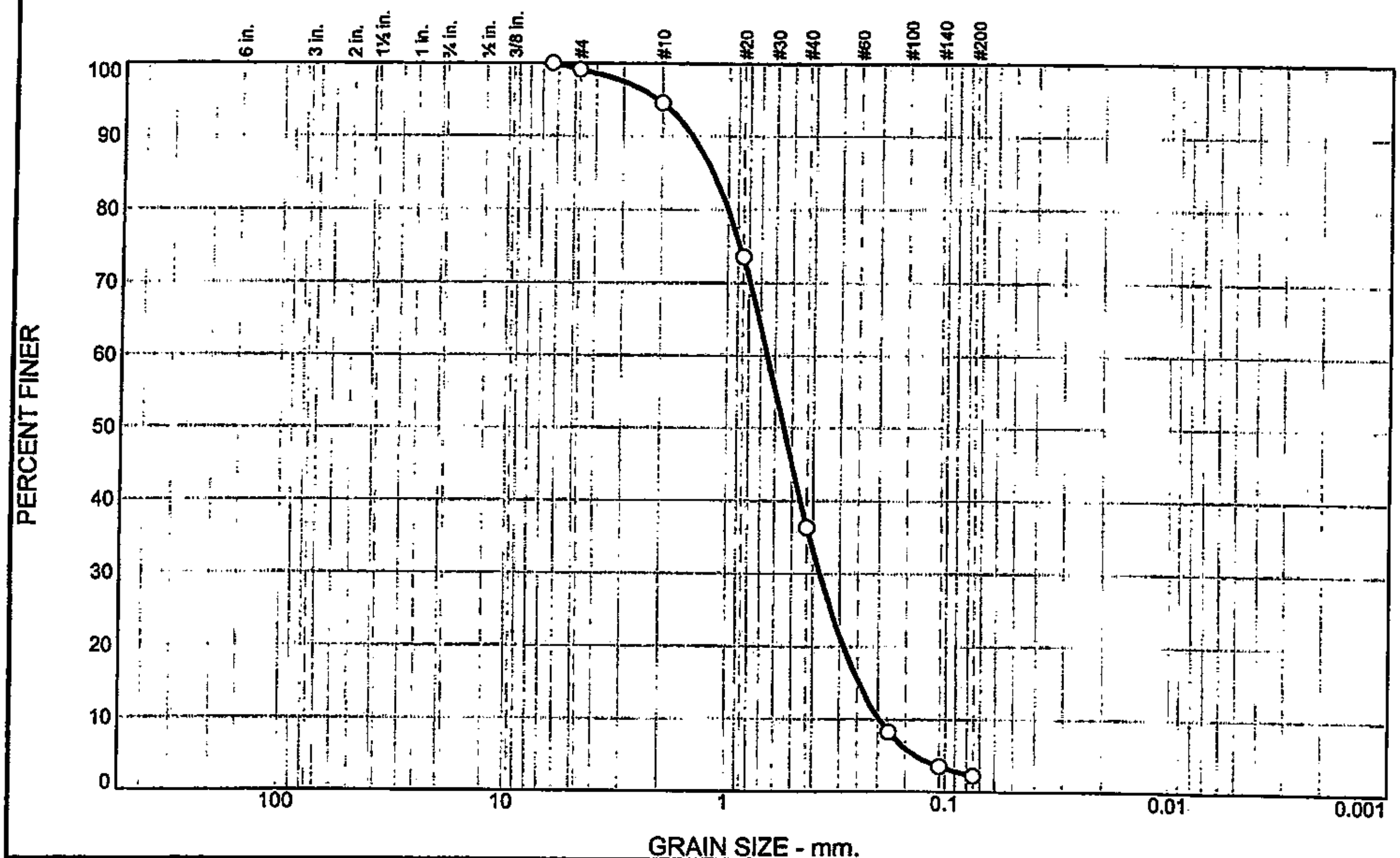
Sample No.: S-3 **Source of Sample:** University of New England, Portland, Maine **Date:** 10/17/07
Location: HA07-19 **Elev./Depth:** 9.5'-11.5'

R.W. Gillespie & Associates, Inc.
Saco, Maine

Client: Haley & Aldrich, Inc.
Project: Misc. Testing
Project No: 956-04 **Lab #** 9867d

Tested By: JJH/DCH **Checked By:** MTG MTG

Particle Size Distribution Report



% +3"	% Gravel Coarse	% Gravel Fine	% Sand Coarse	% Sand Medium	% Sand Fine	% Fines Silt	% Fines Clay
0.0	0.0	0.9	4.5	58.3	34.0	2.3	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1/4"	100.0		
#4	99.1		
#10	94.6		
#20	73.6		
#40	36.3		
#80	8.3		
#140	3.5		
#200	2.3		

* (no specification provided)

Soil Description

poorly graded sand

Atterberg Limits

PL= np LL= nv PI=

Coefficients

D_{85}= 1.1707 D_{60}= 0.6515 D_{50}= 0.5460
D_{30}= 0.3720 D_{15}= 0.2453 D_{10}= 0.1984
C_u= 3.28 C_c= 1.07

Classification

USCS= SP AASHTO= A-1-b

Remarks

Moisture content: 2.0%

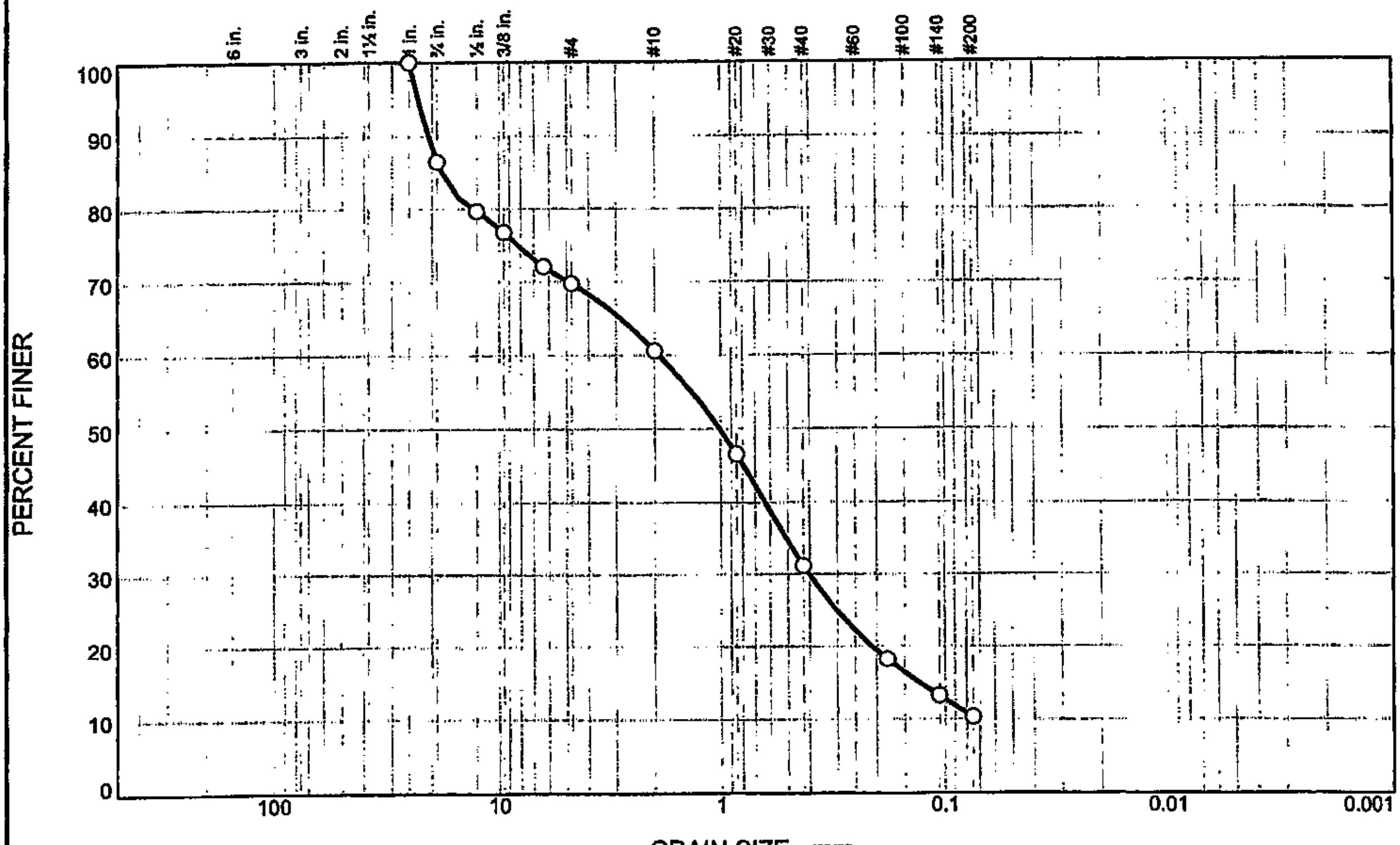
Sample No.: S-3 **Source of Sample:** University of New England, Portland, Maine **Date:** 10/17/07
Location: HA07-20 **Elev./Depth:** 9.5'-11.5'

R.W. Gillespie & Associates, Inc. Saco, Maine

Client: Haley & Aldrich, Inc.
Project: Misc. Testing
Project No: 956-04 **Lab #** 9867e

Tested By: JJH/DCH **Checked By:** MTG MTG

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	13.5	16.7	9.2	29.4	20.9	10.3	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1"	100.0		
3/4"	86.5		
1/2"	79.7		
3/8"	76.8		
1/4"	72.1		
#4	69.8		
#10	60.6		
#20	46.6		
#40	31.2		
#80	18.2		
#140	13.2		
#200	10.3		

* (no specification provided)

Soil Description

poorly graded sand with silt and gravel

Atterberg Limits

PL= np LL= nv PI=

Coefficients

D_{85}= 18.1366 D_{60}= 1.9138 D_{50}= 1.0098
D_{30}= 0.4010 D_{15}= 0.1307 D_{10}=
C_u= C_c=

Classification

USCS= SP-SM AASHTO= A-1-b

Remarks

Moisture content: 2.8%

Sample No.: S-1 **Source of Sample:** University of New England, Portland, Maine **Date:** 10/17/07
Location: HA07-22 **Elev./Depth:** 0-2'

R.W. Gillespie & Associates, Inc. Saco, Maine	**Client:** Haley & Aldrich, Inc. **Project:** Misc. Testing **Project No:** 956-04 **Lab #** 9867f

Tested By: JJH/DCH **Checked By:** MTG

HALEY & ALDRICH, INC.
GEOTECHNICAL LABORATORY

TEST DATE: 10/18/2007

ORGANIC CONTENT RESULTS

FILE No.:	34718-000
PROJECT:	Proposed College of Pharmacy
	Portland, Maine

EXPL. No.:	HA07
SAMPLE No.:	S03
DEPTH (ft.):	4.0-6.0
SAMPLE DESCRIPTION:	Dark brown Organic Soil

NATURAL WATER CONTENT

WT CONT. + WET SAMPLE (g)	128.8600
WT CONT. + DRY SAMPLE (g)	45.1200
WT CONTAINER (g)	10.9400
WATER CONTENT (%)	**245.0**

LOSS ON IGNITION

WT CONTAINERS + OVEN DRY SAMPLE BEFORE COMBUSTION (g)	35.2983
WT CONTAINERS + OVEN DRY SAMPLE AFTER COMBUSTION (g)	33.4725
WT CONTAINER (CRUCIBLE + B CAN)	29.6978
ORGANIC CONTENT (%)	**32.6**

J:\EXCEL\CLASSIF\Organic Content\34718-000\[HA07 S03.xls]Data Report

APPENDIX D

17 December 2007 Memorandum by Haley & Aldrich, Inc. entitled "Summary of Site Visit, Elevator Pit in Finley Hall Athletic Center"

Haley & Aldrich
75 Washington Avenue
Suite 203
Portland, ME 04101-2617

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Fax: 207.775.7666
HaleyAldrich.com

HALEY&
ALDRICH

MEMORANDUM

17 December 2007
File No. 34718-010

TO:	University of New England Alan Thibeault
C:	Port City Architecture; Attn.: Lita Semrau Becker Structural Engineers; Attn.: Dan Burne SYTDesign; Attn.: Andy Morrill, Peter Biegel
FROM:	Haley & Aldrich, Inc. Andrew R. Blaisdell, P.E.; Wayne A. Chadbourne, P.E.
SUBJECT:	Summary of Site Visit Elevator Pit in Finley Hall Athletic Center University of New England Portland, Maine

On 7 and 14 December 2007, Andrew Blaisdell of Haley & Aldrich, Inc. visited Finley Hall to observe the basement and elevator pit to check for indications of past groundwater infiltration and other conditions that could be relevant as we finalize the foundation drainage and waterproofing details for the proposed College of Pharmacy (COP) building. This memorandum summarizes our on-site observations and presents photographs that were taken during the site visit.

Observations from Site Visit

Elevator Pit Sump

The elevator pit is located along the northern wall of Finley Hall, approximately 75 ft south of the southern edge of the proposed COP building (see attached structural plans for location). The bottom of the elevator pit (i.e., top of elevator pit slab) is approximately 4.1 ft below the basement finish floor level (which was surveyed at El. 116.32 according to the plan entitled "Existing Conditions, July 2007, College of Pharmacy," dated 31 July 2007, prepared by Colonial Surveying Company, LLC), corresponding to approximately El. 112.2. The elevator pit base slab was constructed using cast-in-place (CIP) concrete. "Negative-side" waterproofing (i.e., waterproofing located on the inside face of the pit walls and slab) was not observed.

A sump pit with a submersible pump is present in the southeast corner of the elevator pit (see Photographs 5 and 6, and attached structural plans for location). As shown on Photograph 6, the sump pit appears to have been "chipped out" of the elevator pit slab at some point after the slab was initially constructed. Based on our discussions with UNE facility personnel, the actual timing regarding when the pump was installed is not known. The bottom of the sump pit is 0.9 ft below the base of the elevator pit (El. 111.3). At the time of our site visit, the sump pit was partially filled with water to 0.5 ft below the base of the pit (El. 111.7). The water appeared to contain a concentration of some sort of chemical constituent, possibly antifreeze.

An approximately 1.25-in. diameter vertical PVC discharge pipe was attached to the pump and exited the elevator sump pit through its eastern wall, at approximately El. 116.5 (invert). The discharge pipe extends through the wall, extending approximately 2 in. beyond the other side before reaching a 90-degree elbow and extending down through the floor slab, as shown in Photograph 9. Based on these observations, we anticipate that the discharge pipe ties into the foundation drainage system for Finley Hall.

The northern wall of the elevator pit was constructed using concrete masonry blocks (CMU blocks) for the entire height of the wall, down to (and potentially below) the base of the elevator pit. The northern wall is the only wall that is also an exterior building wall. The other walls were constructed with cast-in-place (CIP) concrete from the base of the pit up to the level of the top of the basement finish floor (El. 116.32). CMU blocks were used to construct the other walls above the basement floor level.

Rust-colored staining was observed on the lower approximately 0.7 ft of the elevator pit walls (up to El. 112.9). Dark gray coloring was observed on the portion of the walls between 0.7 and 1.8 ft above the base of the pit (El. 112.9 to El. 114). Staining was not observed on the remaining portions of the walls (see Photograph 1).

Several cracks were documented in the mortar between CMU blocks on the exterior (northern) wall and interior walls. One such crack on the northern wall of the pit is shown on Photograph 2. A similar crack was observed on the eastern wall of the stairway down to the basement, between CMU and CIP concrete portions of the walls, as shown on Photograph 13. This crack had a maximum open width of about 3/32 in.

A cemented white substance is present on the elevator pit walls and slab in the northeast and northwest corners of the pit (see Photographs 7 and 8). It appears that the substance may have leached from the mortar between the CMUs when water infiltrated into the pit area.

Foundation Drainage System Sump

The sump pit for the foundation drainage system is located along the eastern wall of Finley Hall, approximately 90 ft south of the southern edge of the proposed COP building (see attached structural plans for location). The level of the bottom of the drain sump pit (i.e., top of pit slab) is reportedly at El. 112.5, approximately 3.8 ft below the basement finish floor level.

The sump pit is covered with a steel plate (see Photograph 10) that we were unable to remove during our site visit. Two, 2-in. diameter PVC pipes extend through the steel plate and up the basement walls. A six-foot ruler was inserted through a hole in the steel plate (for the cords from the submersible pump) to attempt to measure the depth of the pit. Water was documented in the pit at a depth of 1.9 ft below the basement finish floor level (El. 114.5). The submersible pump was not operating during our 14 December 2007 site visit. We anticipate that the water in the sump pit is below the level that triggers operation of the pump. Because of the steel plates, we were unable to visually inspect the pump.

During insertion of the six-foot ruler, a relatively soft substance was encountered approximately 2.8 ft below the finish floor level (El. 113.5). We were able to advance the an additional 6 in. (to El. 113) before meeting refusal. We anticipate that the 6 in. of soft material encountered in the sump pit consists of silt sized soil particles that have washed into the pit from the surrounding natural soil through the foundation/underslab drain pipes (geotextile separation fabric was not part of the underdrain design). The portion of the ruler that extended into the silt exhibited a slight hydrocarbon odor upon removal.

<u>Sewer Ejector Pit</u>

The sewer ejector pit is also located along the eastern wall of Finley Hall, approximately 4 ft south of the southern edge of the foundation drainage system sump (see attached structural plans for location). The sewer ejector pit is reportedly 3 ft below the basement finish floor level. We were able to remove the western steel plate that covered the sewer ejector pit. The ejector pit is shown with the western cover removed in Photograph 12.

Two, 2-in. diameter PVC pipes extend through the steel plate that remained in place over the pit. One of the pipes extended down to the top of the pump, consisting of the effluent pipe. The second pipe apparently terminated just below the bottom of the steel plate. A 5-in. diameter pipe extended through the western wall of the sump pit with an invert level approximately 1.6 ft below the finish floor level (El. 114.7). This pipe appears to consist of an influent pipe. Liquid occasionally dripped from this pipe while the cover was removed.

The liquid level in the pit on 14 December 2007 was approximately 2.6 ft below the slab finish floor level (El. 113.7). The submersible pump did not operate during the time of our site visit, indicating that the liquid level was too low to trigger operation of the pump. We were unable to take detailed measurements of the pump, but it did appear larger than the pump that was observed in the elevator pit.

The submersible pump was plugged into an outlet that was connected to a pump control box manufactured by Gould Pumps (Simplex Pump Control Model A3-2012). The switch on the control panel was set to "auto".

Review of Available Structural and Electrical Plans

Upon completion of our site inspection, we reviewed available structural and electrical plans to obtain additional information on the existing foundation drainage system for Finley Hall. Relevant excerpts from the structural drawings are attached to this memo for reference. Based on our review of these plans, we have the following observations:

- The Finley building has an existing foundation drainage system consisting of 6-in. dia. PVC perimeter drain pipes located along the outside of the foundation wall, and a network of 6-in. dia. PVC underslab drain pipes installed within an 18-in. thick layer of crushed stone beneath the slab. The details do not include any geotextile separation fabric between the crushed stone and natural soil.

- All foundation drainage pipes are pitched towards the foundation drain sump pit located on the interior side of the eastern basement wall (see attached structural plan). The bottom of the sump pit consists of a 12-in. thick concrete mat, the top of which is at El. 112.5. At the sump, the invert of the underslab drain system is El. 114.0, and the invert of the perimeter drain system is El. 114.5.

- The outside face of the below-grade portions of the Finley basement walls have been damproofed. Incorporation of waterproofing of the exterior portion of foundation walls and below the ground floor slab were not part of the original design for Finley Hall.

- According to the electrical plans, the sump pit and the sewage ejector pit are each outfitted with a ¼ HP pump, 120 volt motor and a power rating of 13 AMPs.

- The structural plans show a 1-in. thick metallic waterproofing should have been installed on the inside face of the elevator pit base slab and walls. This waterproofing material was not observed during our site visit. There is no elevator sump pit shown on the structural plans.

- There is a small discrepancy in the level of the top of the basement slab between the structural plans (El. 116.5) and the plans with the recent surveyed information provided by Colonial Surveying Company, LLC (El. 116.32).

Conclusions

Based on our observations during the site visit and our review of the available structural and electrical drawings, we have the following general conclusions regarding the foundation drainage system for Finley Hall:

- Waterproofing of the elevator pit was not installed as shown on the structural plans. We believe that the elevator pit sump was a retrofit that was installed after initial pit construction and was likely installed in place of the waterproofing membrane.

- The pumps in the elevator sump pit and the foundation drain system sump pit are currently operational and are performing satisfactorily. Based on discussions with UNE facilities personnel, both pumps are believed to be inactive most of the time. The pumps are not on separate electric meters, so actual pump usage is not known.

- There is no evidence that the water level within the elevator pit has risen to a level higher than El. 114. It is not known whether this high water level occurred prior to or after installation of the pump into the elevator pit. Based on discussions with UNE facility personnel, the only time water was observed in the elevator pit was when the pump had been inadvertently unplugged from the power outlet.

- The electrical plans indicate that effluent from the foundation drainage system is removed from the system by a ¼-HP, 120-volt pump. Based on our experience and review of similar sizes of pumps, we anticipate that this corresponds to a maximum pump discharge rate of between 20 and 30 gpm.

- The pump in the elevator sump pit is apparently smaller than the one observed in the sewer ejector pit. Therefore, it is anticipated that it has a maximum pump discharge rate of less than 20 gpm.

- The foundation drain system for Finley Hall has been effective in keeping the below-grade space dry. UNE facilities personnel cited no event during the life of the building when water encroached into the basement.

- Up to 6 in. or more of silt may have collected in the bottom of the foundation drain sump pit. If this material is silt, it was likely washed in from the natural soils, through the crushed stone, and into the sump pit. Given the size of the sump pit (18 in. by 18 in.), the volume of silt present in the sump pit is relatively insignificant compared to soil loss surrounding the crushed stone.

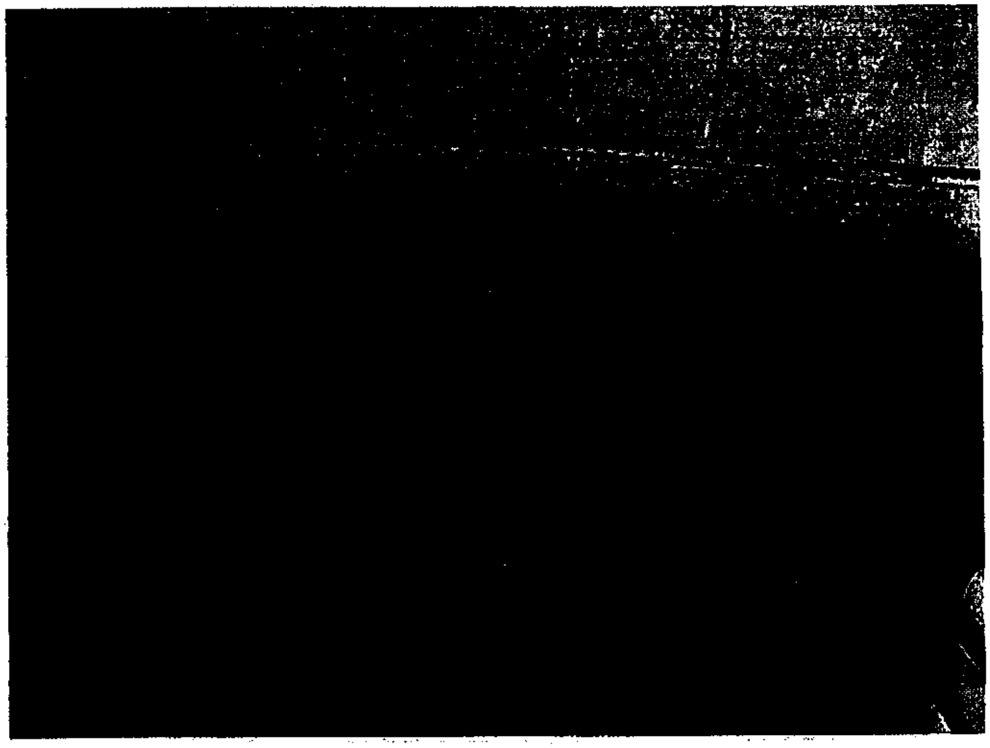
- The existing Finley Hall foundation drainage system and dampproofing design is essentially the same system that we proposed in our 2 November 2007 geotechnical report.

Closure

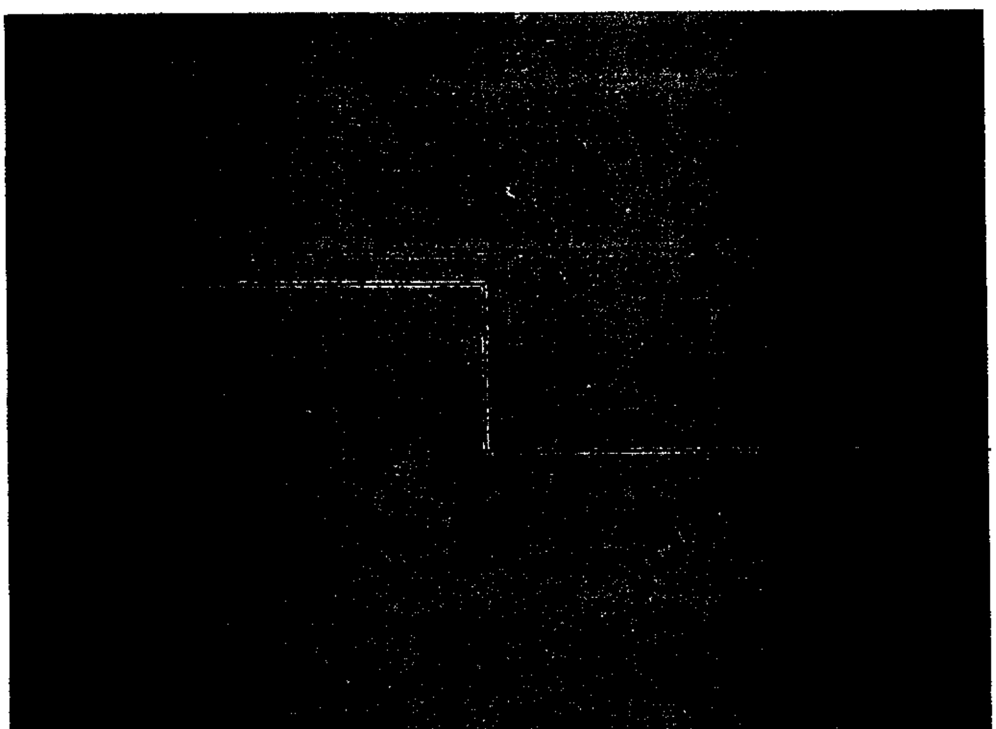
We will use the information summarized in this memorandum to provide our final design recommendations for the foundation drainage system and waterproofing/dampproofing. Please contact us if you have any questions regarding the information submitted herein.

Attachments:
Photograph Summary (7 pages)
Excerpts from available Structural Drawings for Finley Hall (4 pages)

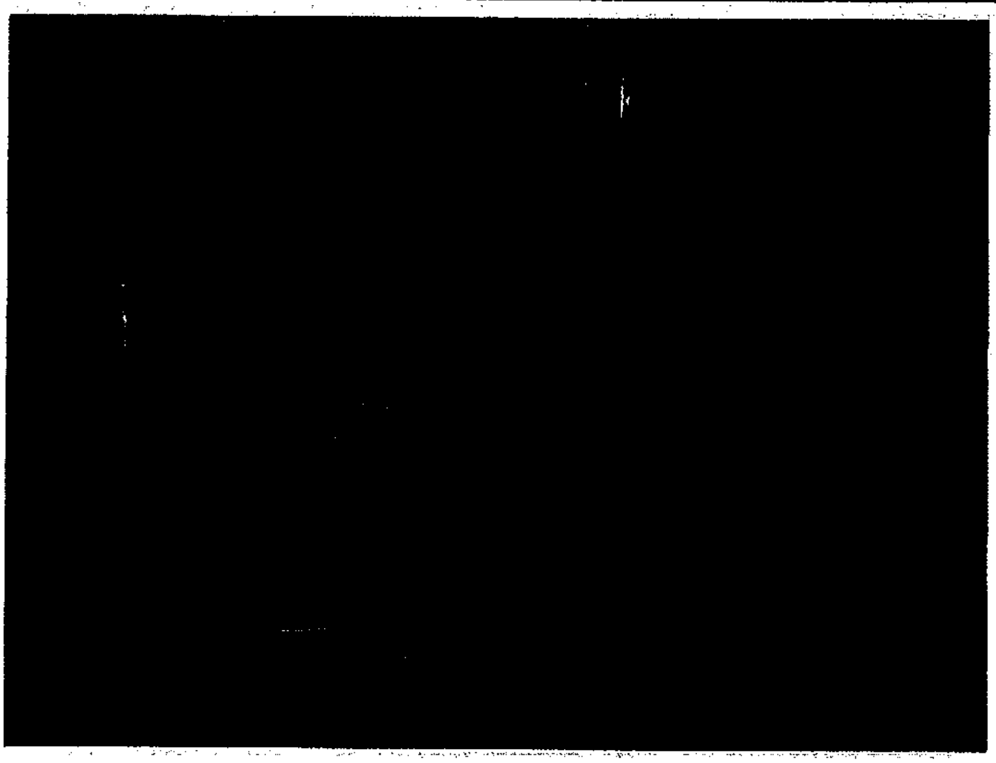
G:\PROJECTS\34718\010\2007-1214-wac-FinleyMemo-f.doc



Photograph 1. Northwest corner of elevator pit, looking north. Rust coloring extends 0.7 ft above top of elevator slab (El. 112.9), dark gray coloring extends 1.8 ft above top of pit slab (El. 114.0)



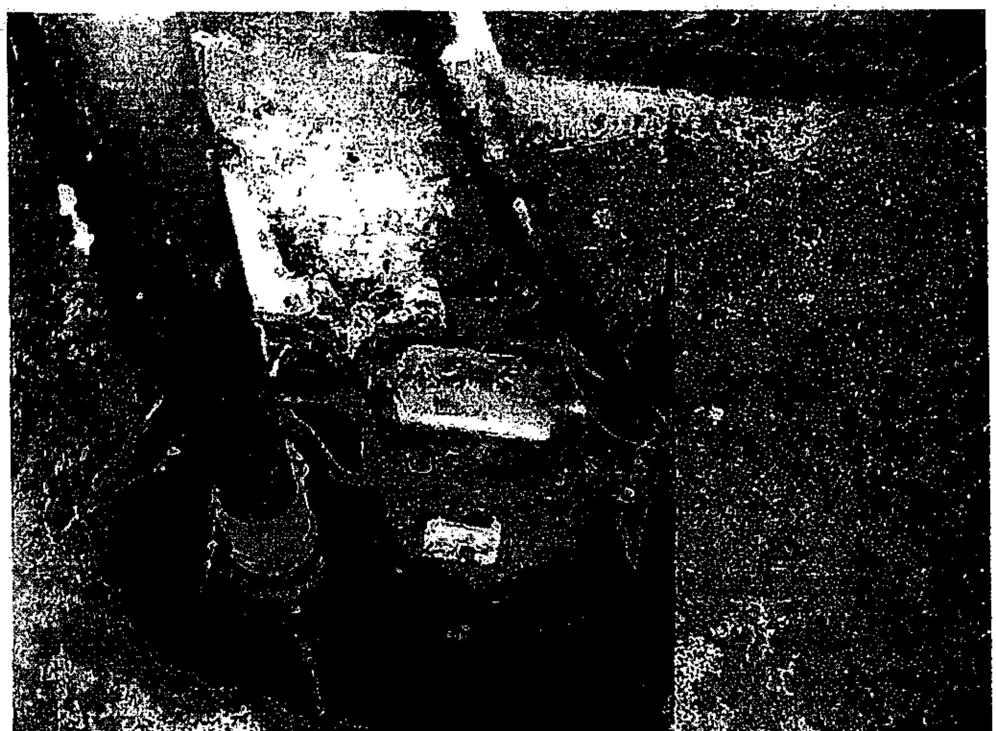
Photograph 2. Concrete masonry unit wall, north wall of elevator pit, looking north. Crack visible in grout between CMUs between approximately El. 117 and El. 118 (above black dotted line).



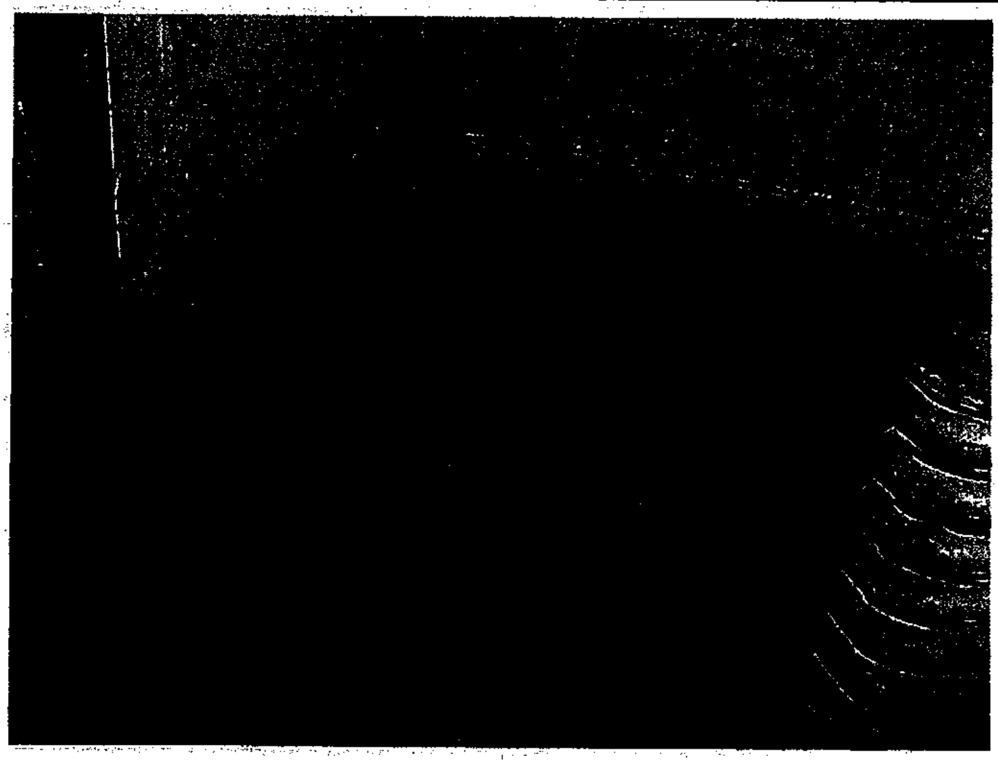
Photograph 3. Eastern wall of elevator pit, looking east. Wall is cast-in-place concrete from bottom to basement floor level, CMUs above. Southernmost PVC piping comes up from sump pump, apparently piped into foundation drainage system.

Photograph 4. Southeast corner of elevator pit, looking southeast. PVC piping from sump pump is approx. 1.25-in. OD. Sump pump is plugged into outlet shown.

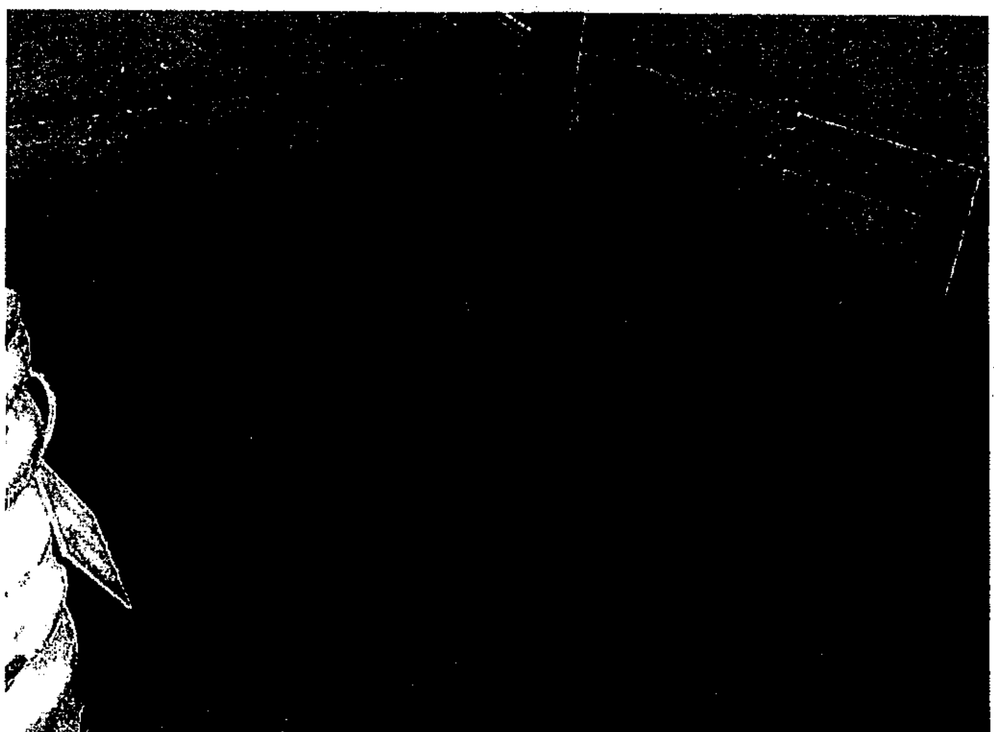
Photograph 5. Sump pump in roughly cut sump pit in southeast corner of elevator pit, looking down (southeast). Bottom of sump pit is 0.9 ft below top of elevator slab (El. 111.3), water level is 0.5 ft below top of slab (El. 111.7). Water apparently contains antifreeze.



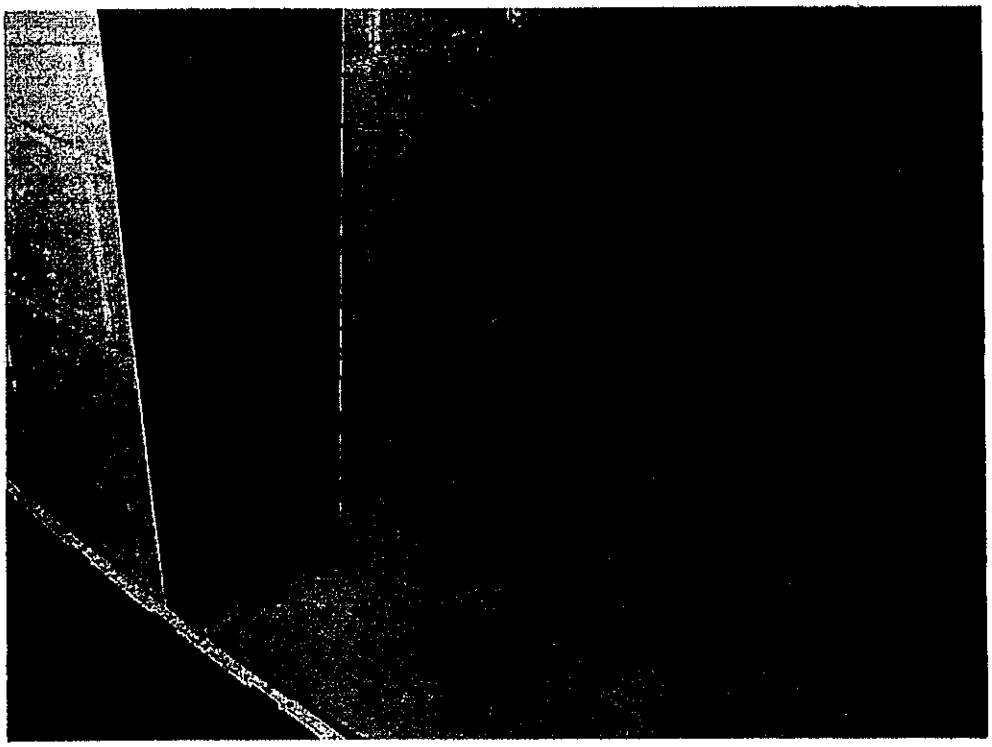
Photograph 6. Sump pump in roughly cut sump pit in southeast corner of elevator pit, looking down (south).



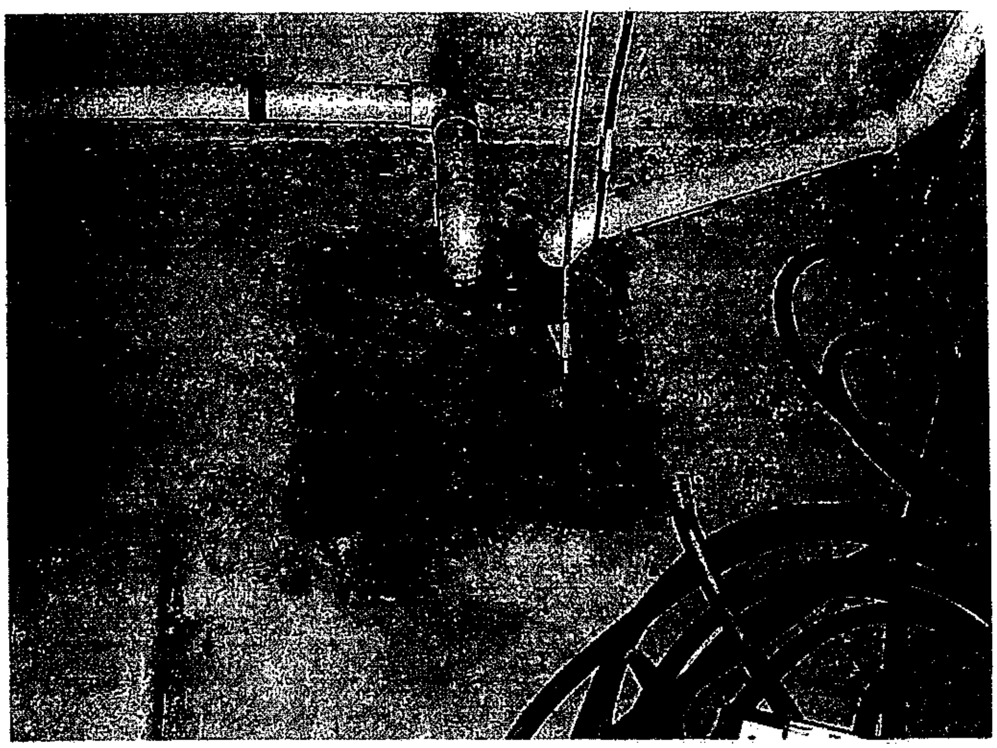
Photograph 7. Northwest corner of elevator pit, looking northwest. Apparent leachate from grout coats joint between CMU wall and cast-in-place wall and covers top of elevator pit slab in corner.



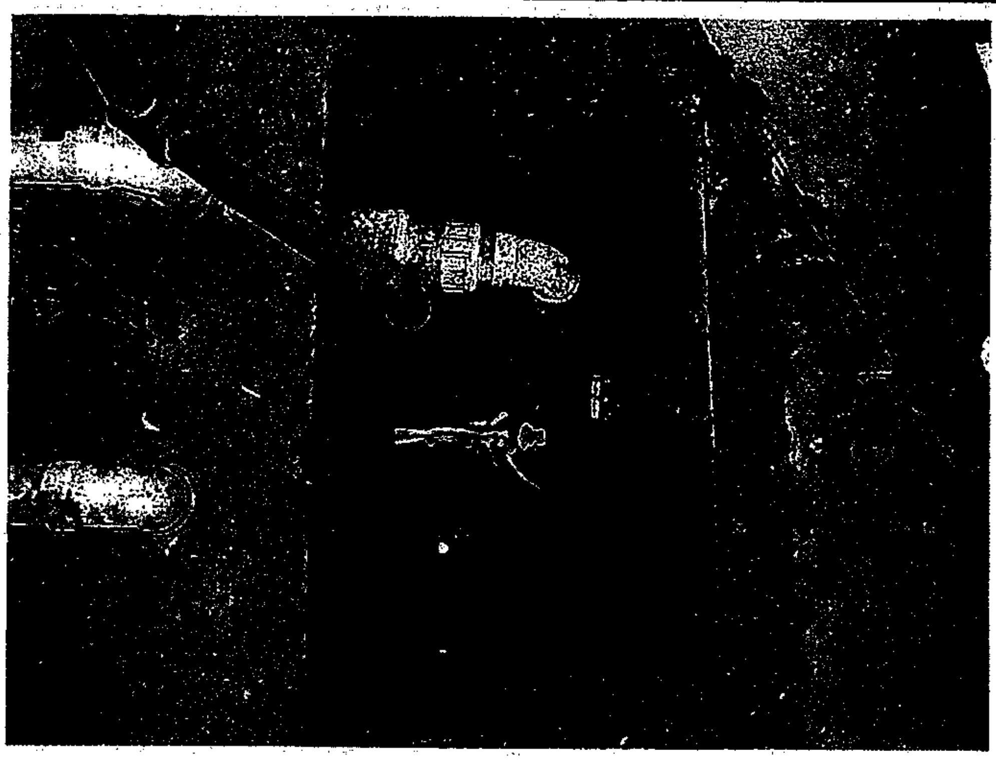
Photograph 8. Northeast corner of elevator pit, looking northeast. Apparent leachate from grout coats joint between CMU wall and cast-in-place wall and covers top of elevator pit slab in corner.



Photograph 9. PVC pipe from elevator sump pit (invert El. 116.5), extending through elevator wall and taking 90 degree bend down through floor slab, looking northwest.

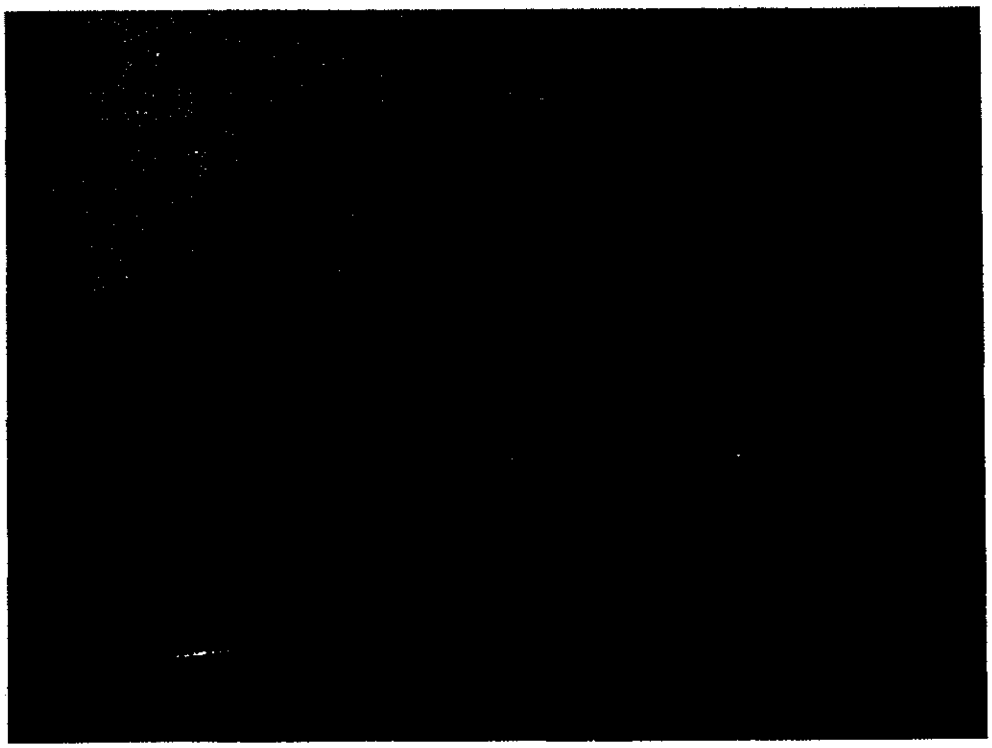


Photograph 10. Foundation drainage system sump pit, looking north. Documented measurements were taken through the hole with two cords extending through.

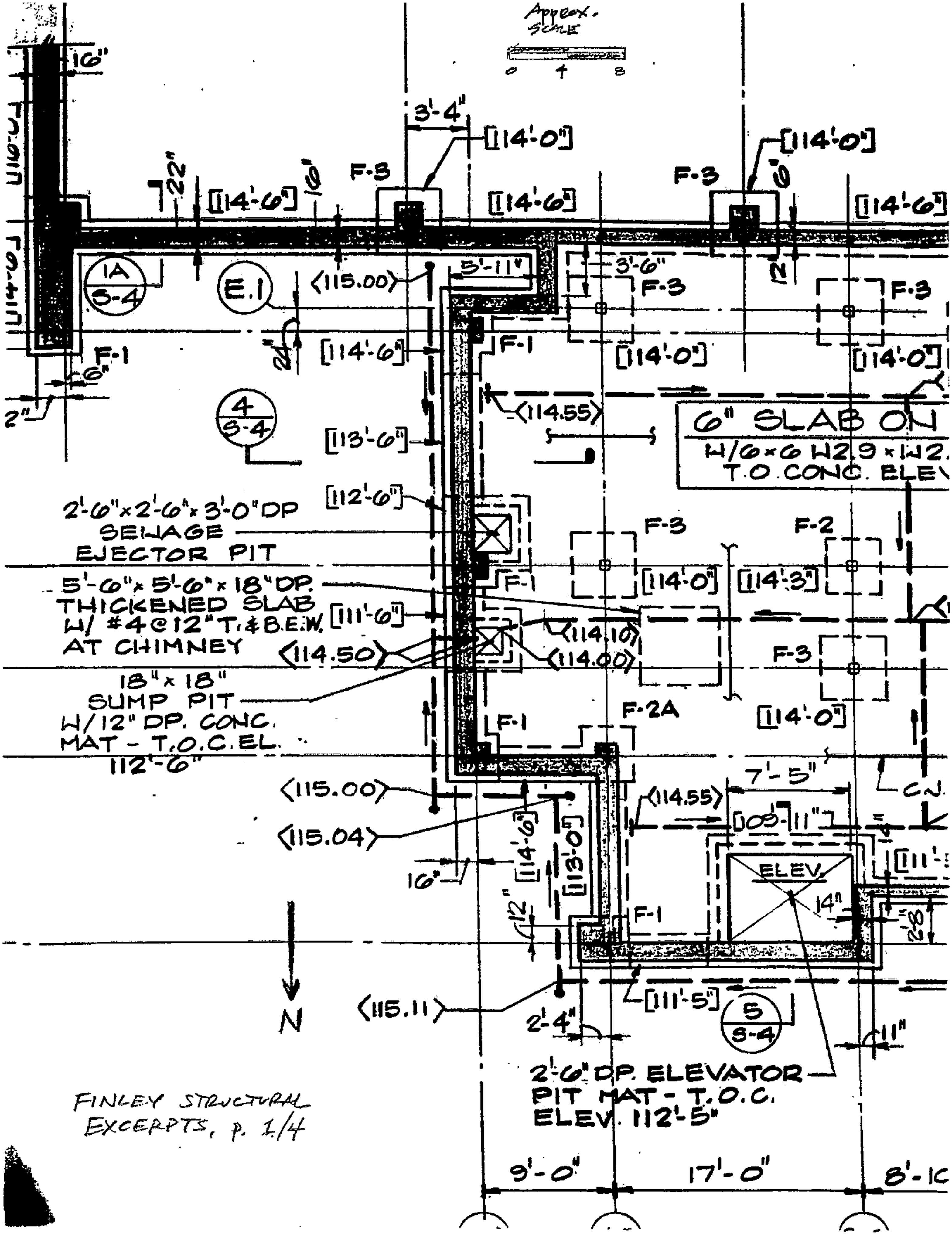


Photograph 11. Sewer ejector pit with steel plate removed, looking down (south). Top of sump pump visible with 2-in. diameter PVC effluent pipe, extending through portion of steel plate still in place.

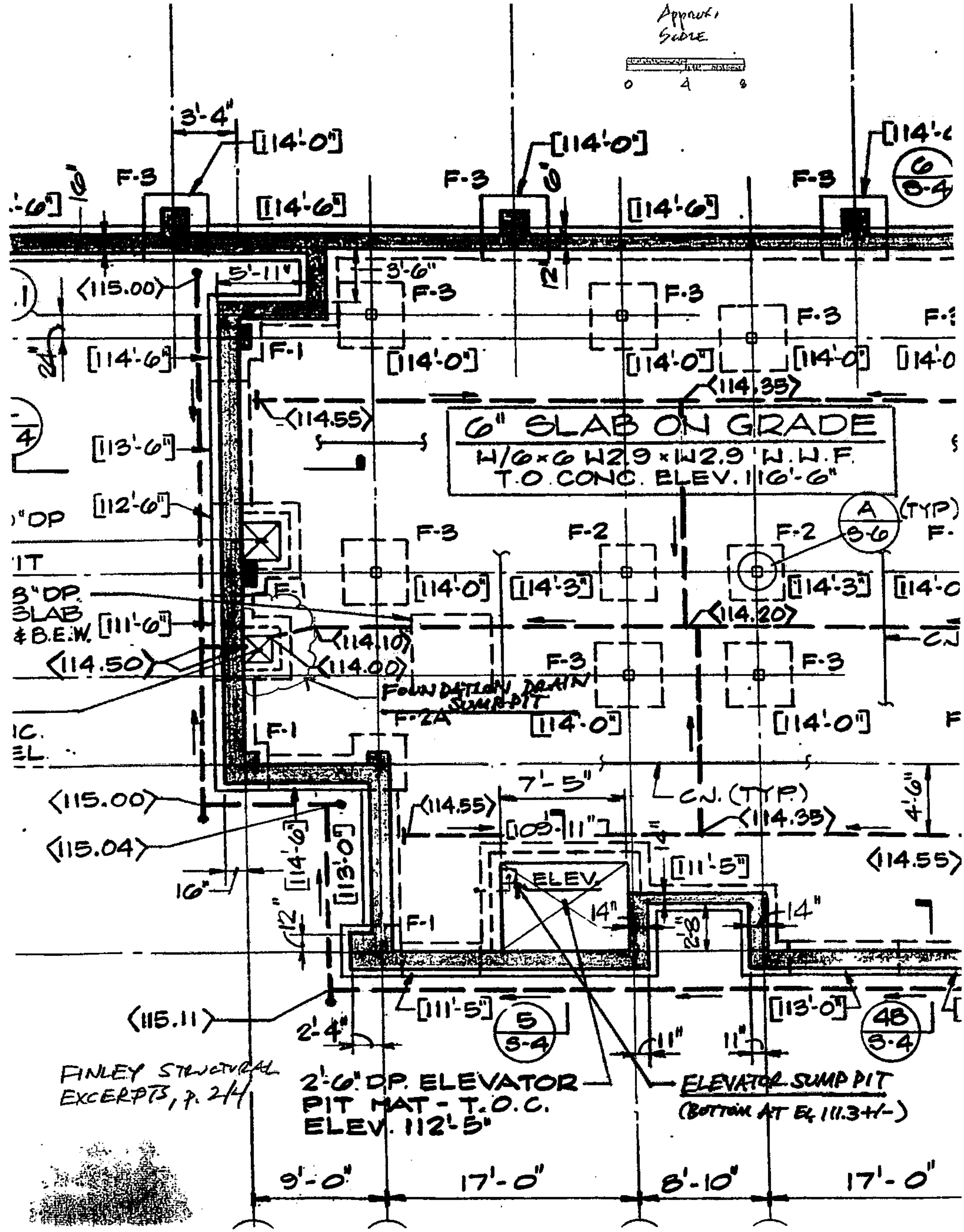
Photograph 12. Ejector sump pit, PVC pipes extending up wall, and control system for ejector pit, looking east.



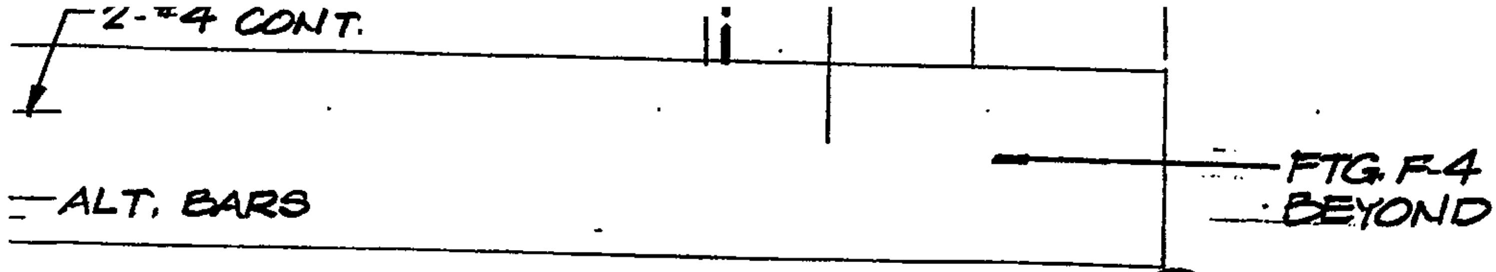
Photograph 13. Crack observed between CMU and cast-in-place concrete on east side of stairway wall, looking east. Maximum crack opening width was approximately 3/32 in. wide.



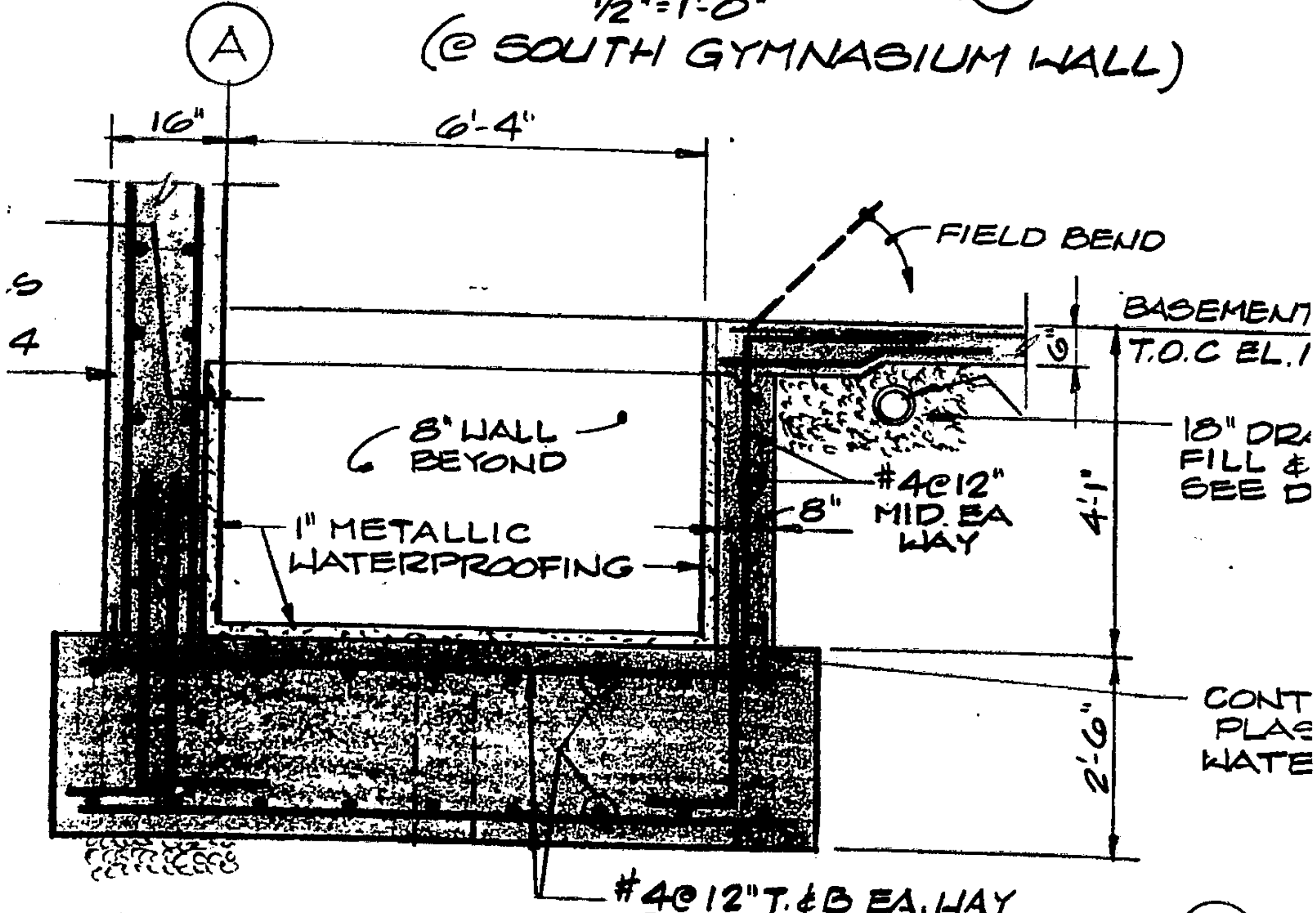
FINLEY STRUCTURAL
EXCERPTS, p. 1/4



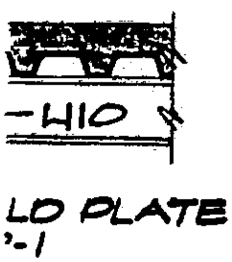
Approx. Scale
0 4 8
3'-4"
[114'-0"]
[114'-0"]
F-3
[114'-6"]
5'-11"
3'-6"
<115.00>
[114'-0"]
F-1
<114.35>
<114.55>
6" SLAB ON GRADE
W/6×6 W2.9 × W2.9 W.W.F.
T.O. CONC. ELEV. 116'-6"
[113'-6"]
[112'-6"]
F-2
A
S-6
(TYP)
8" DP.
SLAB
& B.E.W.
[111'-6"]
[114'-3"]
<114.20>
<114.10>
<114.50>
<114.00>
FOUNDATION DRAIN
SUMP PIT
F-2A
C.J. (TYP)
7'-5"
4'-6"
<115.04>
[114'-6"]
[113'-0"]
16"
12"
[109'-11"]
[111'-5"]
ELEV
14"
2'-8"
<115.11>
2'-4"
11"
5
S-4
48
S-4
6
FINLEY STRUCTURAL
EXCERPTS, p. 2/4
2'-6" DP. ELEVATOR
PIT MAT - T.O.C.
ELEV. 112'-5"
ELEVATOR SUMP PIT
(BOTTOM AT EL 111.3+/-)
9'-0"
17'-0"
8'-10"
17'-0"



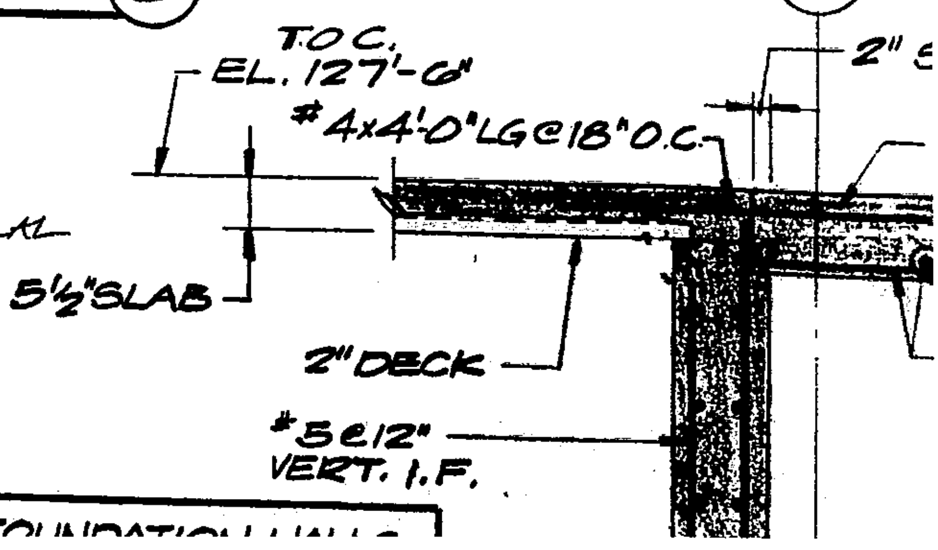
SECTION 2
1/2"=1'-0"
(@ SOUTH GYMNASIUM WALL)

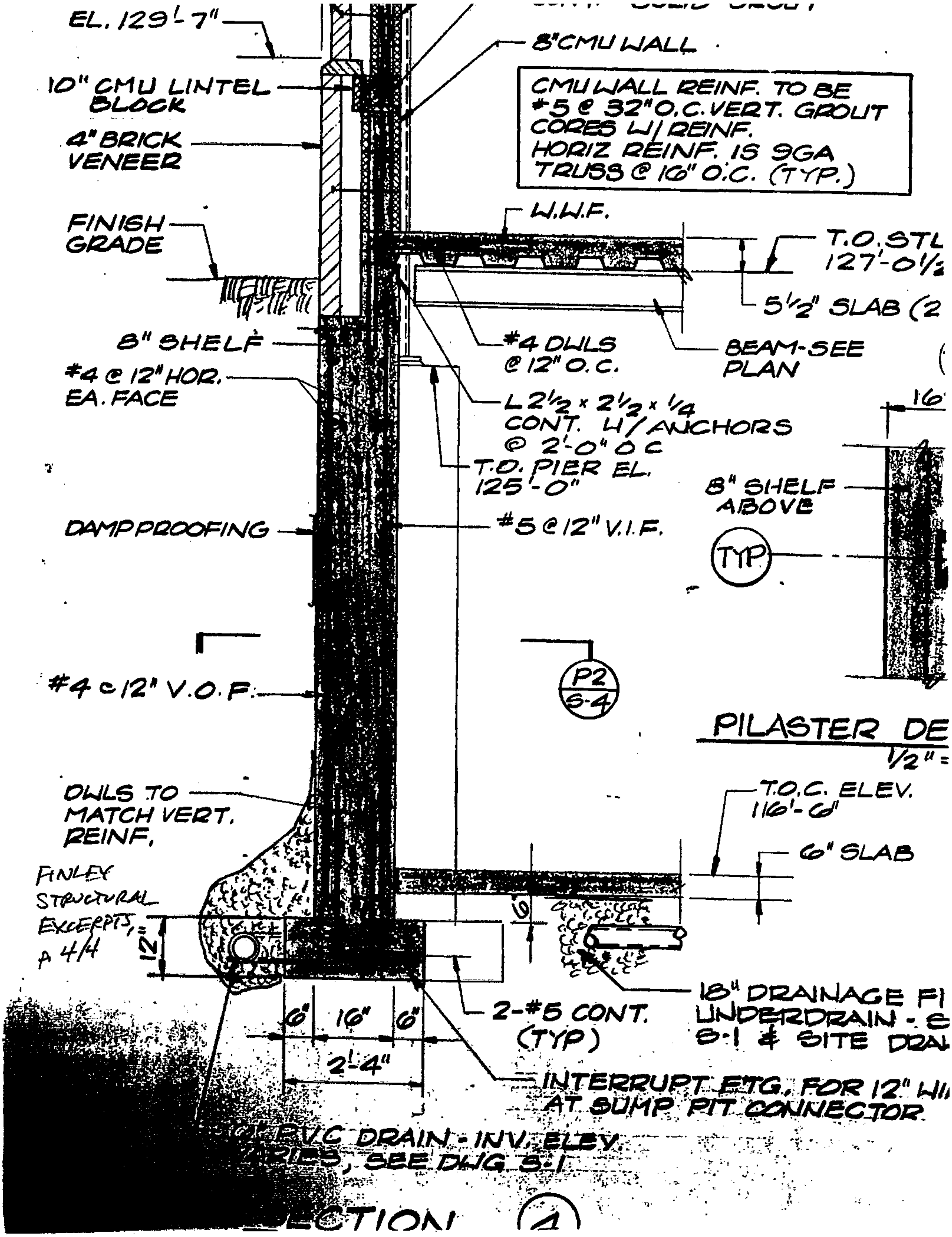


SECTION 5
1/2"=1'-0"



FINLEY STRUCTURAL
EXCEPTS, p. 3/4




EL. 129'-7"
8"CMU WALL
10" CMU LINTEL BLOCK
CMU WALL REINF. TO BE #5 @ 32"O.C. VERT. GROUT CORES W/ REINF. HORIZ REINF. IS 9GA TRUSS @ 16" O.C. (TYP.)
4" BRICK VENEER
W.W.F.
FINISH GRADE
T.O. STL 127'-0½
5½" SLAB (2
8" SHELF
#4 DWLS @ 12" O.C.
BEAM-SEE PLAN
#4 @ 12" HOR. EA. FACE
L 2½ x 2½ x ¼ CONT. W/ ANCHORS @ 2'-0" O C
T.O. PIER EL. 125'-0"
16"
8" SHELF ABOVE
DAMPPROOFING
#5 @ 12" V.I.F.
TYP
#4 @ 12" V.O.F.
P2
S-4
PILASTER DE
½" =
DWLS TO MATCH VERT. REINF.
T.O.C. ELEV. 116'-6"
6" SLAB
FINLEY STRUCTURAL EXCERPTS, p 4/4
12"
6"
6"
16"
6"
2-#5 CONT. (TYP)
2'-4"
18" DRAINAGE FI
UNDERDRAIN - S
S-1 & SITE DRAI
INTERRUPT FTG. FOR 12" WI
AT SUMP PIT CONNECTOR
PVC DRAIN - INV. ELEV.
ARIES, SEE DWG S-1
ECTION
4