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ADDENDUM NO. 1

TO THE

CONTRACT DRAWINGS AND SPECIFICATIONS

FOR

ENERGY & EFFICIENCY HVAC UPGRADES FOR THE
MILO PECK CHILD CARE SCHOOL
WINDSOR, CT

This addendum issued on December 6, 2021 shall form part of the Contract Documents dated November 10, 2021 and modifies the Contract Drawings and Specifications. The bidder shall acknowledge receipt of this addendum in the space provided on the bid form. Failure to do so may subject the bidder to disqualification. This addendum consists of Three Hundred and Three (303) pages.

I. SPECIFICATIONS:

Add Specifications attached to the Front End.

END OF ADDENDUM NO. 1

Mechanical • HVAC • Plumbing • Fire Protection • Electrical • Specialized Systems • Structural • Roofing

PART 1 - GENERAL

1.1 SUMMARY

A. This Section discusses the minimum requirements necessary for general coordination and precautionary measures which are to be undertaken by the Contractor during the progression of work generally specified as follows.

PART 2 - PRODUCTS

NOT APPLICABLE

PART 3 - EXECUTION

3.1 PROJECT COORDINATION AND SCHEDULING

A. The Contractor shall coordinate all construction activities with the Owner, including but not limited to demolition and window and siding installation, as necessary to minimize disruption with facility operations. Sufficient notice shall be provided by the Contractor as necessary for the Owner to make the necessary arrangements to relocate personnel and tenants surrounding areas of work.

B. Prior to the commencement of work, the Contractor shall submit a construction schedule to the Owner establishing the sequencing of work. Construction operations shall be scheduled in such a manner to accommodate the Owner and minimize disruption to facility operations.

3.2 PRECAUTIONARY MEASURES

A. The Contractor shall undertake all necessary precautions to avoid interference and/or disturbance of existing construction to remain resulting from, but not limited to, the demolition of windows and synthetic stucco finish. Any damage resulting from this work, shall be repaired at the Contractor's expense.

3.3 PROTECTION AND CLEANING

A. The Contractor shall maintain an uninterrupted means of building egress and roadway access at all times until completion of the work.

B. The contractor shall attend weekly job progress meetings with the Owner to discuss construction scheduling.

END OF SECTION 01051

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

A. Work of this Section shall be governed by the Contract Documents. Provide materials and services necessary to furnish and deliver the work of this Section as specified herein, and/or as required by job conditions.

1.2 SHOP DRAWINGS AND PRODUCT DATA

A. Definitions
   1. Shop Drawings are drawings, diagrams, schedules and other data specially prepared for the Work by the Contractor or any Subcontractor, Manufacturer, Supplier or Distributor to illustrate some portion of the work.
   2. Product Data are illustrations, standard schedules, performance charts, instructions, brochures, diagrams and other information furnished by the Contractor to illustrate a material, product or system for some portion of the work.
   3. Samples are physical examples which illustrate materials, equipment or workmanship and establish standards by which the work will be judged. See Schedule of Samples under each Section of the Specifications.

B. The Contractor shall review, approve and submit, within seven (7) days after receipt thereof and in such sequence as to cause no delay in the Work or in the Work of the Owner or any separate contractor, all Shop Drawings, Product Data, Samples and Certificates required by the Contract Documents.

C. By approving and submitting Shop Drawings, Product Data Samples, the Contractor represents that he has determined and verified all materials, field measurements, and field construction criteria related thereto, or will do so, and that he has checked and coordinated with information contained within such submittal with the requirements of the Work of the Contract Documents.

D. The Contractor shall "not be relieved of responsibility" for any deviation from the requirements of the Contract Documents by the Engineers review of Shop Drawings, Product Data or Samples unless the Contractor has specifically informed the Engineer in writing of such deviation at the time of submission and the Engineer has given written notice to the specific deviation. The Contractor shall not be relieved from responsibility for errors or omissions in the Shop Drawings, Product Data or Samples by the Engineer's review thereof Contract Documents indicate the work to be performed.

E. The Contractor shall direct specific attention, in writing or on resubmitted Shop Drawings, Product Data or Samples to revisions other than those requested by the Engineer on previous submittal.

F. No portion of the Work requiring submission of a Shop Drawing, Product Data or Samples shall be commenced until the submittal has been reviewed by the Engineer. All such portions of the Work shall be in accordance with reviewed submittal.

1.3 SUBMISSION PROCEDURES

A. After the date specified for commencement of work the Contractor, within a mutually agreed to time with Engineer and Owner, -shall submit a shop Drawing Schedule to the Engineer, This schedule shall be broken down into the various items of work and shall list a "Begin" date and a "Complete" date for Shop Drawing Submission.

B. Submit to the Engineer Shop Drawings, Product Data and Samples in sufficient time to allow at least fifteen **(15)** working days for review. Submittal **shall be** checked and signed **by** the Contractor prior to submission to indicate that the Contractor has coordinated the work and that it conforms to the Contract Documents.

C. When catalog cuts, brochures, product data or other printed data are sent to the Engineer for review, a minimum of four **(4)** copies **of** each shall **be** submitted.

D. The quantities and types of samples are listed in each Section of the Specifications.

E. Each Shop Drawing shall contain a title block with provisions for the following:
1. Number and title of drawing.
2. Date of drawing and revision
3. Name of project building or facility.
4. Name of Contractor or Subcontractor submitting drawing.
5. Specification Section title and number,
6. Space for Engineer's stamp and received stamps (51lx5l').

F. Each Shop Drawing shall have listed on it all contract reference drawing numbers plus shop drawing numbers on related work by other Subcontractors if available. The Engineer's drawings may not be reproduced and submitted as Shop Drawings, unless consent is obtained from the Engineer in writing prior to such use.

G. Each Shop Drawing submission shall have indicated on the Drawing a submission number (whether first, second, third, etc.) and each submission after the first submission shall be clear of all previous stamps.

H. Shop Drawings for work of one trade shall be checked by Subcontractors of related trades if available, and shall have received their stamp of approval, before being submitted to the Engineer.

I. Shop Drawings which involve change or variances with Contract Documents shall be so noted by the Contractor, and the Owner and Engineer shall be advised in writing of the recommended change and reasons for such changes.

1.3 ENGINEER'S ACTION

A. After the completion of his checking, the Engineer will return the (2) two copies of shop drawings to Contractor marked in one of the following ways. As explained below.

With notation as follows:

corrections or comments made on the shop drawings during this review do not relieve contractor from compliance with requirements of the drawings and specifications. This check is only for review of general conformance with the design concept of the project and general compliance with the information given in the Contract Documents, The Contractor is responsible for confirming and correlating all quantities and dimensions- selecting fabrication processes and techniques of construction; coordinating his work with that of all other trades-, and performing his work in a safe and satisfactory manner.

B. EXPLANATION OF COMMENTS

1. No Exceptions Taken: No corrections, contractor may proceed with the work; only these drawings should be used for fabrication and in the field.
2. Comment Attached, Resubmit: minor amount of corrections; all items can be fabricated in accordance with notes; review is completed; record copy incorporating the minor changes, must be submitted and shall not be considered as a re-submission.
3. Rejected: Drawings and/or catalogs are rejected as not in accordance with design concept of the project and information given in the contract documents.
4. Remarks: See note on shop drawings review stamp. Changes in shop drawings, other than those noted by Engineer shall be brought to Engineer's attention in writing.

C. Shop Drawings that are returned: "Revise and Resubmit" or "Rejected" shall be corrected and resubmitted to the **Engineer** promptly.

D. The review of a specific item shall not imply review of an entire assembly of which the item is a component unless the whole assembly is submitted and approved.

E. Engineer may withhold review on any Shop Drawing until Shop Drawings indicating all related items have been submitted. Submit (and Resubmit) Shop Drawings for such related items as approximately the same date to permit coordinating checking,

1.4 SAMPLES

A. Submit for review, to the Engineer, samples of materials listed under each Section of the Specification. Samples shall be properly labeled for identification, consisting of the following information-. Job Titles, Sample No, and Submission No.

B. Do not commence work under Sections of the Specifications until the Engineer's review in writing is obtained for all listed samples.

C. Do not construe review of advance samples as total guarantee of acceptance of materials. Materials will be submitted to field inspections, from time to time, as work progresses.

D. Samples of Specific manufactured product shall be accomplished with appropriate manufacturers literature at time of submission.

1.5 PROGRESS SCHEDULE

A. The Contractor shall prepare a construction schedule in a form acceptable to the Engineer and Owner within two (2) weeks from the execution date of the Contract for the Engineer's and Owner approval.

B. The progress schedule shall be in the form of a network schedule chart.

C. The progress schedule shall be updated at least once a month or more frequently, if necessary, should the Project be faced with the threat of delay for any reason. Should changes that have occurred since previous submission of updated schedule, indicate progress of activity, show completion dates.

D. Furnish the Engineer and the Owner with sufficient copies of the original schedules and all updated schedules as the Owner or Engineer may require.

E. After approval of the schedule, the Contractor shall be responsible for seeing that it is adhered to, and for ascertaining that proper coordination is maintained between all work of the Contract.

1.6 SCHEDULE OF VALUES

A. The Contractor shall submit to the Engineer and Owner a Schedule of Values, on form supplied by Owner, at least ten (10) days prior to submitting the first application for payment

B. The Schedule of Values shall list the breakdown of the work generally following the Table of Contents of this Specification, with identification of project, issue date, Contractors name and address.

C. Each item shall be accompanied by a dollar value rounded off to the nearest ten dollars. As requested by the Engineer support values given with data that will substantiate their correctness.

D. The use of the Schedule of Values shall be only as a basis for Contractor's Application for Payment.

E. Sum total of all costs of items listed in the Schedule shall be equal to the total contract sum.

F. The Schedule of Values shall be submitted each month along with the Application for the payment.

1.7 MATERIAL AND EQUIPMENT LIST

A. Within appropriate time after the date of award of the Contract, the Contractor shall submit for approval a complete list of suppliers, materials and equipment proposed for use in connection with the Project.

B. After a material piece of equipment has been approved, no change in brand or make will be permitted unless satisfactory written evidence is presented and approved by the Engineer that the manufacturer cannot make scheduled delivery of approved material, or that material delivered has been rejected and the substitution of a suitable material is an urgent necessity, or that other conditions have become apparent which indicate that the approval of such other material is in the best interest of the Owner.

1.8 PRODUCT ACCEPTANCE STANDARDS

A. Where the words "or and acceptable equal" or other synonymous terms are used, it is expressly understood that they shall mean that the acceptance of any such

submission is vested in the Engineer, whose decision shall be final and binding upon all concerned. All submissions are subject to such review.

B. The intent of this article is to encourage and permit competition on qualified products by reputable and qualified Contractors, suppliers and manufacturers, whose product, reputation and performance warrant review for the conditions, intent of design and performance considerations.

C. When descriptive catalog designations including manufacturers name, product brand name, or model number are referred to in the Contract Documents, such designations shall be considered as being those found in industry publications of current issue at date of first invitation to bid.

D. When standards of the Federal Government, Trade Societies, or Trade Associations are referred to in the Contract Documents by specific date of issue, these shall be considered a part of this contract. When such references do not bear a date of issue, the current published edition at date of first invitation to bid shall be considered as part of this contract, Suppliers need not be a member of such trade societies or associations referred to in the Specifications.

E. Whenever any product is specified or shown by describing proprietary items, model numbers, catalog numbers, manufacturer, trade names or similar reference, the bidder obligates himself to submit proposals and accepts awards of contract based upon the use of such products. Use of such reference is intended to establish the measure of quality which the Engineer has determined as requisite and necessary for this project, Where two or more products are. chosen or specified, the bidder has his option of which to use, provided the product used meets all requirements of specifications and design criteria. The right is reserved to review proposed deviations of design, function, construction or similar differences which will effect the design intent

1.9 SUBSTITUTIONS

A. Requests for substitution will NOT be considered prior to Bid.

B. After the Contract has been executed, the Engineer will consider a formal request for the substitution of products in place of those specified under the following conditions:

1. The request is accompanied by complete data an the proposed substitution substantiating compliance with the Contract Documents including product identification and description, performance and test data, references and samples where applicable, and an itemized comparison of the proposed substitution with the products specified or named by addenda, with data relating to Contract time schedule, design and artistic effect where applicable.

2. The request is accompanied by accurate cost data on the proposed, substitution in comparison with the product specified, whether or not modification of the Contract Sum is to be a consideration.

C. Requests for substitution based on paragraph (1) above, when forwarded by the Contractor to the Engineer and Owner, are understood to mean that the Contractor.
   1. Represents that he has personally investigated the proposed substitute product and determined that it is equal or superior in all respects to that specified.
   2. Will provide the same guarantee for the substitution that he would for that specified.
   3. Certified that the cost data presented is complete and Includes all related costs under this contract, and that he waives all claims for additional costs related to thin substitution which subsequently become apparent and
   4. Will coordinate the installation of the accepted substitute, making such changes as may be required for the work to be complete in all respects, at no additional cost to the Owner and at no extension of the contract completion date.

D. Substitutions will not be considered if:
   1. They are indicated or implied on shop drawings submissions without the formal request required in paragraph (1) above; or
   2. for their implementation they require a substantial revision of the Contract Documents in order to accommodate their use,

END OF SECTION 01300

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section requires the selective removal and subsequent offsite disposal of all items on the Contract Drawings as required to complete the proposed scope of work.

1.2 SUBMITTALS

A. Submit schedule indicating proposed sequence of operations for selective demolition work to the Owner for review prior to start of work.

B. Take photographs of existing conditions of building surfaces, equipment, and adjacent improvements that might be misconstrued as damage related to the removal operations. File with the Owner prior to start of work.

1.3 JOB CONDITIONS

A. Occupancy: The building shall be occupied during this project. Conditions satisfactory to the building tenants and the Owner must be maintained throughout the project.

B. Condition of Structures: Owner assumes no responsibility for actual condition of items or structures to be demolished.
   1. Conditions existing at time of inspection for bidding purpose will be maintained by Owner insofar as practical.

C. Partial Demolition and Removal: Items indicated to be removed, but not salvaged but of salvageable value to the Contractor may be removed as the work progresses. Transport salvaged items from site as they are removed.
   1. Extended storage or sale of removed items on site will not be permitted.

D. Protections: Provide temporary barricades and other forms of protection to protect building tenants and the general public from injury due to selective demolition work.
   1. Provide protective measures as required to provide free and safe passage of building tenants and the general public to the occupied portions of the buildings.

   2. Provide interior and exterior shoring, bracing, or support to prevent movement, settlement, or collapse of any element to be demolished and adjacent facilities or work to remain.

   3. Protect from damage existing finish work that is to remain in place and becomes exposed during demolition operations.

   4. Remove protections at completion of the work.

E. Damages: Promptly repair damages caused to adjacent facilities by demolition work

F. Traffic: Conduct selective demolition operations and debris removal to ensure minimum interference with roads, streets, walks, or other occupied or used facilities.
   1. Do not close, block, or otherwise obstruct streets, walks, or other occupied or used facilities without written permission from authorities having jurisdiction. Provide alternate routes around closed or obstructed traffic ways if required by governing regulations.

G. Utility Services: Maintain existing utilities indicated to remain in service and protect them against damage during demolition operations.

H. Environmental Controls: Use water sprinkling, temporary enclosures, and other methods to limit dust and dirt migration. Comply with governing regulations pertaining to environmental protection.

   1. Do not use water when it may create hazardous or objectionable conditions such as ice, flooding, and pollution.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 PREPARATION

A. General:
   1. Cease operations and notify the Engineer immediately if safety of the structure appears to be endangered. Take precautions to support structure until determination is made as to continuing operations.

   2. Locate, identify, stub off, and disconnect utility services that are to be removed.

3.2 DEMOLITION

A. General: Perform selective demolition work in a systematic manner. Use such methods as required to complete work indicated on the Contract Drawings in accordance with governing regulations.

3.3 DISPOSAL OF DEMOLISHED MATERIALS

A. Remove from the building site, all debris, rubbish, and other materials resulting from demolition operations, on a daily basis. Transport and legally dispose off site.

   1. If hazardous materials are encountered during demolition operations, comply

with applicable regulations, laws, and ordinances concerning removal, handling, and protection against exposure or environmental pollution.

2. Burning of removed materials is not permitted on the project site.

3.4 CLEANUP AND REPAIR

A. General: Upon completion of demolition work, remove tools, equipment, and demolished materials from site. Remove protections and leave interior areas broom clean. Return elements of construction and surfaces to remain too a condition existing prior to the start of operations. Repair adjacent construction or surfaces soiled or damaged by the selective demolition work.

END OF SECTION 02070

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
   1. Preparing of subgrade for sidewalks, CDU pads, pavements and utility company vaults/pads.
   2. Excavating and backfilling for underground/buried electrical utilities/ appurtenances.
   3. Excavating for installation of retaining wall and fencing.

1.3 DEFINITIONS

A. Excavation consists of removal of material encountered to subgrade elevations indicated and subsequent disposal of materials removed.

B. Unauthorized excavation consists of removal of materials beyond indicated subgrade elevations or dimensions without specific direction of the Engineer. Unauthorized excavation, as well as remedial work directed by the Engineer, shall be at Contractor's expense.
   1. Backfill and compact unauthorized excavations as specified for authorized excavations of same classification, unless otherwise directed by Engineer.

C. Subgrade: The undisturbed earth or the compacted soil layer immediately below granular subbase, drainage fill, or topsoil materials.

1.4 SUBMITTALS

A. Submittals: Submit copies of the following directly to Architect and one to Owner:
   1. Intent of the actual excavation work to be performed and route of excavation.
   2. Protection of actual excavation from persons and automobiles.
   3. Proposed repairs of walks, driveways and lawn areas
   4. Expected time frame.

1.5 QUALITY ASSURANCE

A. Codes and Standards: Perform excavation work in compliance with applicable requirements of authorities having jurisdiction.

1.6 PROJECT CONDITIONS

A. Existing Utilities: Locate existing underground utilities in areas of excavation work. If utilities are indicated to remain in place, provide adequate means of support and protection during earthwork operations.
   1. Should uncharted, or incorrectly charted, piping or other utilities be encountered during excavation, consult utility owner immediately for directions. Cooperate with Owner and utility companies in keeping respective services and facilities in operation. Repair damaged utilities to satisfaction of utility owner.
   2. Do not interrupt existing utilities serving facilities occupied by Owner or others, during occupied hours, except when permitted in writing by Architect and then only after acceptable temporary utility services have been provided.
      a. Provide minimum of 72 hour notice to Owner, and receive written notice to proceed before interrupting any utility.

B. Use of Explosives: Use of explosives is not permitted.

C. Protection of Persons and Property: Barricade open excavations occurring as part of this work and post with warning lights.
   1. Operate warning lights as recommended by authorities having jurisdiction.
   2. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earthwork operations.
   3. Perform excavation by hand within dripline of large trees to remain. Protect root systems from damage or dryout to the greatest extent possible. Maintain moist condition for root system and cover exposed roots with moistened burlap.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

A. Satisfactory soil materials are defined as those complying with ASTM D2487 soil classification groups GW, GP, GM, SM, SW, and SP.

B. Unsatisfactory soil materials are defined as those complying with ASTM D2487 soil classification groups GC, SC, ML, MH, CL, CH, OL, OH, and PT.

C. Subbase Material: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, crushed slag, and natural or crushed sand.

D. Drainage Fill: Washed, evenly graded mixture of crushed stone, or crushed or uncrushed gravel, with 100 percent passing a 1 1/2 inch sieve and not more than 5 percent passing a No. 4 sieve.

E. Backfill and Fill Materials: Satisfactory soil materials free of clay, rock or gravel larger than 2 inches in any dimension, debris, waste, frozen materials, vegetation and other deleterious matter.

PART 3 - EXECUTION

3.1 EXCAVATION

A. Excavation is unclassified and includes excavation to subgrade elevations indicated, regardless of character of materials and obstructions encountered.

3.2 STABILITY OF EXCAVATIONS

A. General: Comply with local codes, ordinances, and requirements of agencies having jurisdiction.

B. Slope sides of excavations to comply with local codes, ordinances, and requirements of agencies having jurisdiction. Shore and brace where sloping is not possible because of space restrictions or stability of material excavated. Maintain sides and slopes of excavations in safe condition until completion of backfilling.

C. Shoring and Bracing: Provide materials for shoring and bracing, such as sheet piling, uprights, stringers, and cross braces, in good serviceable condition. Maintain shoring and bracing in excavations regardless of time period excavations will be open. Extend shoring and bracing as excavation progresses.

3.3 DEWATERING

A. Prevent surface water and subsurface or ground water from flowing into excavations and from flooding project site and surrounding area.

B. Do not allow water to accumulate in excavations. Remove water to prevent softening of foundation bottoms, undercutting footings, and soil changes detrimental to stability of subgrades and foundations. Provide and maintain pumps, well points, sumps, suction and discharge lines, and other dewatering system components necessary to convey water away from excavations.

C. Establish and maintain temporary drainage ditches and other diversions outside excavation limits to convey rain water and water removed from excavations to collecting or runoff areas. Do not use trench excavations as temporary drainage ditches.

3.4 STORAGE OF EXCAVATED MATERIALS

A. Stockpile excavated materials acceptable for backfill and fill where directed. Place, grade, and shape stockpiles for proper drainage.
   1. Locate and retain soil materials away from edge of excavations. Do not store within drip line of trees indicated to remain.
   2. Dispose of excess excavated soil material and materials not acceptable for use as backfill or fill.

3.5 TRENCH EXCAVATION FOR PIPES AND CONDUIT

A. Excavate trenches to uniform width, sufficiently wide to provide ample working room and a minimum of 6 to 9 inches of clearance on both sides of pipe or conduit.

B. Excavate trenches and conduit to depth indicated or required to establish indicated slope and invert elevations and to support bottom of pipe or conduit on undisturbed soil. Beyond building perimeter, excavate trenches to allow installation of top of pipe below frost line.
   1. Where rock is encountered, carry excavation 6 inches below required elevation and backfill with a 6 inch layer of crushed stone or gravel prior to installation of pipe.
   2. For pipes or conduit less than 6 inches in nominal size, and for flat bottomed, multiple duct conduit units, do not excavate beyond indicated depths. Hand excavate bottom cut to accurate elevations and support pipe or conduit on undisturbed soil.
   3. For pipes and equipment 6 inches or larger in nominal size, shape bottom of trench to fit bottom of pipe for 90 degrees (bottom 1/4 of the circumference). Fill depressions with tamped sand backfill. At each pipe joint, dig bell holes to relieve pipe bell of loads ensure continuous bearing of pipe barrel on bearing surface.

3.6 COLD WEATHER PROTECTION

A. Protect excavation bottoms against freezing when atmospheric temperature is less than 35 degrees F.

3.7 BACKFILL AND FILL

A. General: Place soil material in layers to required subgrade elevations, for each area classification listed below, using materials specified in Part 2 of this Section.
   1. Under grassed areas, use satisfactory excavated or borrow material.
   2. Under walks and pavements, use subbase material, satisfactory excavated or borrow material, or a combination.
   3. Under steps, use subbase material.
   4. Under piping and conduit and equipment, use subbase materials where required over rock bearing surface and for correction of unauthorized excavation. Shape excavation bottom to fit bottom 90 degrees of cylinder.

5. Backfill trenches with concrete where trench excavations pass within 18 inches of column or wall footings and that are carried below bottom of such footings or that pass under wall footings. Place concrete to level of bottom of adjacent footing.
   a. Concrete is specified in Division 3.
   b. Do not backfill trenches until tests and inspections have been made and backfilling is authorized by Architect. Use care in backfilling to avoid damage or displacement of pipe systems.

B. Backfill excavations as promptly as work permits, but not until completion of the following:
   1. Acceptance of construction below finish grade including, where applicable, dampproofing, waterproofing, and perimeter insulation.
   2. Inspection, testing, approval, and recording locations of underground utilities have been performed and recorded.
   3. Removal of concrete formwork.
   4. Removal of shoring and bracing, and backfilling of voids with satisfactory materials.
   5. Removal of trash and debris from excavation.

3.8 DISPOSAL OF EXCESS AND WASTE MATERIALS

A. Removal from Owner's Property: Remove waste materials, including unacceptable excavated material, trash, and debris, and dispose of it off Owner's property.

END OF SECTION 02300

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. The work in this section consists of the following:

B. The construction of concrete pads, sidewalks, aprons, etc. Their construction shall be on a gravel base course at the locations shown on the Contract Drawings or as ordered by the Engineer and in accordance with the Contract Drawings and Specifications. Replacement of sidewalks which have been damaged due to excavation shall be included.

1.3 SUBMITTALS

A. Concrete mix design (for 4000 psi), and material certificates for reinforcing steel, shall be submitted to the Engineer for approval prior to construction. Copies of test results from testing laboratories for 7 and 28 day concrete compressive strength and slump test results shall be submitted to the Engineer.

1.4 QUALITY ASSURANCE

A. Testing: Concrete shall be tested for compressive strength, slump, etc. in accordance with requirements of Division 3 for Concrete. Cost for testing laboratory services shall be per Division 1 requirements.

PART 2 - PRODUCTS

2.1 MATERIAL

A. Bank Run Gravel Base: Shall conform to Section 02200 of these Specifications for Gravel Fill.

B. Concrete: Shall conform to Division 3 of these Specifications; sidewalks, driveways, and slabs shall be 3500 psi air entrained 3/4 inch aggregate concrete. Surface aggregate shall be nominal size 1/2 inch and approved by the Engineer.

C. Portland Cement shall be Type II conforming to ASTM Standard C-150.

D. Coarse Aggregate shall be crushed stone or gravel consisting of hard, durable fragments of

rock of uniform quality throughout and shall conform to quality requirements of ASTM Standard C-33 except that the following limitations shall apply:

1. Soft particles - 2%

2. Chert as a soft impurity - 1%

3. Total of soft particles and chert as a soft Impurity - 2%

4. Flat and elongated particles (long dimension more than 5 times short dimension) - 15%

E. Fine Aggregate shall conform to ASTM Standard C-33 except as noted herein. Fine aggregate shall be natural sand consisting of clean, hard, durable, uncoated particles of quartz or other rock, free from lumps of clay, soft or flaky material, loam or other injurious material. Sand containing lumps of frozen material shall not be used.

F. Fine aggregate shall be uniformly graded from fine to coarse and shall meet the following gradation requirements:

Square Mesh Sieves	Percent Passing By Weight
3/8"	100
No. 4	95 - 100
No. 16	45 - 80
No. 30	20 - 55
No. 50	10 - 20
No. 100	2 - 10

G. Mixing water shall be clean, shall not be salty or brackish, and shall be free from oil, acid, and injurious alkali and vegetable matter.

H. Maximum water/cement ratio shall be 0.45 with 5 gallons of water per bag of cement maximum. Bags per cubic yard shall be 6.5.

I. The proposed design mix shall be submitted to the Engineer along with test results from a certified testing laboratory indicating the date the test was taken, the slump at time of test, the 7-day compressive strength, the 28 day compressive strength, and the percent of air content.

J. Slump shall be determined in accordance with ASTM Standard C-143 and shall be as follows:

1" Minimum
4" Maximum for sidewalks and slabs

K. Reinforcement: Where indicated on the Contract Drawings shall conform to Division 3 of these Specifications. Reinforcing steel fabric for sidewalks and pavements shall conform to AASHTO M55 for cold drawn steel.

L. Air-Entrained Portland Cement: And air-entrained admixtures shall conform to Division 3 of these Specifications and shall meet all the requirements of ASTM Standard C-260. The air content, as determined by ASTM Standard C-231 or C-173, shall be 4 to 6 percent.

M. Premolded Bituminous Expansion Joints: Shall consist of resilient premoulded bituminous impregnated cane fiber board with core stock weighing not more than 16 lbs per cubic foot, and with 35-50 percent asphalt content by weight, specifically made for sidewalk construction.

N. Liquid Membrane Forming Compounds shall conform to the requirements of AASHTO M 148 Type 2, Class B, or shall be a water-soluble linseed oil-based compound conforming to the requirements of AASHTO M 148, Type 2.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Excavation, including removal of any existing sidewalk or driveway shall be made to the required depths below the finished grade,. All soft and yielding material shall be removed and replaced with suitable material. Compact the subgrade to a smooth even surface per Section 02200 requirements for subgrade preparation.

B. Concrete sidewalks, pads, etc. shall be constructed as shown on the Contract Drawings and in conformance with the following requirements:

1. Bank Run Gravel Base: Shall be placed to the dimensions shown on the Contract Drawings and properly compacted. For sidewalks and slabs
the base shall be wetted and rolled with a minimum 5 ton power roller after the spreading of each layer.

2. Forms: Shall be of metal or wood, straight, free from warp and of sufficient strength to resist spring from the pressure of the concrete. Wood shall be of 2 inch surfaced plank, except that at sharp curves thinner material may be used provided sufficient bracing is maintained. Metal shall be of approved section and shall have a flat surface on the top. Forms shall be securely staked, braced, and held firmly to the required line and grade and shall be sufficiently tight to prevent leakage of

concrete or mortar. All forms shall be cleaned and oiled or wetted before concrete is placed against them. Premolded bituminous expansion joints 1/2 inch in thickness, shall be provided once every (30) feet for sidewalks or as otherwise indicated on the Contract Drawings for concrete, and shall be filled up to one half (1/2) inch below the surface of the walk or slab. All construction and expansion jointing shall extend to the bottom of the concrete and radial joints shall be installed on the curve walks. A similar joint shall be provided at each intersection of sidewalk and street curb and at walls abutting catch basins, structures and other fixed objects and at each intersection of sidewalk with concrete driveway and pavements. Sidewalks shall be separated from abutting buildings by a one-half (1/2) inch joint. Extend joint fillers full width and depth of joint, and not less than 1/2 inch or more than 1 inch below finished surface where joint sealer is indicated.

3. Air-Entrainment: Shall not be less than 5 %, nor more than 7 %, and shall be obtained and the concrete cured in accordance with the following:

(1) Curing Under Normal Weather Conditions: The Contractor shall have the option, upon approval of the Engineer, of using any of the following methods:

(a) Moist Curing: Immediately after finishing, the concrete surface shall be protected by careful covering with moist cotton mats. The mats shall be kept saturated for a period of seven (7) days.

(b) Cover Sheet Curing: As soon as practicable after finishing the concrete surface, waterproof paper or white polyethylene sheeting shall be carefully placed so that adjoining sheets shall overlap at least 12 inches, and the lap shall be securely weighted down to form a closed joint. Upon removal of the forms, the exposed edges shall be completely covered. Cover sheets shall remain in place for a period of seven (7) days. Reused cover sheets shall be in good condition in the opinion of the Engineer. If haircheckking develops before the cover sheets can be placed, moist curing mats shall be used for the initial 24-hours of the curing period, and cover sheets placed for the remaining six (6) days.

(c) Where moisture retaining covers are used, care shall be taken to cover the entire concrete surface including exposed sides of members. The covers shall be kept constantly moist and have sufficient strength to withstand wind and abrasive action. Covers shall be placed as soon as possible after free surface water has disappeared and the surface is hard enough to resist marring from the covers. Covers shall remain in place for seven (7) days.

(d) Liquid Membrane-Forming Compound: Compound shall be applied immediately following the disappearance of water seen following final finishing and before any marked dehydration of the concrete or surface checking occurs. The compound shall be applied by an approved pressure sprayer provided with an agitator device to prevent settlement.

4. The compound shall be applied in a continuous, uniform film at not less than one gallon per 200 square feet.

5. If the forms are removed before the seven (7) days curing period, the exposed sides shall be pointed, cleaned and covered with the compound.

6. Treated areas that become damaged by rain or wear shall be retreated to the original requirements.

7. Curing: Curing of concrete shall be by use of a colorless membrane type curing material which shall not permanently discolor the surface, or by moisture retaining covers of burlap, cotton, or watertight paper. Where curing compounds are used it shall be suitable to seal the surface of the concrete in one application and shall harden within 60-minutes after application. Curing material shall be applied to all exposed surfaces by means of approved spraying equipment. It shall be sprayed uniformly to the surface at a rate of one gallon per 200 square feet as soon as possible after free surface water has disappeared from the concrete surface.

8. Cold Weather Protection: When the Engineer directs the Contractor to provide protection against low temperatures during the curing period, the Contractor shall use one of the above curing methods and in addition, shall place a layer of hay or straw eight inches thick over the entire surface upon which shall be placed another layer of mats or cover sheets. The edges of the covers shall be firmly fastened in place. This protective covering shall be maintained in good condition by the Contractor for a minimum of seven (7) days or for such time as the Engineer may direct.

9. Placing Concrete: The correct cross-section of the base shall be checked before the concrete is placed by testing with a template of wood or metal, the bottom surface of which conforms to the desired cross-section. Any irregularities shall be corrected. The base shall be kept in a satisfactory condition by rolling with an approved roller, as often as may be necessary to maintain the required contour and compaction. Concrete shall be placed on a moist base. If the base is dry, it shall be thoroughly wetted a sufficient time prior to placing concrete.

C. The base shall not be allowed to dry out before the concrete is placed. Concrete shall not be placed in puddles of water. The Inspector must be present during concrete placement.

D. Any concrete laid during foul or cold weather is done at the Contractor's risk, and all damaged sections shall be removed and replaced at his own expense.

E. Removal of forms shall not commence from freshly placed concrete until concrete has set for at least 24 hours.

F. Finishing: The surface of the concrete sidewalks and pavements shall be a fine broom finish unless otherwise directed to be a wood float finish by the Engineer. Broom finish all walks and paved areas by drawing a fine-hair broom across concrete surface, perpendicular to line of traffic. Repeat operation if required to provide a fine line texture acceptable to Engineer.

G. On exposed aggregate paving, immediately after each slab has been floated, aggregate shall be broadcast and evenly distributed so that at least 85% of the surface is covered. Aggregate shall be thoroughly imbedded and surface shall be hand floated so that aggregate is completely surrounded and slightly covered with grout.

H. At proper time, as determined by test sample, the aggregate shall be exposed by simultaneously brushing and hosing with water. Care shall be taken not to over-expose dislodge stones.

I. With Engineer's approval, a weak solution of acid may be used to clean such areas that do not show clear aggregate color.

J. The outside edges of the slab and all joints shall be edged to match existing or in the case where no match is required, the edge shall be tooled with a 1/4 inch radius edging tool. Weakened plane joints (dummy joints) will be provided as directed/or as provided on the Contract Drawings. Scoring pattern shall be per the Contract Drawings and shall be formed using a recommended cutting tool and finishing edges with a jointing tool to a proper condition, tools shall be frequently renewed to insure a minimum depth of 3/8" at all times. All tool marks made by edge and joint tool shall be float finished out to the edge of the joint.

K. In exposed aggregate concrete form weakened-plane joints using powered saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut joints into hardened concrete as soon as surface will not be torn, abraded, or otherwise damaged by cutting action.

L. Do not remove forms for 24 hours after concrete has been placed. After form removal, clean ends of joints and point-up minor honeycombed areas. Remove and replace areas or sections with major defects, as directed by Engineer.

M. Backfilling and Removal of Surplus Material: The sides of the sidewalks, driveways and

ramps and pavements shall be backfilled with suitable material, thoroughly compacted and finished flush with the top of the adjacent sidewalk, driveway ramp or pavement as indicated on the Contract Drawings or as ordered by the Engineer. All surplus material shall be removed and the site left in a neat and presentable condition to the satisfaction of the Engineer.

N.. Reinforcement: Shall be as indicated on the Contract Drawings in accordance with the applicable methods of Division 3 of the Specifications or as directed by the Engineer. Any existing exposed reinforcement to be incorporated in new sidewalks, ramps and slabs shall be wire brushed to remove rust, scale and excess concrete. Existing reinforcement shall be given one coat of bituminous or epoxy coating if ordered by the Engineer.

END OF SECTION - 02520

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions apply to this Section.

1.2 SUMMARY

A. This Section includes chain link fencing.

1.3 SUBMITTALS

A. Prepare and submit shop drawings of all components and layouts for review and approval.

B. Submit certificates stating that the quality of all materials supplied fully conforms to the requirements set forth in this specification.

1.4 GUARANTEE

A. Contractor shall guarantee that all materials, equipment and workmanship furnished shall be entirely free of defects and that he will repair or replace at his own expense any material, equipment or workmanship in which defects may develop within one year after date of final inspection and subsequent acceptance of the work by the Engineer.

PART 2 PRODUCTS

2.1 CHAIN LINK FENCE MATERIALS

A. Fence shall be 6'-0" or as indicated on the drawings.

B. Fabric shall be #9 gauge, chain link open hearth steel wire, hot-dipped galvanized after weaving with minimum coating of 2.0 ounce of zinc per square feet or aluminum coating with .40 ounces per square foot, woven in a 2” diamond mesh and #9 gauge, 3/8@ mesh hot-dipped galvanized as indicated above.

C. Line posts shall be SS.40 2-1/2” O.D. steel pipe, weight 2.28 lbs. per foot, hot-dipped galvanized.

D. Top and bottom rails shall be 1-5/8” O.D., Type I steel pipe, weight 2.27 lbs. per square foot or 1-5/8” O.D., Type II steel pipe, weight 1.84 lbs. per foot.

E. Concrete for setting posts shall be 3000 psi and shall conform to the requirements specified elsewhere.

F. Stretcher bar bands, tie wires, hogs rings, couplings, nuts, stretcher bars, bolts and miscellaneous fastening devices shall be manufacturer=s standard for heavy construction fence.

PART 3 - EXECUTION

3.1 FENCE INSTALLATION

A. The fence installation shall include furnishing all labor, materials and equipment necessary to complete satisfactorily all digging of post holes, installing fence, backfilling holes and cleanup.

B. Prior to the fence installations, all grading work and placement of topsoil shall be measurements from fixed points.

C. The fences shall be accurately located either through survey means or measurements from fixed points.

D. Post holes shall be neatly dug, either by hand or by mechanical means such as an auger.

E. Posts shall be evenly spaced and shall be set in concrete.

F. Install fence according to manufacturers instructions, using care to align, level and plumb each section.

G. End posts shall be braced; and corner posts shall have two braces.

H. Fabric shall be fastened to line posts with bands of No.9 gauge galvanized steel wire 5-1/4 inches long. These bands shall be spaced approximately 14 inches apart.

I. Provide top and bottom rails.

J. All upright and horizontal posts and rails shall be located on the inside face of fence.

K. Pipe posts shall have tops that exclude moisture.

L. Threaded Connectors and Accessories: After installation, all threaded connectors and accessories shall be peened or tack welded.

3.2 CLEANUP, INSPECTION, AND ACCEPTANCE

A. Upon completion of fence installation and prior to inspection and acceptance, removal from the site excess soil and debris and repair any damage to pavement, plantings, etc. a result of fence installations or removals.

END OF SECTION - 02820

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. All of the Contract Documents, including General and Supplementary Conditions and Division 0 - Bidding Documents, Contract Forms and Conditions of the Contract and Division 1 - General Requirements, apply to the work of this Section.

B. Carefully examine all of the Contract Documents for requirements which affect the work of this Section. The exact scope of work of this Section cannot be determined without a thorough review of all specifications sections and other Contract Documents.

1.2 REQUIREMENTS, CODES

A. All applicable portions of Division 1 - General Requirements shall be considered as included with this section.

B. The following are minimum requirements and shall govern that all Federal, Local and/or State Codes and Ordinances shall govern when their requirements are in excess hereof.

1.3 DESCRIPTION

A. Provide all materials, labor, equipment, services etc., necessary and incidental to the completion of all Formwork required and as specified herein.

B. Work included consists of but is not limited to the following formwork:
1. Exterior sidewalk slabs, aprons, ramps, curbs, etc.

C. Work installed but finished by others:
1. Setting of miscellaneous rough hardware, frames, angles, bolts, etc. Those items embedded in flat work concrete, not requiring formwork, shall be set by Concrete Contractor.

1.4 FORMING REQUIREMENTS

A. Forms shall be used, wherever necessary to confine the concrete and shape it to the required dimensions. Forms shall have sufficient strength to withstand the pressure resulting from placement and vibration of the concrete and shall have sufficient rigidity to maintain specified tolerances.

B. Provide all forms as required to form poured in place curbs, combination curb and gutters, sidewalks, pavements, exterior slabs, ramps, aprons, grade beams, etc.

1.5 QUALITY ASSURANCE

A. This contractor shall be required to have available at all time, for reference, the latest editions of the following regulations, standards, etc., which are hereby included in and made a part of these specifications.
   1. Recommended Practice for Concrete Formwork ACI 347.

   2. Specifications for Structural Concrete for Buildings ACI 301.

   3. Building Code Requirements for Reinforced Concrete ACI 318.

B. The design, engineering and construction of all formwork shall be the responsibility of the Formwork Subcontractor. Formwork design, allowable loads, lateral pressure and stresses shall be in accordance with Recommended Practice for Concrete Formwork ACI 347 and for wind loads and other applicable requirements of the controlling local building code.
   1. Tolerances for formed concrete shall not exceed ACI standards.

   2. This subcontractor shall maintain sufficient control points and benchmarks to establish locations of the construction and to remain specified tolerances.

1.6 JOB CONDITIONS

A. Make provisions for, coordinate with and provide access to Mechanical and Electrical Contractor for the installation of required pipe sleeves, conduit, etc.

B. Provide ample notice to all trades and subcontractors to facilitate installation of all items embedded in formed concrete.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Steel forms or form liners shall be standard commercially available prefabricated steel forms.

B. Fiberglass forms shall be standard quality.

C. Plywood forms shall be B-B plyform, Class I or Class II, 5/8@ minimum thickness, edge sealer.

D. Boards, sheathing and form lumber shall be No. 3, common or better, 3/4@ minimum thickness.

E. Framing lumber shall be standard or better.

F. Form accessories embedded in concrete shall be commercially manufactured type. Nonfabricated wire ties are not permitted.

2.2 CONSTRUCTION

A. All forms used for exposed concrete work shall be new plywood forms. Reused plywood forms, fiberglass forms and standard steel may be used for all concealed concrete work, provided that the reused forms are cleaned and re-oiled prior to reinstallation.

B. All exterior corners and edges of exposed concrete shall be chamfered or bullnosed.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Rigidly support and substantially construct forms. Forms shall be erected plumb, straight and true to line, shape and dimensions and in precise position to form the lines and designs indicated. Forms shall be suitable for removal without prying against the concrete. Make forms tight, without cracks or holes and prevent any leakage of mortar or loss of fine particles from the concrete. Knots that have loosened, leaving holes, holes that are not used and cracks that have opened up shall be covered with sheet metal for unexposed concrete. No loose knots, holes or cracks allowed for exposed concrete.

B. Set all miscellaneous rough hardware, etc. required to be cast-in formed concrete.
1. All items shall be firmly supported, in true alignment and plane and in accordance with approved erection and shop drawings.

C. Forms for exterior concrete sidewalks, slabs, pads, aprons, etc., shall be set directly in contact with prepared subgrade or base which shall be compacted for a sufficient distance outside the area of the pavement to support the form.
1. Forms shall be securely staked, braced and tamped into position. Top surface of form shall be set within a tolerance of 1/8@ in ten feet.

D. Surfaces of forms coming in contact with newly placed concrete shall be coated with an approved non-staining form oil, a commercial form release agent or a non-absorptive form liner to prevent bond with the concrete.
1. Do not permit coating to puddle or come in contact with reinforcing steel and hardened concrete at construction joints.

3.2 FORM REMOVAL

A. Formwork may be removed as soon as the concrete has hardened sufficiently to resist damage form removal operations and developed sufficient strength to sustain its own weight and any superimposed loads.

3.3 ADJUST AND CLEAN

A. After completion of all formwork this subcontractor shall remove all debris from site.

END OF SECTION - 03100

PART 1 - GENERAL

1.1 DESCRIPTION

A. Description of Work:
   1. Work under this Section shall consist of the furnishing of all labor, material, and equipment required for all concrete work in place, including footings, walls, slabs and all concrete work as required under Division 15 and 16.

1.3 QUALITY ASSURANCE

A. Applicable Codes:
   1. All work shall conform to the current editions of the following codes, standards and recommendations practices of the American Concrete Institute, except as modified in this Specification.
      a. Specification for Structural Concrete for Building, ACI 301.

      b. Recommended Practice for Concrete Floor and Slab Construction, ACI 302.

      c. Recommended Practice for Measuring, Mixing, Transporting, and Placing Concrete, ACI 304.

      d. Recommended Practice for Hot Weather Concreting, ACI 305.

      e. Recommended Practice for Cold Weather Concreting, ACI 306.

      f. Building Code Requirements for Reinforced Concrete, ACI 318.

   2. State of Connecticut Basic Building Code, Concrete Reinforcing Steel Institute (CRSI) and American Society for Testing and Materials (ASTM).
      a. Materials specified by ASTM Designation shall comply with the latest issue, amendment, and revision in effect.

B. Testing Agency:
   1. The Contractor will engage and pay for a commercial testing laboratory to test concrete used on the project.

   2. The Contractor shall provide concrete for cylinders, cooperate in making tests, and shall be responsible for notifying designated laboratory in advance of pours.

1.4 SUBMITTALS

A. Concrete Mix Design:
   1. The design of the concrete mixes using the materials specified shall be the responsibility of the Contractor as set forth under ASTM C94.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Portland Cement - a standard brand, conforming to the requirements of ASTM C150, Type 1. Use same brand type and source to supply throughout.

B. Fine aggregate - natural sand consisting of clean, hard, durable uncoated particles. Organic content shall be determined according to ASTM C40. Sand shall conform to the requirements and grading of ASTM C33.

C. Coarse Aggregate - crushed stone or crushed washed gravel from approved source, free of dirt and organic materials, conforming to the requirements and grading of ASTM C33.
   1. Max Aggregate Size: 1" for footings, and slabs on grade; 3/4" for walls, and slabs on metal deck.

D. Water - from approved source; clean, potable, and free form oils, salt, alkali, or organic matter.

E. Admixtures - formulate admixtures to avoid an increase in water-cement ratio or loss of strength. Each admixture shall be approved by the Engineer. No admixtures containing calcium chloride or other chlorides will be allowed. Each manufacturer shall submit in writing to the Engineer the chloride content of each admixture.
   1. Air entraining agent - shall conform to the requirements of ASTM C260, and shall be used in all concrete.

   2. Water reducing admixture shall be used in all concrete and conform to the requirements of ASTM C494. Submit proposed admixture for approval.

2.2 SPECIFIC CONCRETE REQUIREMENTS

A. Compressive strength at 28 days shall be not less than 3,000 psi.

B. The strength of the concrete proposed for use shall be established by testing prior to beginning concreting operation. A test consists of the average of three cylinders made and cured in accordance with ASTM C192 and tested in accordance with ASTM C39.

C. Slump shall not be more than 4 inches for vibrated concrete tested in accordance with ASTM C143.

D. Air content shall be 4% to 7%.

PART 3 - EXECUTION

3.1 PRIOR TO PLACING CONCRETE

A. Soil bottoms for footings and slabs shall be accepted by the Engineer before placing concrete. The subgrade shall be free of frost before concrete placing begins.

B. All space to be occupied by concrete shall be free from debris, ice, and water.
C. Prior to placing any concrete, the Contractor shall notify the Engineer 24 hours in advance so that formwork and reinforcing may be inspected. Do not place concrete until inspection has been made or waived.

3.2 MIXING

A. Concrete shall be ready mixed in conformance with the requirements of ASTM C94 for measurement of materials, batching, mixing and delivery, and shall be discharged within 45 minutes after mixing.

B. Mixing and conveying equipment shall be thoroughly clean and free from hardened concrete and foreign materials before concrete operation is started.

C. Water shall not be added to ready mixed concrete and the concrete shall not be mixed enroute to the project site. Water shall be added to the mix on the project site and mixed prior to its use.

D. Mixer shall produce a thoroughly mixed, uniform mass, and discharge the mixture without segregation. Entire batch shall be discharged before the mixer is recharged.

3.3 DEPOSITING CONCRETE

A. Depositing of all concrete shall be in accordance with ACI 304.

B. Concreting shall conform to the requirements of ACI 305 or 306 in hot or cold weather as required (above 70^{O}F and below 40^{O}F).

C. Unless adequate protection is provided by the Contractor and accepted by the Engineer, concrete shall not be placed during rain, sleet, or snow.

D. Concrete shall be conveyed from the mixer to the place of final deposit in a practically continuous flow by methods which will prevent the separation or loss of the ingredients. It shall be placed in the forms or on-grade as nearly as practicable to its final position and shall be thoroughly vibrated around all reinforcing bars and mesh to assure complete absence of voids. Under no circumstances shall partially hardened concrete be placed in the work.

E. Use of chutes longer than 10 feet is prohibited.

F. Concrete may be pumped. Use of aluminum alloys in the pumping train is prohibited.

G. Delivery Tickets:
   1. One copy of all concrete delivery tickets shall be furnished to the Engineer. Tickets shall be printed, stamped, or written and contain all the information as required by ASTM C94.

3.4 FINISHING

A. Vertical Surfaces:
   1. It is the intent of this Specification that forming operations be performed in a manner which will produce sound concrete surfaces free of bulges and offsets, with a minimum of fins, blemishes due to form defects, and honeycomb areas.

   2. Remove any cones remaining after ties are snapped off and patch all tie holes, including those below grade with concrete mortar.

B. Slabs:
   1. Included are all interior slabs on- grade.

   2. All finishing shall conform to the requirements outlined in ACI 307-latest revision, Chapter 11.
      a. Finished slab surfaces shall have a maximum variation in finish elevation of 1/8" in 8 feet from elevations shown on the Contract Drawings.

   3. Exposed walking surfaces, treads, etc:
      a. The surface shall be given a broom finish as outlined in ACI 301 (slip resistant).

   4. Interior slabs which are to receive floor finishes shall be given a steel trowel finish.

3.5 CURING

A. Protect concrete against surface temperature below 50^{O}F for at least 7 days after pouring. When heat of any kind is used, it shall be gradually reduced after the required minimum heating period, at the rate of not more than 2^{O}F per hour before discontinuing.

B. All concrete shall be kept constantly moist and protected against any drying action for not less than 7 days after placing of the concrete, and shall be accomplished in the following manner:
   1. Walls:
      a. Formwork shall not be removed for a minimum of 3 days.

      b. Prior to its removal, the formwork shall be kept wet to prevent any drying from solar heat.

      c. For the remainder of the curing period, the concrete shall be kept moist by continuous sprinkling or by the application of absorptive mats or other moisture retaining covering as accepted by the Engineer, kept continuously wet.

   2. All slabs, either slab on-grade, slabs on metal deck, or structural shall be cured in accordance with provisions of ACI 301, Chapter 8. The Contractor shall submit to the Engineer his proposed method(s) of curing.

3.7 TEST RESULTS

A. The average of the 28 day tests for any portion of the structure shall equal or exceed the specified strength.

B. No strength test shall have a value less than 90 percent of the specified strength.

C. If the concrete does not comply with these requirements, the Owner may require other tests, such as cored cylinders (in conformance with ASTM C42) or load tests at the Contractor's expense. Should the concrete fail to pass such tests, it shall be removed and replaced at no cost to the Owner.

END OF SECTION 03310

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Provide wood, fasteners, and other items required, and perform carpentry for the construction shown on the Drawings, as specified herein, and as needed for a complete and proper installation. These items include, but are not limited to:
   1. Rough carpentry work.

   2. Structural lumber.

   3. Rough hardware, including nails, bolts, screws, anchors, fasteners, sheet metal connectors, etc. as needed to secure any and all carpentry wood members.

   4. Blocking, furring, anchoring, grounding, stapling, nailers for work, etc. including those required for electrical and mechanical trades, etc.

   5. Provide pressure treated wood at the following locations: all wood used for curbs, blocking, shoes or plates which come in direct contact with concrete or masonry.

1.2 QUALITY ASSURANCE

A. Use adequate number of skilled workmen who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the work of this Section.

B. Conform to the requirements of the National Forest Products Association "National Design Specification for Wood Construction".
   1. Softwood Lumber Standards: Comply with PS 20 and with applicable grading rules of the respective grading and inspecting agency for the species and product indicated.

   2. Hardwood Lumber Standard: Comply with National Hardwood Lumber Association (NHLA) rules.

1.3 SUBMITTALS

A. Submit product data on all products proposed for usage.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Lumber shall be manufactured according to the requirements of the U.S. Department of Commerce American Softwood Lumber Standard, PS 20, and shall be graded by an agency certified by the Board of Review of the American Lumber Standards Committee.

B. Species shall be one of the species grades by above associations and intended for structural use. Treated wood shall be by Southern Pine.

C. Nonstructural wood shall be Stud Grade or S4s No. 3 grade or better.

D. Structural wood, including floor joists, stud walls, columns, and roof rafters shall be either Southern Pine or Douglas Fir-Larch #2 or better possessing the following allowable stresses:

	Allowable Stress (PSI)
Bending (Fb)	1,400 (multiple) 1,200 (single)
Horizontal Sher (Fv)	90
Compression (F)	1,000
Modulus of Elasticity (E)	1,600,000

2.2 OTHER MATERIALS

A. Provide other materials, not specifically described but required for a complete and proper installation, as selected by the Contract subject to the approval of the Engineer.

PART 3 - EXECUTION

3.1 SURFACE CONDITIONS

A. Examine the areas and conditions under which work of this Section will be performed. Correct conditions detrimental to timely and proper completion of the Work. Do not proceed until unsatisfactory conditions are corrected.

3.2 WORKMANSHIP

A. Install items, straight, true, level, plumb, and securely anchored into position.

B. Where blocking or backing is required, coordinate as necessary with other trades to assure placement of required blocking and backing in a timely manner.

C. Nailing shall conform to recommended nailing schedule of state building code.

D. Execute rough carpentry according to established good practice. Anchor work firmly to adjoining structure.

E. Provide wooden blocking in gypsum drywall partitions for door stops, shelf standards, accessories, and other applied products.

3.3 FRAMING GENERAL

A. Framing shall be nominal sizes and spacing as shown on Drawings.
   1. Cut framing square on bearings, closely fitted; accurately set to required lines and levels and plumb; secure rigidly in place at bearings and connections.

   2. Framing members for passage of pipes and duct to avoid cutting structural members. Do not cut, notch, or bore framing members for passage of pipes or conduits without permission. Reinforce framing members as directed where damaged by cutting with S.B.C.

3.4 INSTALLATION OF FRAMING

A. Stud Framing:
   1. Provide single bottom plate and double top plates for loadbearing partitions, 2" thick by width of studs.

   2. Provide single bottom plates and single top plates for non-load-bearing partitions, 2" thick by width of studs.

   3. Provide studs in continuous lengths without splices.

4. Overlap double top plate minimum of 6".

5. Nail bottom plate to wood construction.

6. Triple studs at corner and partition intersections.

3.5 STORAGE OF MATERIALS

A. All materials shall be packaged, delivered, stored and handled as to prevent the inclusion of foreign materials and damaged by water or leakage.

B. Storage and handling of materials shall be in a manner approved by the Engineer and consistent with good workmanlike practices.

3.6 CLEANING

A. Keep the premises in a neat, safe, and orderly condition at all times during execution of this portion of the Work, free from accumulation of sawdust, cut ends, and debris.

B. Sweeping:
1. At the end of each working day, and more often if necessary, thoroughly sweep surfaces where refuse from this portion of the Work has settled.

2. Remove the refuse to the area on the job site set aside for its storage prior to removal off-site.

3. Upon completion of this portion of the Work, thoroughly broom clean all surfaces.

END OF SECTION 06100

PART 1 - GENERAL

1.1 SCOPE

A. Provide all labor, materials, equipment, and services necessary to furnish, deliver, and install all finish carpentry and related work required by the Contract Drawings and/or generally specified herein. Work generally includes the following:
   1. Wood blocking
   2. Wood trim

1.2 PRODUCT STORAGE

A. Store lumber a minimum of six (6) inches off the ground in a dry, well ventilated place, protected from the weather. Lumber material sections directly exposed to moisture shall not be acceptable for application and shall be subject to approval by the Engineer.

1.3 SUBMITTALS

A. Submit samples of all proposed lumber and related associated fasteners.

PART 2 - PRODUCTS

2.1 LUMBER

A. All materials shall be subject to approval by the Engineer and shall conform to the Lumber Grade Use Guide of the National Lumber Manufacturer's Association.

B. Nominal sizes are indicated, except as shown by detail dimensions. Provide actual sizes as required by PS 20, for moisture content specified for each use.

C. Provide kiln dried (KD) lumber within an average moisture content range of not exceeding 12%.

2.2 FASTENERS

A. Fasteners and Anchorages: Provide size and type as indicated or as recommended by applicable standards, complying with applicable federal specifications for nails, screws, bolts, nuts, washers and anchorage devices.

B. Adequately secure all work in place in a rigid and substantial manner.

C. All proposed fasteners shall be corrosion and rust resistant, hot dip galvanized.

PART 3- EXECUTION

3.1 GENERAL REQUIREMENTS

A. All carpentry shall be erected true to lines, levels, and dimensions shown or required; shall be squared, aligned and plumbed; securely fastened in place in an approved manner.

B. The work shall be constructed in the most careful and thorough manner in accordance with details shown. All exposed finish surfaces and edges shall be finished smooth, free from marks, blemishes, or defacement caused by workmanship or manufacture.

C. All joints shall be neatly and accurately made, fitted tight, blocked, or otherwise assembled to avoid opening.

D. Carefully select all members. Select individual pieces so that knots and obvious defects will not interfere with placing fasteners or proper nailing or making proper connections.

E. Securely attach carpentry work to substrates by anchoring and fastening as shown and as required by recognized standards.

END OF SECTION 06300

PART 1 – GENERAL

1.1 SECTION INCLUDES

A. Spray-in-place rigid closed-cell polyurethane foam insulation in assemblies indicated on the Drawings, to provide an air barrier and improved thermal resistance. (HEATLOK SOY 200 PLUS) (HEATLOK XT) (HEATLOK HFO High-Lift)

B. Water based intumescing coating. (BLAZELOK IB4) (BLAZELOK TBX) (DC315)

1.2 RELATED SECTIONS

A. Section 03 30 00 - Cast-in-Place Concrete.

B. Section 06 10 00 - Rough Carpentry.

1.3 REFERENCES

A. ASTM International (ASTM).

B. International Code Council – International Residential Code.

C. International Code Council – International Building Code.

1.4 SUBMITTALS

A. Submit under provisions of Section 01300.

B. Before commencing work, submit in accordance with local code:
   1. Technical data sheet from the manufacturer showing the test results from the ASTM E84 (Surface Burning Characteristics).
   2. Other technical data sheets and samples as required by local code officials.

C. Product Data: Manufacturer's data sheets on each product to be used, including:
   1. Preparation instructions and recommendations.
   2. Storage and handling requirements and recommendations.
   3. Installation methods.

1.5 QUALITY ASSURANCE

A. Installer Qualifications:
   1. Contractor performing work under this section shall be trained by Demilec in applying spray polyurethane foam insulation.
   2. Provide current Demilec Authorized Contractor Certification.

B. Mock-Up: Provide a mock-up for evaluation of surface preparation techniques and application workmanship.
   1. Contractor performing work under this section shall be trained by Demilec in applying spray polyurethane foam insulation.
   2. Provide current Demilec Authorized Contractor Certification.
   3. Rework mock-up area as required to produce acceptable work.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Materials shall be delivered in manufacturer's original containers clearly labeled with manufacturer's name, product identification, safety information, net weight of contents and expiration date.

B. Material shall be stored in a safe manner and where the temperatures are in the limits specified by the material manufacturer.

C. Empty containers shall be removed from site on a daily basis.

1.7 PROJECT CONDITIONS

A. Maintain environmental conditions (temperature, humidity, and ventilation) within limits recommended by manufacturer for optimum results. Do not install products under environmental conditions outside manufacturer's recommended limits.

B. Ventilate area to receive insulation to maintain safe working conditions.

C. Protect workers as recommended by standards and manufacturer's recommendations.

D. Protect adjacent surfaces, windows, equipment and site areas from damage of overspray.

1.8 WARRANTY

A. Manufacturer's Warranty: Demilec warrants spray-in-place urethane foam insulation, when installed by authorized contractors using factory-trained applicators and applied in accordance to the Installation Instructions, will perform as stated in the Product Technical Data Sheet.
   1. This warranty is in effect throughout the life of the building provided the original purchaser registers with the Warranty Department of the Manufacturer within thirty days of occupancy.
   2. Manufacturer's sole responsibility under this Limited Lifetime Warranty shall be to repair or replace any defective Product at the cost of the material only.
   3. Manufacturer shall not be responsible for labor cost or any other costs whatsoever related to, or in connection with the removal or installation of either the original or replacement product.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturer:
1. Demilec, which is located at: 3315 E. Division St.; Arlington, TX 76011; Toll Free Tel: 888-261-7705; Tel: 817-640-4900; Fax: 817-633-2000; Email: buildingscience@demilec.com; Web: www.demilec.com

2.2 SPRAY FOAM INSULATION

A. Spray Applied Rigid Polyurethane Closed Cell Foam Insulation System:
1. Product: HEATLOK SOY 200 PLUS manufactured by Demilec, Arlington, TX
2. Product Approval:
a. International Code Council Evaluation Services Report #3210.
b. Approved for non-structural walls in building types I, II, III, IV, and V construction under IBC and dwellings for IRC.
c. Approved for exterior walls in building types I, II, III, and IV construction. (In progress.)
d. Passed AC 377 Appendix X compliant NFPA 286.
3. Installation:
a. Application with a prescriptive Thermal Barrier:
i. Up to 9-1/4 inches (235 mm) for wall cavities and 11-1/4 inches (286 mm) in floors or ceilings with 1/2 inch gypsum wall board or equivalent 15 minute thermal barrier in accordance with IBC 2603.4 or IRC R316.4.
b. Application without a Thermal or Ignition Barrier (exposed foam)
i. Up to 9-1/4 inches (235 mm) in walls and 11-1/4 inches (286 mm) in floors and ceilings with all foam surfaces covered with BLAZELOK TBX intumescent coating.
c. Application without a Thermal or Ignition Barrier (exposed foam)
i. Up to 5-1/2 inches (171 mm) in walls and 7-1/2 inches (190 mm) in floors and ceilings with all foam surfaces covered with 12 dry mils (18 wet mils) of BLAZELOK TBX intumescent coating.
ii. Refer to ESR 3210 Section 4.3 Thermal Barrier.
d. Attics and Crawlspaces: Passed AC 377 Appendix X compliant NFPA 286.
i. Up to 7-1/2 inches (190.5 mm) on vertical surfaces and 11-1/2 (292 mm) inches on the underside of the space with no intumescent coating.
e. Use on Attic Floors:
i. Up to 7-1/4 inches (190.5 mm) between and over the joists in attic floors.

f. Use as Water-Resistive Barrier:
    i. Minimum 1-1/2 inches (38 mm) continuous layer applied to suitable exterior substrate.
    ii. Refer to ESR # 3210 Section 4.5.
g. One-hour Fire-resistance-rated Wall Assembly: Nonload-bearing:
    i. Refer to ESR #3210 Section 4.6.

4. Physical Properties:
    a. Density (ASTM D 1622): 2.1 lb/ft3 (34 Kg/m3).
    b. Thermal Resistance (ASTM C 518): Aged R value at 1 inch (180 days at 76 degrees F (23 degrees C)) - R-7.4 (sf.h degree F/BTU).
    c. Water Vapor Permeance at 1.2 inches (ASTME 96-05): Less than 1 perms (is a vapor barrier per IBC Section 202 definitions at 1.2 inches)
    d. Air Permeance at 75 Pa at 1 inch (ASTME 2178-03): 0.02 L/sm2.
    e. Air Leakage of Air Barrier Assembly (static loading to 600 Pa and gust loading to 1,200 PA) Complies with ABAA requirements (ASTME 2357-05): Less than 0.02L/sm2 .
    f. Compressive Strength (ASTM D 1621): 28.7 psi (198 kPa).
    g. Tensile Strength (ASTM D 1623): 46.2 psi
    h. Off Gassing Test (VOC Emissions) (CGSB 51.23-92): Pass (no toxic vapor).
    i. Surface Burning Characteristics (ASTM E 84) 4 inches: Class I. Flame Spread Index 20, Smoke Developed Index 400.
    j. Closed Cell Content (ASTM D2856) : Greater than 90%.
5. Equipment used to apply the foam insulation shall have fixed ratio positive displacement pumps and approved by foam manufacturer.

B. Spray Applied Rigid Polyurethane Closed Cell Foam Insulation System:
1. Product: HEATLOK XT manufactured by Demilec, Arlington, TX
2. Product Approval:
    a. International Code Council Evaluation Services Report 3824: HEATLOK XT-s.
    b. International Code Council Evaluation Services Report 3883: HEATLOK XT-w.
    c. Code Compliance Research Report, (CCRR) designed by Deer Ridge Consulting, Inc.
    d. Approved for use in building types I, II, III, IV, and V construction under IBC and dwellings for IRC.
    e. Approved for use in wall cavities, floor assemblies, ceiling assemblies, and attics and crawl spaces in Type VB construction under IBC and dwellings under IRC.
    f. Passed AC 377 Appendix X compliant NFPA 286.
3. Installation:
    a. Application with a prescriptive Thermal Barrier:

i. There is no thickness limit when installed in floors or ceilings behind 1/2 inch gypsum wall board or equivalent 15 minute thermal barrier in accordance with IBC 2603.4 or IRC R316.4.

b. Application without a Thermal or Ignition Barrier (exposed foam)
   i. Up to 11-1/2 inches (292 mm) on the underside of the roof sheathing or in floor assemblies and 7-1/2 inches (191 mm) on vertical surfaces with all foam surfaces covered with 12 dry mils of DC-315 Fireproof Paint.

c. Application without a Thermal or Ignition Barrier (exposed foam)
   i. Up to 11-1/2 inches (292 mm) on the underside of the roof sheathing or in floor assemblies and 7-1/2 inches (191 mm) on vertical surfaces with all foam surfaces covered with 12 dry mils (18 wet mils) of BLAZELOK TBX intumescent coating.
   ii. Refer to ESR 3824 & 3883 Section 4.3 Thermal Barrier.

d. Attics and Crawlspaces: Passed AC 377 Appendix X compliant NFPA 286.
   i. Up to 11-1/2 inches (292 mm) on the underside of the roof sheathing or in floor assemblies and 7-1/2 inches (191 mm) on vertical surfaces, the insulation may be left exposed without a thermal barrier, ignition barrier or intumescent coating.

e. Use on Attic Floors:
   i. Up to 11-1/2 inches (190.5mm) between and over the joists in attic floors.

f. Use as Vapor Retarder:
   i. Class II vapor retarder at less than 1.0 perm, HEATLOK XT-s minimum thickness of 1.625 inches, HEATLOK XT-w minimum thickness of 1.10 inches.

4. Physical Properties:
   a. Density (ASTM D 1622): 2.1 lb/ft3 (34 Kg/m3).
      i. Summer: 2.23 lb/ft3 (34 Kg/m3).
      ii. Winter: 2.17 lb/ft3 (34 Kg/m3).
   b. Thermal Resistance (ASTM C 518): Aged R value at 1 inch (180 days at 76 degrees F (23 degrees C)) - R-7.4 (sf.h degree F/BTU).
      i. Summer: R 6.7 (sf.h degree F/BTU).
      ii. Winter: R 6.9 (sf.h degree F/BTU).
   c. Water Vapor Permeance at 1.2 inches (ASTME 96-05): Less than 1 perms (is a vapor barrier per IBC Section 202 definitions at 1.2 inches)
      i. Summer: At 1.625 inches, less than 1 perms.
      ii. Winter: At 1.1 inches, less than 1 perms.
   d. Air Permeance at 75 Pa at 1 inch (ASTME 2178-03): 0.02 L/sm2.
   e. Air Leakage of Air Barrier Assembly (static loading to 600 Pa and gust loading to 1,200 PA) Complies with ABAA requirements (ASTME 2357-05): Less than 0.02L/sm2 .
   f. Compressive Strength (ASTM D 1621): 28.7 psi (198 kPa).
      i. Summer: 18.0 psi (124 kPa).

ii. Winter: 23.1 psi (139 kPa).

g. Tensile Strength (ASTM D 1623): 46.2 psi
   i. Summer: 37.9 psi (261 kPa).
   ii. Winter: 53.7 psi (370 kPa).

h. Dimensional Stability (ASTM D 2126): percent volume change at 158 degrees F (70 degrees C) and 97 percent relative humidity:
   i. Summer: 5.45 percent.
   ii. Winter: 4.14 percent.

i. Off Gassing Test (VOC Emissions) (CGSB 51.23-92): Pass (no toxic vapor).

j. Surface Burning Characteristics (ASTM E 84) 4 inches: Class I. Flame Spread Index 5:
   i. Summer: Smoke Developed: 350-400.
   ii. Winter: Smoke Developed : 250-300.

k. Recycled Content:
   i. Summer: 22.7 percent.
   ii. Winter: 21.0 percent.

l. Fungi Resistance (ASTM C 1338): No Fungal Growth.

m. Closed Cell Content (ASTM D2856) : Greater than 90%.

5. Equipment used to apply the foam insulation shall have fixed ratio positive displacement pumps and approved by foam manufacturer.

C. Spray Applied Rigid Polyurethane Closed Cell Foam Insulation System:
1. Product: HEATLOK HFO High Lift manufactured by Demilec, Arlington, TX
2. Product Approval:
   a. Code Compliance Research Report, (CCRR) designed by Deer Ridge Consulting, Inc.
   b. Approved for use in building types I, II, III, IV, and V construction under IBC and dwellings for IRC.
   c. Approved for use in wall cavities, floor assemblies, ceiling assemblies, and attics and crawl spaces in Type VB construction under IBC and dwellings under IRC.
   d. Passed AC 377 Appendix X compliant NFPA 286.
3. Installation:
   a. Application with a prescriptive Thermal Barrier:
      i. There is no thickness limit when installed in floors or ceilings behind 1/2 inch gypsum wall board or equivalent 15 minute thermal barrier in accordance with IBC 2603.4 or IRC R316.4.
   b. Application without a Thermal or Ignition Barrier (exposed foam)
      i. Up to 11-1/2 inches (292 mm) on the underside of the roof sheathing or in floor assemblies and 7-1/2 inches (191 mm) on vertical surfaces with all foam surfaces covered with 12 dry mils of DC-315 Fireproof Paint or a minimum of 12 mils DFT of Blazelok TBX.

c. Attics and Crawlspaces: Passed AC 377 Appendix X compliant NFPA 286.
    i. Up to 11-1/2 inches (292 mm) on the underside of the roof sheathing or in floor assemblies and 7-1/2 inches (191 mm) on vertical surfaces, the insulation may be left exposed without a thermal barrier, ignition barrier or intumescent coating.
d. Use on Attic Floors:
    i. Up to 11-1/2 inches (190.5mm) between and over the joists in attic floors.
e. Use as Vapor Retarder:
    i. Class II vapor retarder at less than 1.0 perm, HEATLOK HFO High Lift minimum thickness of 0.7 inches.

4. Physical Properties:
    a. R-Value/in at 4 inch (ASTM C518): 7.5 ft2hdegreesF/BTU.
    b. R-Value/in at 1 inch (ASTM C518): 6.3 ft2hdegreesF/BTU.
    c. R-Value at 6.5 inches (ASTM C518): 48 ft2hdegreesF/BTU.
    d. R-Value at 4 inches (ASTM C518): 30 ft2hdegreesF/BTU.
    e. R-Value at 2 inches (ASTM C518): 14 ft2hdegreesF/BTU..
    f. Core Density (ASTM D 1622): 2.2 lb/ft3/
    g. Water Vapor Permeance (ASTM E 96): Less than 1 perm at 0.7 inches.
    h. Air Permeance at 75 Pa at 1inch (ASTM E 2178): Less than 0.02 L/sm2
    i. Air Leakage at 75 Pa at 1 inch (ASTM E 283): Less than 0.02 L/sm2.
    j. Compressive Strength (ASTM D 1621): 34.8 lb/in2 (240 kPa).
    k. Tensile Strength (ASTM D 1623): 101.3 lb/in2 (699 kPa).
    l. Dimensional Stability (ASTM D 2126): 11.4 (% volume change) at 158 degrees F (70 degrees C) 97% R.H.
    m. VOC Content, Greenguard Gold: PASS, Meets Criteria/
    n. Flame Spread (ASTM E84): Class I, 0-15.
    o. Smoke Developed (ASTM E84): Class I, 350 - 400.
    p. Recycled Content, Finished Foam Renewable & Recycled Content: 12%.
    q. Recycled Content, Polyol Renewable Content: 6%
    r. Recycled Content, Polyol Recycled Content: 19%.
    s. Fungi Resistance (ASTM C 1338): No Fungal Growth.
    t. Closed Cell Content (ASTM D 2856): 91%.
5. Equipment used to apply the foam insulation shall have fixed ratio positive displacement pumps and approved by foam manufacturer.

2.3 ACCESSORY PRODUCTS

A. Water Based Intumescing Coating:
    1. Product: BLAZELOK IB4, Distributed by Demilec, Manufactured by TPR2.
    2. Approval: Complies with 2006 IRC 314.6, 2009 IRC 316.6, IBC 2603.9 and AC 377 over all surfaces of SEALECTION 500 for use without a prescriptive ignition barrier in attics and crawlspaces.
    3. Application: Follow manufacturer's application recommendations.

4. Physical Properties:
    a. Surface Burning Characteristics (ASTM E 84): Class I. Flame Spread Index 0, Smoke Developed Index 20.
    b. Expands up to 2000 percent.
    c. Flash Point: None.
    d. Volatility/VOC: 0.
    e. Flexible, ductile, elastomeric.
    f. Non-toxic, drain safe, water based, non-fuming.
    g. Can be latex or oil base top coated.
5. Color: Gray.

B. Water Based Intumescing Coating:
1. Product: BLAZELOK TBX, Distributed by Demilec, Manufactured by TPR2.
2. Approval: Complies with 2009 IBC 2603.9 and 803.2; 2009 IRC 302.9.4 and 316.6; 2006 IRC 314.6 and 315.4 and the NFPA 101 paragraph 10.2.3.7.2 for use without a prescriptive thermal barrier.
3. Application: Follow manufacturer's application recommendations.
4. Physical Properties:
    a. Surface Burning Characteristics (ASTM E 84): Class I. Flame Spread Index less than 25, Smoke Developed Index less than 50.
    b. Expands up to 2000 percent.
    c. Flash Point: None.
    d. Volatility/VOC: Less than 50 g/L.
    e. Non-toxic, drain safe, water based, non-fuming.
    f. Can be latex or oil base top coated.
5. Color: Dull flat white / gray.
    a. Do not add tint.
    b. Wait minimum 24 hours prior to top coating with quality latex paint. Verify dryness with moisture meter.

C. Water Based Intumescing Coating:
1. Product: DC315 Intumescing Coating, Distributed by Demilec, Manufactured by International Fireproof Technologies, Inc. (IFTI).
2. Application: Follow manufacturer's application recommendations.
3. Physical Properties:
    a. Surface Burning Characteristics (ASTM E 84): Class I. Flame Spread Index of 0, Smoke Developed Index less than 25
    b. Expands up to 2000 percent.
    c. Flash Point: None.
    d. Volatility/VOC: Less than 50 g/L.
    e. Non-toxic, drain safe, water based, non-fuming.
4. Color: Dull flat / ice gray.
    a. Do not add tint.
    b. Wait minimum 24 hours prior to top coating with quality latex paint. Verify dryness with moisture meter.

5. Refer to products International Code Council Evaluation Services Report for additional Intumescent Coating information.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Do not begin installation until substrates have been properly prepared.

B. If substrate preparation is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.

C. Commencement of work outlined in this section shall be deemed as acceptance of existing work and conditions.

3.2 PREPARATION

A. Clean surfaces thoroughly prior to installation.

B. Apply only when surfaces and environmental conditions are within limits prescribed by the material manufacturer.

C. Prepare surfaces using the methods recommended by the manufacturer for achieving the best result for the substrate under the project conditions.

3.3 INSTALLATION

A. Install in accordance with manufacturer's instructions. Apply as recommended by manufacturer to thickness as indicated on drawings.

B. Apply thermal barrier as required by applicable codes noting the following:
   1. Except as provided in Section 314.5 and Section 314.6 of the 2006 International Residential Code, Section 316.5 and Section 316.6 of the 2009 International Residential Code and Section 2603.4.1 and Section 2603.9 of the International Building Code, all plastic insulation shall be separated from the interior of the building by an approved thermal barrier of 1/2 inch (13 mm) gypsum wallboard or equivalent thermal barrier material.
   2. Code compliant fire protection may be achieved with the use of BLAZELOK IB4 and BLAZELOK TBX depending on the details of the application.

3.4 PROTECTION

A. Protect installed products until completion of project.

B. Touch-up, repair or replace damaged products before Substantial Completion.

END OF SECTION 07215

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work included:
   1. Prime and paint walls throughout.
   2. Prime and paint doors, door casework.

1.2 QUALITY ASSURANCE

A. Use adequate numbers of skilled workmen who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the work of this Section.

B. Paint coordination:
   1. Provide finish coats which are compatible with the prime coats actually used.

   2. Upon request, furnish information on the characteristics of the specific finish materials to assure that compatible prime coats are used.

1.3 SUBMITTALS

A. Provide testing lab results on existing paint.

B. Submit manufacturer's literature for all products.

1.4 JOB CONDITIONS

A. Do not apply solvent-thinned paints when the temperature of surfaces to be painted and the surrounding air temperatures are below 45 degrees F, unless otherwise permitted by the manufacturers' printed instructions.

B. Weather conditions:
   1. Do not apply paint in snow, rain, fog, or mist; or when the relative humidity exceeds 85%; or to damp or wet surfaces, unless otherwise permitted by the manufacturer's printed instructions.

   2. Applications may be continued during inclement weather only within the temperature limits specified by the paint manufacturer as being suitable for use during application and drying periods.

PART 2 - PRODUCTS

2.1 PAINT MATERIALS

A. Acceptable materials:
   1. The Painting Schedule in Part 3 of this Section is based, in general, on products of the Benjamin Moore Company. Equal products may be substituted if approved by the Engineer.

B. Undercoats and thinners:
   1. Provide undercoat paint produced by the same manufacturer as the finish coat.

   2. Use only the thinners recommended by the paint manufacturer, and use only to the recommended limits.

   3. Use one undercoat and one finish coat.

2.2 COLOR

A. The color shall be selected and approved by the Owner.

2.3 APPLICATION EQUIPMENT

A. For application of the approved paint, use only such equipment as is recommended for application of the particular paint by the manufacturer of the particular paint.

B. Prior to use of application equipment, verify that the proposed equipment is actually compatible with the material to be applied, and that integrity of the finish will not be jeopardized by use of the proposed equipment.

2.4 OTHER MATERIALS

A. Provide other materials, not specifically described but required for a complete and proper installation, as selected by the Contractor subject to the approval of the Engineer.

PART 3 - EXECUTION

3.1 SURFACE CONDITIONS

A. Examine the areas and conditions under which work of this Section will be performed. Correct conditions detrimental to timely and proper completion of the Work. Do not proceed until unsatisfactory conditions are corrected.

3.2 MATERIALS PREPARATION

A. General:
   1. Mix and prepare paint materials in strict accordance with the manufacturers' recommendations.

   2. When materials are not in use, store in tightly covered containers.

   3. Maintain containers used in storage, mixing, and application of paint in a clean condition, free from foreign materials and residue.

B. Stirring:
   1. Stir materials before application, producing a mixture of uniform density.

   2. Do not stir into the material any film which may form on the surface, but remove the film and, if necessary, strain the material before using.

3.3 SURFACE PREPARATION

A. General:
   1. Perform preparation and cleaning procedures in strict accordance with the paint manufacturers' recommendations.

   2. Schedule the cleaning and painting so that dust and other contaminants from the cleaning process will not fall onto wet newly painted surfaces.

B. Preparation of metal surfaces:
   1. Thoroughly clean surfaces until free from dirt, oil, and grease.

   2. Remove all loose paint and rust by wire brushing, scraping and sanding. Surfaces shall be approved by the engineer as to the acceptability and completeness of the rust removal. This shall serve as the standard for all remaining work.
   3. Allow to dry thoroughly before application of paint.

3.4 PAINT APPLICATION

A. General:
   1. Sand and dust between coats to remove defects visible to the unaided eye from a distance of five feet.

B. Drying:
   1. Allow sufficient drying time between coats, modifying the period as recommended by the material manufacturer to suit adverse weather conditions.

C. Brush applications:
   1. Brush out and work the brush coats onto the surface in an even film.

   2. Cloudiness, spotting, holidays, laps, brush marks, runs, sags, ropiness, and other surface imperfections will not be acceptable.

D. The initially painted walls, doors and frames shall be approved by the Engineer and Owner as to appearance and conformance to these specifications before any further work is performed. This shall serve as the standard for all remaining work.

3.5 PAINTING SCHEDULE

A. Provide the following paint finish:
   1. Ceilings:

      1st Coat: Regal Primer N216 by Benjamin Moore or approved equal.

      2nd Coat: Regal Matte Finish N221 Paint by Benjamin Moore or approved equal.

      3rd Coat: Regal Matte Finish N221 Paint by Benjamin Moore or approved equal.

   2. Walls:
      1st Coat: Regal Primer N216 by Benjamin Moore or approved equal.

      2nd Coat: Regal Eggshell Finish N319 Paint by Benjamin Moore or approved equal.

      3rd Coat: Regal Eggshell Finish N319 Paint by Benjamin Moore or approved equal.

   3. Doors, Door Casework and Windows:

      1st Coat: Regal Primer N216 by Benjamin Moore or approved equal.

      2nd Coat: Regal Semi Gloss N333 Paint by Benjamin Moore or approved equal.

      3rd Coat: Regal Semi Gloss N333 Paint by Benjamin Moore or approved equal.

B. Colors to be determined by Owner from manufacturers standard color charts.

END OF SECTION 09900

PART 1 - GENERAL

1.1 DESCRIPTION

A. General: Materials and methods for performance of all mechanical work.

B. Provide complete and operational mechanical systems including, but not limited to, all required materials, parts, equipment, labor, tools, and accessories.

1.2 SUMMARY

A. This Section includes general administrative and procedural requirements for mechanical installations.
   1. Codes & standards.
   2. Submittals.
   3. Quality control.
   4. Permits, fees, and inspections.
   5. Schedule and sequence.
   6. Project and site conditions.
   7. Delivery, storage, and handling.
   8. Record documents.
   9. Operation and Maintenance manuals.
   10. Warranties and guaranties.
   11. Rough-ins.
   12. Mechanical installations.
   13. Cutting, patching, and firestopping.
   14. Mechanical indentification.

1.3 CODES AND STANDARDS

A. Except as modified by governing codes, comply with applicable provisions and recommendations of the following:
   1. ANSI Standards.
   2. Owner's Insurance Company.
   3. Current Connecticut Laws and Statutes.
   4. Requirements of the Federal Housing and Urban Renewal Department (ie. HUD).

1.4 SUBMITTALS

A. Increase, by the quantity listed below, the number of mechanical related shop drawings, product data, and samples submitted, to allow for required distribution.
   1. Shop Drawings: Initial Submittal: 1 additional blue- prints.
   2. Product Data: 1 additional copy of each item.
   3. Samples: 1 addition as set.

B. Additional copies may be required by individual sections of these Specifications.

C. Shop Drawings:
1. Submit for review, detailed shop drawings and product data of all the equipment and material required to complete the work. No material or equipment may be delivered to the jobsite or installed until accepted shop drawings for the particular material or equipment have been approved by the Owner or his authorized representative.

2. Failure to submit shop drawings in ample time for checking will not entitle Contractor to claim extension of Contract time, or increase in contract cost.

3. The proposed piping layout for the Boiler system is required.

D. Tests & Certificates:
1. As specified in other sections.

1.5 QUALITY ASSURANCE

A. Drawings:
1. Drawings are diagrammatic. They indicate the general arrangement of systems and work included in the contract. Drawings are not to be scaled. Site and Architectural drawings and details shall be examined for exact location of fixtures and equipment. Where they are not definitely located, this information shall be obtained from the Owner or authorized representative.

2. Surveys and Measurements:
a. Before submitting bid, visit site, become familiar with conditions under which work will be installed. Contractor will be held responsible for assumptions, omissions, and errors made as a result of failure to become familiar with site and contract documents.

b. Base all measurements, both horizontal and vertical, from established bench marks. All work shall agree with established lines and levels. Verify all measurements at site and check the correctness of same.

c. Notify the Engineer promptly of discrepancies between actual measurements and those indicated, which prevents following good practice or intent of drawings and specifications. Do not proceed with work until Contractor has received instructions from Engineer.

B. Labor:
1. Cooperation with Other Trades:

a. Give full cooperation to other trades; furnish in writing to General Contractor, with copies to the Engineer, information necessary to permit the work of all trades to be installed satisfactorily and with the least possible interference or delay.

b. Where work will be installed in close proximity to, or will interfere with work of other trades, assist in working out space conditions to make a satisfactory adjustment. If directed by the Engineer, prepare composite working drawings and sections at a suitable scale not less than 1/4" = 1'0", clearly showing how work is to be installed in relation to the work of other trades. If work under this division is installed before coordinating with other trades, or to cause any interference with work of other trades, make necessary changes to correct the condition without additional cost.

c. Furnish to other trades all necessary templates, patterns, setting plans, and shop details for the proper installation of work and for the purpose of coordinating adjacent work.

2. Materials & Workmanship:
   a. Materials and apparatus required for the work shall be new and of first class quality. Furnished, delivered, erected, connected and finished in every detail. Select and arrange to fit properly into the building spaces. Where no specific kind or quality of material is given, furnish first class standard article as accepted by Engineer.

   b. Furnish the services of an experienced superintendent who shall be in constant charge of the work, together with skilled craftsmen and labor required to unload, transfer, erect, connect-up, adjust, start, operate, and test each system.

   c. All equipment and materials to be installed with the acceptance of the Engineer in accordance with the recommendations of the manufacturer. This includes the performance of such test as the manufacturer recommends.

3. Protection of Materials:
   a. Multiple Units: When two or more units of materials or equipment of the same type or class are required, these units shall be products of one manufacturer.

   b. Welding: Before any welding is performed, submit a copy of the Welding Procedure Specification (WPS) together with the Procedure Qualification Record a required by Section IX of the ASME Boiler and Pressure Vessel Code.

1) Before any welder performs any welding, submit a copy of the Manufacturer's Record of Welder or Welding Operator Qualification Tests as required by Section IX of the ASME Boiler and Pressure Vessel Code. The letter or symbol (as shown on the qualification test form) shall be used to identify the work of that welder and shall be affixed, in accordance with appropriate construction code, to each completed weld.
2) The types and extent of non-destructive examinations required for pipe welds are shown in Table 136.4 of the Code for Pressure Piping, ASNI/ASME B31.1.

c. Manufacturer's Recommendations: Where installation procedures or any part thereof are required to be in accordance with the recommendations of the manufacturer of the material being installed, printed copies of these recommendations shall be furnished to the Engineer prior to the installation. Installation of the item will not be allowed to proceed until the recommendations are received. Failure to furnish these recommendations can be cause for rejection of the material.

1.6 PERMITS, FEES, & INSPECTIONS

A. Give all necessary notices, obtain and pay for all permits, and pay all government sales taxes, fees, and other costs, including utility connections or extensions in connection with work. File necessary approvals of governmental departments having jurisdiction. Obtain required certificates of inspection for work and deliver a copy to the Owner or his authorized representative before requesting acceptance for final payment.

1.7 SCHEDULE & SEQUENCE

A. Temporary Services:
1. Refer to the General Conditions and Special Conditions for a full description of the temporary services to be provided.

B. Temporary Openings:
1. Ascertain from examination of the drawings any special temporary openings in the building required for the admission of apparatus provided under this Division. Notify the Owner accordingly. Contractor shall assume all costs of providing such openings thereafter.

C. Sequencing:
1. Contractor shall coordinate sequence of work with owner's representative.

1.8 PROJECT & SITE CONDITIONS

A. Cutting, Patching, and Firestopping:
   1. Furnish all cutting, drilling and patching. Furnish sketches showing the locations and sizes of openings, chases, etc., required for the installation of work. Furnish the Contractor with an approximation of the number and size of openings, chases, etc., required.

B. Waterproofing:
   1. Where any work pierces existing waterproofing, re-waterproof. The method of installation to be reviewed by Owner or his authorized representative before work is done. Furnish all sleeves, caulking, and flashing required to make openings watertight.

C. Fireproofing:
   1. Where any work penetrates a fire rated assembly, provide UL listed, firestopping with hourly rating equal to that of the penetrated assembly. Fireproofing shall be compatible with the pipe or equipment doing the penetration so that fire rating of the assembly is maintained.

1.9 DELIVERY, STORAGE, & HANDLING

A. Delivery & Receipt:
   1. Contractor is responsible for the delivery and storage of all materials, parts, equipment, etc. required for this project.

B. Storage:
   1. The Contractor shall store all material, parts, and equipment required for this project in accordance with supplier's and manufacturer's recommendations, and Owner's requirements.

C. Handling, Hoisting, Rigging, & Scaffolding:
   1. Furnish all scaffolding, rigging, hoisting, and services necessary for erection and delivery into the premises of any equipment and apparatus furnished under this Division. Remove same from premises when no longer required.

1.10 RECORD DOCUMENTS

A. Maintain at the job site a record set of drawings on which any changes in location of equipment, piping, ducts, valves, cleanouts, panels, and major conduits shall be recorded. These shall be clearly marked on a clean set of prints at the completion of work for record drawings and turned over to the Owner.

B. Prepare record documents in accordance with the requirements below:
   1. Mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located (i.e., traps, strainers, tanks, etc.). Valve location diagrams, complete with valve tag chart.

   2. Equipment locations (exposed and concealed), dimensioned from prominent building lines.

   3. Approved substitutions, Contract Modifications, and actual equipment and materials installed.

   4. Contract Modifications, actual equipment and materials installed.

1.11 OPERATION & MAINTENANCE MANUALS FOR MECHANICAL SYSTEMS

A. Bind Operation & Maintenance Manual for Mechanical System in a hard-backed binder. Spline of each binder shall have the following lettering done in typeset:

OPERATION
AND
MAINTENANCE
MANUAL
For

HVAC EFFICIENCY UPGRADES AT
MILO PECK CHILD CARE SCHOOL
WINDSOR, CT

   1. Provide a master index at beginning of Manual showing items included. Use plastic tab indexes for sections of Manual.

   2. First section shall consist of name, address, and phone number of Architect, Mechanical & Electrical Engineers, General Contractor and Mechanical, Plumbing, Sheet Metal, Refrigeration, Temperature Control & Electrical Contractors. Also include a complete list of equipment installed with name, address, and phone number of vendor.

   3. Provide section for each type of item of equipment.

   4. Submit three copies of Operation & Maintenance Manual to Engineer for his approval. Use one of these approved copies during final inspection and leave with building maintenance personnel.

B. Include descriptive literature (Manufacturer's catalog data) of each manufactured item. Literature shall show capacities and size of equipment used and be marked indicating each specific item with applicable data underlined.

C. Operating instructions shall include:
   1. General description of each mechanical system.

   2. Step by step procedure to follow in putting each piece of mechanical equipment into operation.

   3. Provide schematic control diagrams for each separate fan system, refrigeration system, heating system, control panel, etc. Each diagram shall show locations of start-stop switches, insertion thermostats, room thermostats, thermometers, firestats, pressure gauges, automatic valves, and refrigeration accessories. Mark correct operating setting for each control instrument on these diagrams.

   4. Provide diagram for electrical control system showing wiring of related electrical control items such as firestats, fuses, interlock, electrical switches, and relays.

   5. Provide drawing of each temperature control panel system.

D. Prepare maintenance manuals to include the following information for equipment items:
   1. Manufacturer's maintenance equipment installed in Project. Instructions shall include name of vendor, installation instructions, parts numbers & lists, operation instructions of equipment and maintenance & lubrication instructions.

   2. Summary list of mechanical equipment requiring lubrication showing name of equipment, location and type, and frequency of lubrication.

   3. List of mechanical equipment used indicating name, model, serial number, and name plate data of each item together with number and name associated with each system item.

   4. List spare parts and quantities to be maintained in ready inventory at project site.

   5. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.

6. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.

7. Servicing instructions and lubrication charts and schedules.

E. Air Balance and Water Balance Test Run Reports

1.12 WARRANTIES AND GUARANTIES

A. Guarantee all material and workmanship under this Division for a period of one year, from the date of final acceptance by the Owner.

B. During guarantee period, all defects developing through materials and/or workmanship shall be replaced immediately without expense to the owner. Make such repairs or replacements to the satisfaction of the Owner.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. As specified under other related sections.

B. As specified on drawings.

2.2 MATERIALS

A. As specified under other related sections.

B. As specified on drawings.

2.3 EQUIPMENT DEVIATIONS

A. Where the Contractor proposed to use an item of equipment other than that specified or detailed on the drawings which requires the redesign of the structure, partitions, foundations, piping, wiring or any other part of the mechanical layout, all such redesign, and all new drawings and detailing required therefore, shall be prepared at the Contractor's expense and are subject to the review and approval of the Engineer. Owner reserves the right to have the Engineer prepare any redesign work.

B. Where such accepted deviation requires a different quantity and arrangement of materials or equipment from that specified or indicated on the drawings, the Contractor will provide additional equipment and materials required at no additional cost to the Owner.

C. When equipment or methods deviate from original plans or specifications, the Contractor must submit a written request to deviate to the Engineer. At a minimum the request will address the following:

- equipment which is different than specified
- name and data related to the proposed deviation
- reason for deviation
- advantageous or disadvantageous to the Owner
- credit or increase in cost to the Owner
- guarantees or warranties offered (if any)
- acceptance of liability for equivalent performance.

2.4 MANUFACTURER'S IDENTIFICATION

A. Attach manufacturer's nameplate, name, trademark and address permanently to equipment and material furnished under this Division. Nameplate of a Contractor or Distributor is not acceptable.

2.5 ELECTRICAL REQUIREMENTS

A. Motors:
1. Electric motors furnished as a component part of equipment furnished under this Division shall conform to the requirements of IEEE, NEMA, UL, ANSI C50, and ANSI CI. Motors to be suitable for required load, duty voltage, phase, frequency, service and location.

2. Motors to be suitable for continuous duty at rated horsepower with temperature rise not to exceed 40oC for dripproof motors, 50oC for splashproof motors, and 55oC for totally enclosed motors. Motors to be capable of withstanding momentary overloads of 25 percent without injurious overheating.

3. Motors to have nameplates giving Manufacturer's name, serial number, horsepower, speed and current characteristics.

4. Motor leads shall be permanently identified and supplied with connectors.

5. Each motor to be selected for quiet operation in accordance with NEMA standards.

B. Motor Starters:
1. Electric motor starters shall conform to requirements of IEEE, NEMA, UL, ANSI, CI and shall be suitable for the required load, duty, voltage, phase, frequency, service, and location.

2. When interlocking or automatic control of single phase motors is required, motors to be furnished with full voltage, across-the-line starters.

C. Connections:
1. All wiring to be furnished and installed under Division 16.

2. Power wiring to be furnished and installed complete from power source to motor or equipment junction box, including power wiring through the starters. Starters not factory mounted on equipment shall be furnished and installed under Division 16.

2.6 MECHANICAL REQUIREMENTS

A. Bases & Supports:
1. Provide necessary foundations, supports, pads, bases and piers required for equipment, tanks, and other equipment furnished under this Division. Submit drawings to Engineer for review before purchase, fabrication, or construction.

2. For Boilers/Tanks and for equipment where foundations are indicated, provide 3500 psi concrete pads. Extend pads six (6) inches beyond machine base in all directions with top edge chamfered. Insert steel dowel rods into floors to anchor pads. Submit shop drawings of foundations and pads to Owner for review before construction.

3. Construction of foundations, supports, pads, bases, and piers where mounted on the floor to be of the same materials and same quality of finish as the adjacent surrounding flooring material.

B. Lubrication:
1. Lubricate all equipment having moving parts and requiring lubrication according to manufacturer's recommendations prior to testing and operation. Equipment discovered to have been operated before lubrication is subject to rejection and replacement at no cost to the Owner.

C. Accessibility:
1. Be responsible for the sufficiency of the size of shafts and chases, adequate clearance in double partitions and hung ceilings for proper installation of work. Cooperate with the Contractor and other contractors whose work is in the same space. Advise the Contractor of requirements. Such spaces and clearances shall be kept to the minimum size required.

2. Locate all equipment which requires servicing in fully accessible positions. Equipment shall include but not be limited to, valves, traps, clean-outs, motors, controllers, switchgear, and drain points. Any change shall be submitted to the Owner or his authorized representative for review.

D. Connection to Existing Structures:
   1. Before cutting, drilling, attaching, or any work involving building elements, coordinate work with others and Owner to avoid damage to building elements.

2.7 FIRESTOPPING

A. Firestopping shall be UL listed, and tested in accordance with ASTM E814, E119, and E84.

B. Hourly rating shall be equal to that of the assembly being penetrated.

C. Firestopping shall be compatible with pipe or equipment penetrating the assembly fire rating of the assembly must be maintained.

PART 3 - EXECUTION

3.1 ROUGH-IN

A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.

B. Refer to equipment specifications in Divisions 2 through 16 for rough-in requirements.

3.2 MECHANICAL INSTALLATIONS

A. General: Sequence, coordinate, and integrate the various elements of mechanical systems, materials, and equipment. Comply with the following requirements:
   1. Coordinate mechanical systems, equipment, and materials installation with other building components.

   2. Verify all dimensions by field measurements.

   3. Arrange for chases, slots, and openings in other building components during progress of construction, to allow for mechanical installations.

   4. Coordinate the installation of required supporting devices and sleeves to be set in structural components, as they are constructed.

   5. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the Work.

6. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum headroom possible.

7. Coordinate connection of mechanical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.

8. Install systems, materials, and equipment to conform with approved submittal data, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the Engineer.

9. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished spaces.

10. Install mechanical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.

11. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.

3.3 CUTTING, PATCHING, AND FIRESTOPPING

A. General: Perform cutting and patching in accordance with the following requirements apply:
   1. Protection of Installed Work: During cutting and patching operations, protect adjacent installations.

B. Perform cutting, fitting, and patching of mechanical equipment and materials required to:
   1. Remove and replace defective Work.
   2. Remove and replace Work not conforming to requirements of the Contract Documents.
   3. Remove samples of installed Work as specified for testing.
   4. Install equipment and materials in existing structures.
   5. Upon written instructions from the Engineer, uncover and restore Work to provide for Engineer observation of concealed Work.

C. Cut, remove and legally dispose of selected mechanical equipment, components, and materials as indicated, including but not limited to removal of mechanical piping,

heating units, plumbing fixtures and trim, and other mechanical items made obsolete by the Work.

D. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.
   1. Patch finished surfaces and building components using materials specified for the original installation and experienced Installers. Installers' qualifications refer to the materials and methods required for the surface and building components being patched.

E. Firestop all pipe and equipment that penetrates fire rated assembly. Follow manufacturer's instructions to provide fire rating equal to that of the assembly.

3.4 FIELD QUALITY CONTROL

A. Perform field tests as specified under other sections.

B. Arrange for local inspection authorities to inspect work performed prior to burial, closing-in behind wall and above ceiling or encase in concrete. Also arrange for final inspection of work and obtain Final Inspection Certificate before final inspection by Owner or his representative.

3.5 PAINTING

A. See Division 9 for painting in finished areas.

B. Materials shipped to the job site under this Division to have prime coat and standard manufacturer's finish.

3.6 TESTING & BALANCING: See Section 15990

3.7 EQUIPMENT IDENTIFICATION

A. Valves charts and tags
   1. All valves shall be provided with valve tags secured to the valve stems or handles with brass chains or S hooks. Tags shall be based on Seton Nameplate Co. (Numbers and letter identification shall indicate service where valve is located. Tags shall be 1-3/8" diameter.

   2. Furnish two (2) valve charts, one framed under glass and one unframed copy for record files. Charts shall indicate system designation, valve number, service, and location of valve. Use actual room names on charts.

3.8 CLEANING

A. Any part of a system stopped by foreign matter after being placed in operation, to be disconnected, cleaned, and reconnected to locate and remove obstructions. Work damaged in the course of removing obstructions will be repaired or replaced at no additional cost to the Owner.

B. Cap all pipes to protect against entrance of foreign matter.

C. Remove rubbish, debris, and excess materials. Remove oil and grease stains on floor areas.

END OF SECTION 15010

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General Conditions apply to this Section.

1.2 SUMMARY

A. This Section includes the following basic mechanical materials and methods to complement other Division 15 Sections.
   1. Piping materials and installation instructions common to most piping systems.
   2. Concrete equipment base construction requirements.
   3. Equipment nameplate data requirements.
   4. Non-shrink grout for equipment installations.
   5. Field-fabricated metal and wood equipment supports.
   6. Installation requirements common to equipment specification sections.
   7. Mechanical demolition.
   8. Cutting and patching.
   9. Touch-up painting and finishing.

B. Pipe and pipe fitting materials are specified in piping system Sections.

1.3 DEFINITIONS

A. Pipe, pipe fittings, and piping include tube, tube fittings, and tubing.

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

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

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

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

F. 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.

1.4 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract.

B. Product data for following piping specialties:
   1. Mechanical sleeve seals.
   2. Identification materials and devices.

C. Samples of color, lettering style, and other graphic representation required for each identification material and device.

D. Shop drawings detailing fabrication and installation for metal and wood supports and anchorage for mechanical materials and equipment.

E. Coordination drawings for access panel and door locations.

F. Prepare coordination drawings to a 1/4 inch equals 1 foot scale or larger. Detail major elements, components, and systems of mechanical equipment and materials in relationship with other systems, installations, and building components. Show space requirements for installation and access. Show where sequence and coordination of installations are important to the efficient flow of the Work. Include the following:
   1. Proposed locations of piping, ductwork, equipment, and materials. Include the following:
      a. Planned piping layout, including valve and specialty locations and valve stem movement.
      b. Planned duct systems layout, including elbows radii and duct accessories.
      c. Clearances for installing and maintaining insulation.
      d. Clearances for servicing and maintaining equipment, including space for equipment disassembly required for periodic maintenance.
      e. Equipment service connections and support details.
      f. Exterior wall and foundation penetrations.
      g. Fire-rated wall and floor penetrations.
      h. Sizes and location of required concrete pads and bases.
   2. Scheduling, sequencing, movement, and positioning of large equipment into the building during construction.
   3. Floor plans, elevations, and details to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installations.
   4. Reflected ceiling plans to coordinate and integrate installations, air outlets and inlets, light fixtures, communication systems components, sprinklers, and other ceiling-mounted items.

G. Welder certificates signed by Contractor certifying that welders comply with requirements specified under "Quality Assurance" Article of this Section.

1.5 QUALITY ASSURANCE

A. Qualify welding processes and operators for structural steel according to AWS D1.1 "Structural Welding Code - Steel."

B. Qualify welding processes and operators for piping according to ASME "Boiler and Pressure Vessel Code," Section IX, "Welding and Brazing Qualifications."
   1. Comply with provisions of ASME B31 Series "Code for Pressure Piping."
   2. Certify that each welder has passed AWS qualification tests for the welding processes involved and that certification is current.

C. ASME A13.1 for lettering size, length of color field, colors, and viewing angles of identification devices.

D. Equipment Selection: Equipment of greater or larger power, dimensions, capacities, and ratings may be furnished provided such proposed equipment is approved in writing and connecting mechanical and electrical services, circuit breakers, conduit, motors, bases, and equipment spaces are increased. No additional costs will be approved for these increases, if larger equipment is approved. If minimum energy ratings or efficiencies of the equipment are specified, the equipment must meet the design requirements and commissioning requirements.

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 prevent entrance of dirt, debris, and moisture.

B. Protect stored pipes and tubes from moisture and dirt. Elevate above grade. When stored inside, do not exceed structural capacity of the floor.

C. Protect flanges, fittings, and piping specialties from moisture and dirt.

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

1.7 SEQUENCING AND SCHEDULING

A. Coordinate mechanical equipment installation with other building components.

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

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

D. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the Work. Coordinate installation of large equipment requiring positioning prior to closing in the building.

E. Coordinate connection of mechanical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies.

F. Coordinate requirements for access panels and doors where mechanical items requiring access are concealed behind finished surfaces.

G. Coordinate installation of identifying devices after completion of covering and painting, where devices are applied to surfaces. Install identifying devices prior to installation of acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 PIPE AND PIPE FITTINGS

A. Refer to individual piping system specification Sections for pipe and fitting materials and joining methods.

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

2.2 JOINING MATERIALS

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

B. Pipe Flange Gasket Materials: Suitable for the chemical and thermal conditions of the piping system contents.
   1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness, except where 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. ASME B16.20 for grooved, ring-joint, steel flanges.

3. AWWA C110, rubber, flat face, 1/8-inch thick, except where other thickness is indicated; and full-face or ring type, except where type is indicated.

C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, except where other material is indicated.

D. Plastic Pipe Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, except where other type or material is indicated.

E. Solder Filler Metal: ASTM B 32.
1. Alloy Sn95 or Alloy Sn94: Tin (approximately 95 percent) and silver (approximately 5 percent), having 0.10-percent lead content.
2. Alloy Sn50: Tin (50 percent) and lead (50 percent).
3. Alloy E: Tin (approximately 95 percent) and copper (approximately 5 percent), having 0.10-percent maximum lead content.
4. Alloy HA: Tin-antimony-silver-copper-zinc, having 0.10-percent maximum lead content.
5. Alloy HB: Tin-antimony-silver-copper-nickel, having 0.10-percent maximum lead content.
6. Alloy Sb5: Tin (95 percent) and antimony (5 percent), having 0.20-percent maximum lead content.

F. Brazing Filler Metals: AWS A5.8.
1. BCuP Series: Copper-phosphorus alloys.
2. BAg1: Silver alloy.

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: Manufacturer's standard solvents complying with the following:
1. Acrylonitrile-Butadiene-Styrene (ABS): ASTM D 2235.
2. Chlorinated Poly(Vinyl Chloride) (CPVC): ASTM F 493.
3. Poly(Vinyl Chloride) (PVC): ASTM D 2564.
4. PVC to ABS Transition: Made to requirements of ASTM D 3138, color other than orange.

I. Plastic Pipe Seals: ASTM F 477, elastomeric gasket.

J. Flanged, Ductile-Iron Pipe Gasket, Bolts, and Nuts: AWWA C110, rubber gasket, carbon steel bolts and nuts.

K. Couplings: Iron body sleeve assembly, fabricated to match outside diameters of plain-end, pressure pipes.
1. Sleeve: ASTM A 126, Class B, gray iron.

2. Followers: ASTM A 47, Grade 32510 or ASTM A 536 ductile iron.
3. Gaskets: Rubber.
4. Bolts and Nuts: AWWA C111.
5. Finish: Enamel paint.

2.3 PIPING SPECIALTIES

A. Escutcheons: Manufactured wall, ceiling, and floor plates; deep-pattern type, where required to conceal protruding fittings and sleeves.
1. Inside Diameter: Closely fit around pipe, tube, and insulation of insulated piping.
2. Outside Diameter: Completely cover opening.
3. Cast Brass: One-piece, with set-screw.
a. Finish: Rough brass.
b. Finish: Polished chrome plate.

4. Cast Brass: Split casting, with concealed hinge and set-screw.
a. Finish: Rough brass.
b. Finish: Polished chrome plate.

5. Stamped Steel: One-piece, with set-screw and chrome plated finish.
6. Stamped Steel: One-piece, with spring clips and chrome plated finish.
7. Stamped Steel: Split plate, with concealed hinge, set-screw, and chrome plated finish.
8. Stamped Steel: Split plate, with concealed hinge, spring clips, and chrome plated finish.
9. Stamped Steel: Split plate, with exposed-rivet hinge, set-screw, and chrome plated finish.
10. Stamped Steel: Split plate, with exposed-rivet hinge, spring clips, and chrome plated finish.
11. Cast-Iron Floor Plate: One-piece casting.

B. Dielectric Fittings: Assembly or fitting having insulating material isolating joined dissimilar metals, to prevent galvanic action and stop corrosion.
1. Description: Combination of copper alloy and ferrous; threaded, solder, plain, and weld neck end types and matching piping system materials.
2. Insulating Material: Suitable for system fluid, pressure, and temperature.
3. Dielectric Unions: Factory-fabricated, union assembly, for 250 psig minimum working pressure at 180 deg F temperature.
4. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150 or 300 psig minimum pressure to suit system pressures.
5. Dielectric-Flange Insulation Kits: Field-assembled, companion-flange assembly, full-face or ring type. Components include neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
a. Provide separate companion flanges and steel bolts and nuts for 150- or

300-psig minimum working pressure to suit system pressures.

6. Dielectric Couplings: Galvanized-steel coupling, having inert and non-corrosive, thermoplastic lining, with threaded ends and 300 psig minimum working pressure at 225 deg F temperature.
7. Dielectric Nipples: Electroplated steel nipple, having inert and non-corrosive, thermoplastic lining, with combination of plain, threaded, or grooved end types and 300 psig working pressure at 225 deg F temperature.

C. Mechanical Sleeve Seals: Modular, watertight, mechanical type. Components include interlocking synthetic rubber links shaped to continuously fill annular space between pipe and sleeve. Connecting bolts and pressure plates cause rubber sealing elements to expand when tightened.

D. Sleeves: The following materials are for wall, floor, slab, and roof penetrations:
1. Steel Sheet-Metal: 24 gage or heavier, galvanized sheet metal, round tube closed with welded longitudinal joint.

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

3. Cast-Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, having plain ends and integral water stop, except where other features are specified.

4. Wall Penetration Systems: Wall sleeve assembly, consisting of housing, gaskets, and pipe sleeve, with 1 mechanical-joint end conforming to AWWA C110 and 1 plain pipe-sleeve end.
   a. Penetrating Pipe Deflection: 5 percent without leakage.
   b. Housing: Ductile-iron casting having waterstop and anchor ring, with ductile-iron gland, steel studs and nuts, and rubber gasket conforming to AWWA C111, of housing and gasket size as required to fit penetrating pipe.
   c. Pipe Sleeve: AWWA C151, ductile-iron pipe.
   d. Housing-to-Sleeve Gasket: Rubber or neoprene, push-on type, of manufacturer's design.

5. Cast-Iron Sleeve Fittings: Commercially-made, sleeve having integral clamping flange, with clamping ring, bolts, and nuts for membrane flashing.
   a. Underdeck Clamp: Clamping ring with set-screws.

6. PVC Plastic: Manufactured, permanent, with nailing flange for attaching to wooden forms.

7. PE Plastic: Manufactured, reusable, tapered, cup-shaped, smooth outer surface, with nailing flange for attaching to wooden forms.

2.4 IDENTIFYING DEVICES AND LABELS

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

B. Equipment Nameplates: Metal nameplate with operational data engraved or stamped; permanently fastened to equipment.
   1. Data: Manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliances, and similar essential data.
   2. Location: An accessible and visible location.

C. Stencils: Standard stencils, prepared for required applications with letter sizes conforming to recommendations of ASME A13.1 for piping and similar applications, but not less than 1-1/4-inches-high letters for ductwork and not less than 3/4-inch-high letters for access door signs and similar operational instructions.
   1. Material: Fiberboard.
   2. Material: Brass.
   3. Stencil Paint: Standard exterior type stenciling enamel; black, except as otherwise indicated; either brushing grade or pressurized spray-can form and grade.
   4. Identification Paint: Standard identification enamel of colors indicated or, if not otherwise indicated for piping systems, comply with ASME A13.1 for colors.

D. Snap-On Plastic Pipe Markers: Manufacturer's standard pre-printed, semi-rigid snap-on, color-coded pipe markers, conforming to ASME A13.1.

E. Pressure-Sensitive Pipe Markers: Manufacturer's standard pre-printed, permanent adhesive, color-coded, pressure-sensitive vinyl pipe markers, conforming to ASME A13.1.

F. Engraved Plastic-Laminate Signs: ASTM D 709, Type I, cellulose, paper-base, phenolic-resin-laminate engraving stock; Grade ES-2, black surface, black phenolic core, with white (letter color) melamine subcore, except when other colors are indicated.
   1. Fabricate in sizes required for message.
   2. Engraved with engraver's standard letter style, of sizes and with wording to match equipment identification.
   3. Punch for mechanical fastening.
   4. Thickness: 1/16 inch, except as otherwise indicated.
   5. Thickness: 1/8 inch, except as otherwise indicated.
   6. Thickness: 1/16 inch, for units up to 20 square inches or 8-inches long; 1/8 inch for larger units.
   7. Fasteners: Self-tapping stainless-steel screws or contact-type permanent adhesive.

G. Plastic Equipment Markers: Laminated-plastic, color-coded equipment markers. Conform to following color code:
   1. Yellow: Heating equipment and components.
   2. Brown: Energy reclamation equipment and components.
   3. Blue: Equipment and components that do not meet any of above criteria.
   4. For hazardous equipment, use colors and designs recommended by ASME A13.1.
   5. Nomenclature: Include following, matching terminology on schedules as closely as possible:
      a. Name and plan number.
      b. Equipment service.
      c. Design capacity.
      d. Other design parameters such as pressure drop, entering and leaving conditions, and rpm.

   6. Size: Approximate 2-1/2 by 4 inches for control devices, dampers, and valves; and 4-1/2 by 6 inches for equipment.

H. Lettering and Graphics: Coordinate names, abbreviations, and other designations used in mechanical identification, with corresponding designations indicated. Use numbers, lettering, and wording indicated for proper identification and operation/maintenance of mechanical systems and equipment.
   1. Multiple Systems: Where multiple systems of same generic name are indicated, provide identification that indicates individual system number as well as service such as "Boiler No. 3," "Air Supply No. 1H," or "Standpipe F12."

2.5 GROUT

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

PART 3 - EXECUTION

3.1 PIPING SYSTEMS - COMMON REQUIREMENTS

A. General: Install piping VALVES as described below, except where system Sections specify otherwise. Individual piping system specification Sections in Division 15 specify piping installation requirements unique to the piping system.

B. General Locations and Arrangements: Drawings (plans, schematics, and diagrams) indicate general location and arrangement of piping systems. Install piping as indicated, except where deviations to layout are approved on coordination drawings.

C. Install piping at indicated slope.

D. Install components having pressure rating equal to or greater than system operating pressure.

E. Install piping free of sags and bends.

F. Install exposed interior and exterior piping at right angles or parallel to building walls. Diagonal runs are prohibited, except where indicated.

G. Install piping tight to slabs, beams, joists, columns, walls, and other building elements. Allow sufficient space above removable ceiling panels to allow for ceiling panel removal.

H. Install piping to allow application of insulation plus 1-inch clearance around insulation.
I. Locate groups of pipes parallel to each other, spaced to permit valve servicing.

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

K. Install couplings according to manufacturer's printed instructions.

L. Install pipe escutcheons for pipe penetrations of concrete and masonry walls, wall board partitions, and suspended ceilings according to the following:
   1. Chrome-Plated Piping: Cast-brass, one-piece, with set-screw, and polished chrome-plated finish. Use split-casting escutcheons where required, for existing piping.
   2. Uninsulated Piping Wall Escutcheons: Cast-brass or stamped-steel, with set-screw.
   3. Uninsulated Piping Floor Plates in Utility Areas: Cast-iron floor plates.
   4. Insulated Piping: Cast-brass or stamped-steel, with concealed hinge, spring clips, and chrome-plated finish.
   5. Piping in Utility Areas: Cast-brass or stamped-steel, with set-screw or spring clips.

M. Sleeves are not required for core drilled holes.

N. Permanent sleeves are not required for holes formed by PE plastic (removable) sleeves.

O. Install sleeves for pipes passing through concrete and masonry walls, concrete floor and roof slabs, and where indicated.

P. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, concrete floor and roof slabs, and where indicated.

1. Cut sleeves to length for mounting flush with both surfaces.
   a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring where specified.

2. Build sleeves into new walls and slabs as work progresses.
3. Install large enough sleeves to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
   a. PVC Pipe Sleeves: For pipes smaller than 6 inches.
   b. Steel Pipe Sleeves: For pipes smaller than 6 inches.
   c. Steel Sheet-Metal Sleeves: For pipes 6 inches and larger, penetrating gypsum-board partitions.
   d. Cast-Iron Sleeve Fittings: For floors having membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level. Flashing is specified in Division 16 Section "Basic Electrical Materials and Methods."

      1) Seal space outside of sleeve fittings with nonshrink, nonmetallic grout.

4. Except for below-grade wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using elastomeric joint sealants specified in Division 7 Section "Joint Sealants."

Q. Above Grade, Exterior Wall, Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Size sleeve for 1-inch annular clear space between pipe and sleeve for installation of mechanical seals.
   1. Install steel pipe for sleeves smaller than 6 inches.
   2. Install cast-iron "wall pipes" for sleeves 6 inches and larger.
   3. Assemble and install mechanical seals according to manufacturer's printed instructions.

R. Below Grade, Exterior Wall, Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Size sleeve for 1-inch annular clear space between pipe and sleeve for installation of mechanical seals.

S. Below Grade, Exterior Wall, Pipe Penetrations: Install ductile-iron wall penetration system sleeves according to manufacturer's printed installation instructions.

T. Fire Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestopping sealant material.

U. Verify final equipment locations for roughing-in.

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

W. Piping Joint Construction: Join pipe and fittings as follows and as specifically required in individual piping system specification Sections.
1. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
2. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
3. Soldered Joints: Construct joints according to AWS "Soldering Manual," Chapter 22 "The Soldering of Pipe and Tube."
4. Brazed Joints: Construct joints according to AWS "Brazing Manual," Chapter 28 "Pipe and Tube."
5. 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 inside diameter. Join pipe fittings and valves as follows:
   a. Note the internal length of threads in fittings or valve ends, and proximity of internal seat or wall, to determine how far pipe should be threaded into joint.

   b. Apply appropriate tape or thread compound to external pipe threads (except where dry seal threading is specified).

   c. Align threads at point of assembly.

   d. Tighten joint with wrench. Apply wrench to valve end into which pipe is being threaded.

   e. Damaged Threads: Do not use pipe or pipe fittings having threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

6. Welded Joints: Construct joints according to AWS D10.12 "Recommended Practices and Procedures for Welding Low Carbon Steel Pipe" using qualified processes and welding operators according to "Quality Assurance" Article.

7. Flanged Joints: Align flange surfaces parallel. Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly using torque wrench.

8. Plastic Pipe and Fitting Solvent-Cement Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join pipe and fittings according to the following standards:

a. Comply with ASTM F 402 for safe handling practice of solvent-cement and primers.
b. Acrylonitrile-Butadiene-Styrene (ABS): ASTM D 2235 and ASTM D 2661.
c. Chlorinated Poly(Vinyl Chloride) (CPVC): ASTM D 2846 and ASTM F 493.
d. Poly(Vinyl Chloride) (PVC) Pressure Application: ASTM D 2672.
e. Poly(Vinyl Chloride) (PVC) Non-Pressure Application: ASTM D 2855.
f. PVC to ABS (Non-Pressure) Transition: Procedure and solvent cement described in ASTM D 3138.

9. Plastic Pipe and Fitting Heat-Fusion Joints: Prepare pipe and fittings and join with heat-fusion equipment, according to manufacturer's printed instructions.
   a. Plain-End Pipe and Fittings: Butt joining.
   b. Plain-End Pipe and Socket-Type Fittings: Socket-joining.

X. Piping Connections: Except as otherwise indicated make piping connections as specified below.
1. Install unions, in piping 2 inches and smaller, adjacent to each valve and at final connection to each piece of equipment having 2-inches or smaller threaded pipe connection.
2. Install flanges, in piping 2-1/2-inches and larger, adjacent to flanged valves and at final connection to each piece of equipment having flanged pipe connection.
3. Dry Piping Systems (Gas, Compressed Air, and Vacuum): Install dielectric unions and flanges to connect piping materials of dissimilar metals.
4. Wet Piping Systems (Water and Steam): Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

3.2 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to provide the maximum possible headroom, where mounting heights are not indicated.

B. Install equipment according to approved submittal data. Portions of the Work are shown only in diagrammatic form. Refer conflicts to the Engineer.

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

D. Install mechanical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. Connect equipment for ease of disconnecting, with minimum of interference with other installations. Extend grease fittings to an accessible location.

E. Install equipment giving right-of-way to piping systems installed at a required slope.

3.3 LABELING AND IDENTIFYING

A. Piping Systems: Install pipe markers on each system. Include arrows showing normal direction of flow.
   1. Stenciled Markers: Complying with ASME A13.1.
   2. Plastic markers, with application systems. Install on pipe insulation segment where required for hot non-insulated pipes.
   3. Locate pipe markers as follows wherever piping is exposed in finished spaces, machine rooms, accessible maintenance spaces (shafts, tunnels, plenums) and exterior non-concealed locations.
      a. Near each valve and control device.
      b. Near each branch, excluding short take-offs for fixtures and terminal units. Mark each pipe at branch, where flow pattern is not obvious.
      c. Near locations where pipes pass through walls, floors, ceilings, or enter non-accessible enclosures.
      d. At access doors, manholes, and similar access points that permit view of concealed piping.
      e. Near major equipment items and other points of origination and termination.
      f. Spaced at a maximum of 50 feet intervals along each run. Reduce intervals to 25 feet in congested areas of piping and equipment.
      g. On piping above removable acoustical ceilings, except omit intermediately spaced markers.

B. Equipment: Install engraved plastic laminate sign or equipment marker on or near each major item of mechanical equipment.
   1. Lettering Size: Minimum 1/4-inch-high lettering for name of unit where viewing distance is less than 2 feet, 1/2-inch-high for distances up to 6 feet, and proportionately larger lettering for greater distances. Provide secondary lettering 2/3 to 3/4 of size of principal lettering.

   2. Text of Signs: Provide text to distinguish between multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to name of identified unit.

C. Duct Systems: Identify air supply, return, exhaust, intake, and relief ducts with duct markers; or provide stenciled signs and arrows, showing duct system service and direction of flow.
   1. Location: In each space where ducts are exposed or concealed by removable ceiling system, locate signs near points where ducts enter into space and at maximum intervals of 50 feet.

D. Adjusting: Relocate identifying devices which become visually blocked by work of this Division or other Divisions.

3.4 PAINTING AND FINISHING

A. Damage and Touch-Up: Repair marred and damaged factory painted finishes with materials and procedures to match original factory finish.

3.5 CONCRETE BASES

A. Construct concrete equipment bases of dimensions indicated, but not less than 6 inches larger in both directions than supported unit. Follow supported equipment manufacturer's setting templates for anchor bolt and tie locations. Use 4500 psi, 28-day compressive strength concrete and reinforcement.

3.6 ERECTION OF METAL SUPPORTS AND ANCHORAGE

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

B. Field Welding: Comply with AWS D1.1 "Structural Welding Code - Steel."

3.7 ERECTION OF WOOD SUPPORTS AND ANCHORAGE

A. Cut, fit, and place wood grounds, nailers, blocking, and anchorage to support and anchor mechanical materials and equipment.

B. Select fastener sizes that will not penetrate members where opposite side will be exposed to view or will receive finish materials. Make tight connections between members. Install fasteners without splitting wood members.

C. Attach to substrates as required to support applied loads.

3.8 DEMOLITION

A. Disconnect, demolish, and remove Work specified under Division 15 and as indicated.

B. Where pipe, ductwork, insulation, or equipment to remain is damaged or disturbed, remove damaged portions and install new products of equal capacity and quality.

C. Accessible Work: Remove indicated exposed pipe and ductwork in its entirety.

D. Abandoned Work: Cut and remove buried pipe abandoned in place, 2 inches beyond the face of adjacent construction. Cap and patch surface to match existing finish.

E. Removal: Remove indicated equipment from the project site.

F. Temporary Disconnection: Remove, store, clean, reinstall, reconnect, and make operational equipment indicated for relocation.

3.9 CUTTING AND PATCHING

A. Cut, channel, chase, and drill floors, walls, partitions, ceilings, and other surfaces necessary for mechanical installations. Perform cutting by skilled mechanics of the trades involved.

B. Repair cut surfaces to match adjacent surfaces.

END OF SECTION 15050

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification sections, apply to this section.

B. Requirements of the following Division 15 Sections apply to this section:
   1. "Basic Mechanical Requirements."
   2. "Basic Piping Materials and Methods."

1.2 SUMMARY

A. This Section includes general duty valves common to most mechanical piping systems.
   1. Special purpose valves are specified in individual piping system specifications.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

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

1.4 QUALITY ASSURANCE

A. Single Source Responsibility: Comply with the requirements specified in Division 1 Section "MATERIALS AND EQUIPMENT."

B. American Society of Mechanical Engineers (ASME) Compliance: Comply with ASME B31.9 for building services piping and ASME B31.1 for power piping.

C. Manufacturers Standardization Society of the Valve and Fittings Industry (MSS) Compliance: Comply with the various MSS Standard Practices referenced.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Preparation For Transport: Prepare valves for shipping as follows:
   1. Ensure valves are dry and internally protected against rust and corrosion.
   2. Protect valve ends against damage to threads, flange faces, and weld-end preps.
   3. Set valves in best position for handling. Set globe and gate valves closed to prevent rattling; set ball and plug valves open to minimize exposure of functional surfaces; set butterfly valves closed or slightly open; and block swing check valves in either

closed or open position.

B. Storage: Use the following precautions during storage:
   1. Do not remove valve end protectors unless necessary for inspection; then reinstall for storage.
   2. Protect valves from weather. Store valves indoors. Maintain valve temperature higher than the ambient dew point temperature. If outdoor storage is necessary, support valves off the ground or pavement in watertight enclosures.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers:
   1. Engineer approved equal

2.2 VALVE FEATURES, GENERAL

A. Valve Design: Rising stem or rising outside screw and yoke stems as indicated.
   1. Non-rising stem valves may be used where indicated.

B. Pressure and Temperature Ratings: As required to suit system pressures and temperatures.

C. Sizes: Same size as upstream pipe, unless otherwise indicated.

D. Operators: Provide the following special operator features:
   1. Handwheels, fastened to valve stem, for valves other than quarter turn.
   2. Lever handles, on quarter-turn valves 6-inch and smaller, except for plug valves.

E. Extended Stems: Where insulation is indicated or specified, provide extended stems arranged to receive insulation.

F. Bypass and Drain Connections: Comply with MSS SP-45 bypass and drain connections.

G. End Connections: As indicated in the valve specifications.
   1. Threads: Comply with ANSI B1.20.1.
   2. Flanges: Comply with ANSI B16.1 for cast iron, ANSI B16.5 for steel, and ANSI B16.24 for bronze valves.
   3. Solder-Joint: Comply with ANSI B16.18.
      a. Caution: Where soldered end connections are used, use solder having a melting point below 840 deg F for gate, globe, and check valves; below 421 deg F for ball valves.

2.3 GATE VALVES

A. Gate Valves, 2-Inch and Smaller: MSS SP-80; Class 125, body and bonnet of ASTM B 62 cast bronze; with threaded or solder ends, solid disc, copper-silicon alloy stem, brass packing gland, "Teflon" impregnated packing, and malleable iron handwheel. Provide Class 150 valves meeting the above where system pressure requires.

B. Gate Valves, 2-1/2-Inch and Larger: MSS SP-70; Class 125 iron body, bronze mounted, with body and bonnet conforming to ASTM A 126 Class B; with flanged ends, "Teflon" impregnated packing, and two-piece backing gland assembly.

2.4 BALL VALVES

A. Ball Valves, 1 Inch and Smaller: Rated for 150 psi saturated steam pressure, 400 psi WOG pressure; two-piece construction; with bronze body conforming to ASTM B 62, standard (or regular) port, chrome-plated brass ball, replaceable "Teflon" or "TFE" seats and seals, blowout-proof stem, and vinyl-covered steel handle. Provide solder ends for domestic hot and cold water service; threaded ends for heating hot water.

B. Ball Valves, 1-1/4-Inch to 2-Inch: Rated for 150 psi saturated steam pressure, 400 psi WOG pressure; 3-piece construction; with bronze body conforming to ASTM B 62, conventional port, chrome-plated brass ball, replaceable "Teflon" or "TFE" seats and seals, blowout proof stem, and vinyl-covered steel handle. Provide solder ends for domestic hot and cold water service; threaded ends for heating hot water.

2.5 PLUG VALVES

A. Plug Valves, 2-Inch and Smaller: Rated at 150 psi WOG; bronze body, with straightaway pattern, square head, and threaded ends.

B. Plug Valves, 2-1/2-Inch and Larger: MSS SP-78; rated at 175 psi WOG; lubricated plug type, with semisteel body, single gland, wrench operated, and flanged ends.

2.6 GLOBE VALVES

A. Globe Valves, 2-Inch and Smaller: MSS SP-80; Class 125; body and screwed bonnet of ASTM B 62 cast bronze; with threaded or solder ends, brass or replaceable composition disc, copper-silicon alloy stem, brass packing gland, "Teflon" impregnated packing, and malleable iron handwheel. Provide Class 150 valves meeting the above where system pressure requires.

B. Globe Valves, 2-1/2-Inch and Larger: MSS SP-85; Class 125 iron body and bolted bonnet conforming to ASTM A 126, Class B; with outside screw and yoke, bronze

mounted, flanged ends, and "Teflon" impregnated packing, and two-piece backing gland assembly.

2.7 BUTTERFLY VALVES

A. Butterfly Valves, 2-1/2-Inch and Larger: MSS SP-67; rated at 200 psi; cast-iron body conforming to ASTM A 126, Class B. Provide valves with field replaceable EPDM sleeve, nickel-plated ductile iron disc (except aluminum bronze disc for valves installed in condenser water piping), stainless steel stem, and EPDM O-ring stem seals. Provide lever operators with locks.

2.8 CHECK VALVES

A. Swing Check Valves, 2-Inch and Smaller: MSS SP-80; Class 125, cast-bronze body and cap conforming to ASTM B 62; with horizontal swing, Y-pattern, and 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.

B. Swing Check Valves, 2-1/2-Inch and Larger: MSS SP-71; Class 125 cast iron body and bolted cap conforming to ASTM A 126, Class B; horizontal swing, and bronze disc or cast-iron disc with bronze disc ring; and flanged ends. Provide valves capable of being refitted while the valve remains in the line.

PART 3 - EXECUTION

3.1 EXAMINATION

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

B. Actuate valve through an open-close and close-open cycle. Examine functionally significant features, such as guides and seats made accessible by such actuation. Following examination, return the valve closure member to the shipping position.

C. Examine threads on both the valve and the mating pipe for form (i.e., out-of-round or local indentation) and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Check gasket material for proper size, material composition suitable for service, and freedom from defects and damage.

E. Prior to valve installation, examine the piping for cleanliness, freedom from foreign materials, and proper alignment.

F. Replace defective valves with new valves.

3.2 VALVE ENDS SELECTION

A. Select valves with the following ends or types of pipe/tube connections:
   1. Copper Tube Size, 2-Inch and Smaller: Solder ends, except provide threaded ends for heating hot water and low-pressure steam service.
   2. Steel Pipe Sizes, 2-Inch and Smaller: threaded ends.
   3. Steel Pipe Sizes 2-1/2 Inch and Larger: flanged ends.

3.3 VALVE INSTALLATIONS

A. General Application: Use gate, ball, and butterfly valves as indicated.

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

C. Install valves and unions for each fixture and item of equipment arranged to allow equipment removal without system shutdown. Unions are not required on flanged devices.

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

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

F. Installation of Check Valves: Install for proper direction of flow as follows:
   1. Swing Check Valves: Horizontal position with hinge pin level.

3.4 SOLDER CONNECTIONS

A. Cut tube square and to exact lengths.

B. Clean end of tube to depth of valve socket with steel wool, sand cloth, or a steel wire brush to a bright finish. Clean valve socket in same manner.

C. Apply proper soldering flux in an even coat to inside of valve socket and outside of tube.

D. Open gate and globe valves to full open position.

E. Remove the cap and disc holder of swing check valves having composition discs.

F. Insert tube into valve socket, making sure the end rests against the shoulder inside valve.

Rotate tube or valve slightly to ensure even distribution of the flux.

G. Apply heat evenly to outside of valve around joint until solder will melt upon contact. Feed solder until it completely fills the joint around tube. Avoid hot spots or overheating valve. Once the solder starts cooling, remove excess amounts around the joint with a cloth or brush.

3.5 THREADED CONNECTIONS

A. Note the internal length of threads in valve ends, and proximity of valve internal seat or wall, to determine how far pipe should be threaded into valve.

B. Align threads at point of assembly.

C. Apply appropriate tape or thread compound to the external pipe threads (except where dry seal threading is specified).

D. Assemble joint, wrench tight. Wrench on valve shall be on the valve end into which the pipe is being threaded.

3.6 FLANGED CONNECTIONS

A. Align flange surfaces parallel.

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

C. For dead-end service, butterfly valves require flanges both upstream and downstream for proper shutoff and retention.

3.7 FIELD QUALITY CONTROL

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

3.8 ADJUSTING AND CLEANING

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

3.9 VALVE PRESSURE/TEMPERATURE CLASSIFICATION SCHEDULES

VALVES, 2-INCH AND SMALLER

SERVICE	GATE	GLOBE	BALL	CHECK
Domestic Hot and Cold Water	125	125	150	125
Heating Hot Water	150	150	150	150
Chilled Water	150	150	150	150

VALVES, 2-1/2-INCH AND LARGER

SERVICE	GATE	GLOBE	BUTTERFLY	CHECK
Domestic Hot and Cold Water	125	125	200	125
Heating Hot Water	125	125	200	125
Chilled Water	125	125	200	125

END OF SECTION 15100

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following types of meters and gages:
   1. Temperature gages and fittings.
   2. Pressure gages and fittings.
   3. Flow meters.

B. Meters and gages furnished as part of factory-fabricated equipment are specified as part of equipment assembly in other Division 15 sections.

1.2 SUBMITTALS

A. General: Submit the following:
   1. Product data for each type of meter and gage. Include scale range, ratings, and calibrated performance curves, certified where indicated. Submit meter and gage schedule showing manufacturer's figure number, scale range, location, and accessories for each meter and gage.
   2. Product certificates signed by manufacturers of meters and gages certifying accuracies under specified operating conditions and products' compliance with specified requirements.

1.3 QUALITY ASSURANCE

A. UL Compliance: Comply with applicable UL standards pertaining to meters and gages.

B. ASME and ISA Compliance: Comply 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: Plus or minus 1 percent of range span or plus or minus one scale division to maximum of 1.5 percent of range span.

B. Scale range: Temperature ranges for services listed as follows:

   1. Domestic Hot Water: 30 to 240 deg with 2-degree scale divisions (0 to 115 deg C with 1-degree scale divisions).

2. Domestic Cold Water: 0 to 100 deg F with 2-degree scale divisions (minus 18 to 38 deg C with 1-degree scale divisions).
3. Hot Water: 30 to 300 deg with 2-degree scale divisions (0 to 150 deg C with 1-degree scale divisions).

2.2 DIRECT-MOUNT FILLED-SYSTEM DIAL THERMOMETERS

A. Type: Vapor actuated, universal angle.

B. Case: Drawn steel or cast aluminum, glass lens, 4-1/2-inch diameter.

C. Adjustable Joint: Finish to match case, 180-degree adjustment in vertical plane, 360-degree adjustment in horizontal plane, with locking device.

D. Thermal Bulb: Copper with phosphor bronze bourdon pressure tube.

E. Movement: Brass, precision geared.

F. Scale: Progressive, satin faced, nonreflective aluminum, permanently etched markings.

G. Stem: Copper-plated steel, aluminum, or brass, for separable socket, length to suit installation.

2.3 REMOTE-READING FILLED-SYSTEM DIAL THERMOMETERS

A. Type: Vapor actuated.

B. Case: Drawn steel or cast aluminum, glass lens, 4-1/2-inch diameter.

C. Movement: Brass, precision geared.

D. Scale: Progressive, satin faced, nonreflective aluminum, permanently etched markings.

E. Tubing: Bronze double-braided armor over copper capillary, length to suit installation.

F. Bulb: Copper with separable socket for liquids, averaging element for air.

2.4 BIMETAL DIAL THERMOMETERS

A. Type: Direct mounted, bimetal, universal angle.

B. Case: Stainless steel, glass lens, 5-inch diameter.

C. Adjustable Joint: Finish to match case, 180-degree adjustment in vertical plane, 360-degree adjustment in horizontal plane, with locking device.

D. Element: Bimetal coil.

E. Scale: Satin faced, nonreflective aluminum, permanently etched marking.

F. Stem: Stainless steel for separable socket, length to suit installation.

2.5 DIAL-TYPE INSERTION THERMOMETERS

A. Type: Bimetal, stainless steel case and stem, 1-inch-diameter dial, dust- and leakproof, 1/8-inch-diameter tapered-end stem with nominal length of 5 inches.

2.6 THERMOMETER WELLS

A. Thermometer Wells: Brass or stainless steel, pressure rated to match piping system design pressure; with 2-inch extension for insulated piping and threaded cap nut with chain permanently fastened to well and cap.

2.7 PRESSURE GAGES

A. Type: General use, ASME B40.1, Grade A, phosphor bronze bourdon- tube type, bottom connection.

B. Case: Drawn steel or brass, glass lens, 4-1/2-inches diameter.

C. Connector: Brass, 1/4-inch NPS.

D. Scale: White coated aluminum, with permanently etched markings.

E. Accuracy: Plus or minus 1 percent of range span.

F. Range: Conform to the following:
1. Vacuum: 30 inches Hg to 15 psi.
2. All fluids: 2 times operating pressure.

2.8 PRESSURE GAGE ACCESSORIES

A. Syphon: 1/4-inch NPS straight coil constructed of brass tubing with threads on each end.

B. Snubber: 1/4-inch NPS brass bushing with corrosion-resistant porous metal disc. Disc material shall be suitable for fluid served and rated pressure.

2.9 FLOW METERS, GENERAL

A. Flow rate of elements and meters shall be same as connected equipment or system.

2.10 WAFER ORIFICE-TYPE FLOOD ELEMENTS

A. Type: Differential-pressure wafer-type orifice insert flow elements designed for installation between pipe flanges.

B. Construction: Cast-iron body, brass valves with integral check valves and caps, and calibrated nameplate. Elements shall be pressure rated for 300 psig and 250 deg F (120 deg C).

2.11 VENTURI-TYPE FLOW ELEMENTS

A. Type: Differential-pressure venturi type, designed for installation in piping.

B. Construction: Bronze or cadmium-plated steel with brass fittings and attached tag with flow conversion data. Ends shall be threaded for 2 inches and smaller elements and flanged or welded for 2-1/2 inches and larger elements.

2.12 PITOT TUBE-TYPE FLOW ELEMENTS

A. Type: Differential-pressure pitot tube-type design with probe for insertion into piping.

B. Construction: Stainless steel probe of length to span inside of pipe, with brass fittings and attached tag with flow conversion data. Elements shall be pressure rated for 150 psig and 250 deg F (120 deg C).

2.13 METERS

A. Permanently Mounted Meters: Suitable for mounting on wall or bracket, 6-inch dial or equivalent with fittings and copper tubing for connecting to flow element.

B. Scale shall be in gpm unless otherwise indicated.

C. Accuracy: Plus or minus 1 percent between 20 to 80 percent of range.

D. Portable Meters: Differential-pressure gage and two 12-foot hoses in carrying case with handle.

E. Scale: In inches of water unless otherwise indicated.

F. Accuracy: Plus or minus 2 percent between 20 to 80 percent of range.

G. Each meter shall be complete with operating instructions.

2.14 WINDOW-TYPE FLOW METERS

A. Type: Window-type flow meters designed for installation on hydronic piping and measure flow directly in gpm.

B. Construction: Bronze body and impact tube, integral self-closing valve, glass calibrated tube with indicator ball, and protection shield. Meters shall be pressure rated for 150 psig and temperature rated for 240 deg F (116 deg C).

C. Accuracy: Plus or minus 5 percent.

2.15 BTU METERS

A. Type: BTU meters consisting of turbine wheel flow meter, 2 temperature sensors, solid-state calculator with integral battery pack, integral stop valves, strainer, and magnetic trap.

B. Construction: Bronze housing, 125 psig rating.

C. Temperature Ranges: 40 to 250 deg F (5 to 120 deg C).

D. Data Output: 6-digit electromechanical counter with readout in KWH or BTU.

E. Accuracy: Plus or minus 1 percent.

F. Battery Pack: 5-year lithium battery.

2.16 TEST PLUGS

A. Test Plugs shall be nickel-plated brass body, with 1/2-inch NPS fitting and 2 self-sealing valve-type core inserts, suitable for inserting a 1/8-inch O.D. probe assembly from a dial-type thermometer or pressure gage. Test plug shall have gasketed and threaded cap with retention chain and body of length to extend beyond insulation. Pressure rating shall be 500 psig.

B. Core Material: Conform to the following for fluid and temperature range:
   1. Air, Water, Oil, and Gas, 20 to 200 deg F (minus 7 to 93 deg C): Neoprene.
   2. Air and Water, minus 30 deg to 275 deg F (minus 35 to 136 deg C): EPDM.

C. Test Kit: Provide test kit consisting of 1 pressure gage, gage adapter with probe, 2 bimetal dial thermometers, and carrying case.

D. Ranges of pressure gage and thermometers shall be approximately 2 times systems operating conditions.

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 in the following locations and elsewhere as indicated:
1. At inlet and outlet of each hydronic zone.
2. At inlet and outlet of each hydronic boiler.
3. At inlet and outlet of each indirect water heater.

C. Remote-Reading Dial Thermometers: Install in control panels, with tubing connecting panel and thermometer bulb supported to prevent kinks. Use minimum tubing length.

D. Thermometer Wells: Install in piping tee where thermometers are indicated, in vertical position. Fill well with oil or graphite and secure cap.

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 in the following locations, and elsewhere as indicated:
1. At suction and discharge of each pump.
2. At discharge of each pressure-reducing valve.
3. At building water service entrance.

C. Pressure Gage Needle Valves: Install in piping tee with snubber. Install syphon in lieu of snubber for steam pressure gages.

3.3 INSTALLATION OF TEST PLUGS

A. Test Plugs: Install in piping tee where indicated, located on pipe at most readable position. Secure cap.

3.4 INSTALLATION OF FLOW-MEASURING ELEMENTS AND METERS

A. General: Install flow meters for piping systems located in accessible locations at most readable position.

B. Locations: Install flow measuring elements and meters in the following locations and elsewhere as indicated.
   1. At discharge of each pump.
   2. At inlet of each hydronic coil in built-up central systems.

C. Differential-Pressure-Type Flow Elements: Install minimum straight lengths of pipe upstream and downstream from element as prescribed by the manufacturer's installation instructions.

D. Install wafer orifice-type element between 2 Class 125 pipe flanges, ANSI B16.1 (cast iron) or ANSI B16.24 (bronze).

E. Install connections for attachment to portable flow meters in a readily accessible location.

F. Meters For Use With Flow Elements: Install meters on wall or bracket in accessible location.

G. Install connections, tubing, and accessories between flow elements and meters as prescribed by the manufacturer's installation instructions.

H. Window Flow Meters: Install in vertical upward position with impact tube mounted in bushing centered on pipe with 10 pipe diameters upstream and 5 pipe diameters downstream of straight unrestricted piping for 1-1/4 inches and smaller, 20 pipe diameters upstream and 10 pipe diameters downstream for 1-1/2 inches and larger. Calibrate meter after installation in accordance with manufacturer's installation instructions.

3.5 ADJUSTING AND CLEANING

A. Adjusting: Adjust faces of meters and gages to proper angle for best visibility.

B. Cleaning: Clean windows of meters and gages and factory-finished surfaces. Replace cracked and broken windows, and repair scratched and marred surfaces with manufacturer's touch-up paint.

END OF SECTION 15135

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Requirements of the following Division 15 Sections apply to this section:
   1. "Basic Mechanical Requirements."
   2. "Basic Piping Materials and Methods."

1.2 SUMMARY

A. This section includes the following:
   1. Horizontal-piping hangers and supports.
   2. Vertical-piping clamps.
   3. Hanger-rod attachments.
   4. Building attachments.
   5. Saddles and shields.
   6. Spring hangers and supports.
   7. Miscellaneous materials.
   8. Equipment supports.

B. Related sections: The following sections contain requirements that relate to this section:
   1. Division 15 Section "Mechanical Insulation" for pipe insulation.

1.3 DEFINITIONS

A. Terminology used in this section is defined in MSS SP-90.

1.4 SUBMITTALS

A. General: Submit the following in accordance with conditions of contract and Division 1 specification sections.
   1. Product data, including installation instructions for each type of support and anchor. Submit pipe hanger and support schedule showing Manufacturer's figure number, size, location, and features for each required pipe hanger and support.
   2. Product certificates signed by the manufacturer of hangers and supports certifying that their products meet the specified requirements.

3. Assembly-type shop drawings for each type of support and anchor, indicating dimensions, weights, required clearances, and methods of assembly of components.

1.5 QUALITY ASSURANCE

A. Qualify welding processes and welding operators in accordance with AWS D1.1 "Structural Welding Code - Steel."
   1. Certify that each welder has satisfactorily passed AWS qualification tests for welding processes involved and, if pertinent, has undergone recertification.

B. Regulatory Requirements: Comply with applicable BOCA plumbing code pertaining to product materials and installation of supports and anchors.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Hangers and support components shall be factory fabricated of materials, design, and manufacturer complying with MSS SP-58 and MSS SP-69.
   1. Pipe attachments shall have nonmetallic coating for electrolytic protection where attachments are in direct contact with copper tubing.

2.2 MISCELLANEOUS MATERIALS

A. Steel Plates, Shapes, and Bars: ASTM A 36.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substates and conditions under which supports and anchors are to be installed. Do not proceed with installing until unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF HANGERS AND SUPPORTS

A. General: Install hangers, supports, clamps and attachments to support piping properly from building structure; comply with MSS SP-69 and SP-89. Install supports with maximum spacings complying with Boca Plumbing and Mechanical Codes. Where piping of various sizes is supported together by trapeze hangers, space hangers for

smallest pipe size or install intermediate supports for smaller diameter pipe as specified above for individual pipe hangers.

B. Install building attachments within concrete or 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, expansion joints, and at changes in direction of piping.

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

D. Install hangers and supports to allow controlled 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.

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

F. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes, and so that maximum pipe deflections allowed by ASME B31.9 Building Services Piping Code is not exceeded.

G. Insulated Piping: Comply with the following installation requirements.
1. Shields: Install protective shields MSS Type 40 on cold water piping that has vapor barrier. Shields shall span an arc of 180 degrees and shall have dimensions in inches not less than the following:

NPS	LENGTH	THICKNESS
1/4 THROUGH 3-1/2	12	0.048
4	12	0.060

2. Insert material shall be at least as long as the protective shield.
3. Thermal Hanger Shields: Install where indicated, with insulation of same thickness as piping.

3.3 METAL FABRICATION

A. Cut, drill, and fit miscellaneous metal fabrications for pipe anchors and equipment supports. Install and align fabricated anchors in indicated locations.

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

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

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

3.4 ADJUSTING

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

END OF SECTION 15140

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. Identification devices specified in this section include the following:
   1. Painted Identification Materials.
   2. Plastic Pipe Markers.
   3. Plastic Tape.
   4. Underground-Type Plastic Line Marker.
   5. Plastic Duct Markers.
   6. Valve Tags.
   7. Valve Schedule Frames.
   8. Engraved Plastic-Laminate Signs.
   9. Plastic Equipment Markers.
   10. Plasticized Tags.

B. Mechanical identification furnished as part of factory-fabricated equipment, is specified as part of equipment assembly in other Division-15 sections.

C. Refer to other Division-15 sections for identification requirements at central-station mechanical control center; not work of this section.

D. Refer to Division-16 sections for identification requirements of electrical work; not work of this section.

1.2 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacturer of identification devices of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Codes and Standards:
   1. ANSI Standards: Comply with ANSI A13.1 for lettering size, length of color field, colors, and viewing angles of identification devices.

1.3 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data and installation instructions for each identification material and device required.

B. Samples: Submit samples of each color, lettering style and other graphic representation required for each identification material or system.

C. Schedules: Submit valve schedule for each piping system, typewritten and reproduced

on 8-1/2" x 11" bond paper. Tabulate valve number, piping system, system abbreviation (as shown on tag), location of valve (room or space), and variations for identification (if any). Mark valves which are intended for emergency shut-off and similar special uses, by special "flags", in margin of schedule. In addition to mounted copies, furnish extra copies for Maintenance Manuals as specified in Division 1.

D. Maintenance Data: Include product data and schedules in maintenance manuals; in accordance with requirements of Division 1.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS:

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering mechanical identification materials:
1. Engineer approved equal.

2.1 MECHANICAL IDENTIFICATION MATERIALS:

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

2.2 PAINTED IDENTIFICATION MATERIALS:

A. Stencils: Standard fiberboard stencils, prepared for required applications with letter sizes generally complying with recommendations of ANSI A13.1 for piping and similar applications, but not less than 1-1/4" high letters for ductwork and not less than 3/4" high letters for access door signs and similar operational instructions.

B. Stencil Paint: Standard exterior type stenciling enamel; black, except as otherwise indicated; either brushing grade or pressurized spray-can form and grade.

C. Identification Paint: Standard identification enamel of colors indicated or, if not otherwise indicated for piping systems, comply with ANSI A13.1 for colors.

2.3 PLASTIC PIPE MARKERS:

A. Snap-On Type: Provide manufacturer's standard pre-printed, semi-rigid snap-on, color-coded pipe markers, complying with ANSI A13.1

B. Pressure-Sensitive Type: Provide manufacturer's standard pre- printed, permanent

adhesive, color-coded, pressure-sensitive vinyl pipe markers, complying with ANSI A13.1

C. Insulation: Furnish 1" thick molded fiberglass insulation with jacket for each plastic pipe marker to be installed on uninsulated pipes subjected to fluid temperatures of 125 degrees F (52 degrees C) or greater. Cut length to extend 2" beyond each end of plastic pipe marker.

D. Small Pipes: For external diameters less than 6" (including insulation if any), provide full-band pipe markers, extending 360 degrees around pipe at each location, fastened by one of the following methods:
1. Snap-on application of pre-tensioned semi-rigid plastic pipe marker.
2. Adhesive lap joint in pipe marker overlap.
3. Laminated or bonded application of pipe marker to pipe (or insulation).
4. Taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than 3/4" wide; full circle at both ends of pipe marker, tape lapped 1-1/2".

E. Large Pipes: For external diameters of 6" and larger (including insulation if any), provide either full-band or strip-type pipe markers, but not narrower than 3 times letter height (and of required length), fastened by one of the following methods:
1. Laminated or bonded application of pipe marker to pipe (or insulation).
2. Taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than 1-1/2" wide; full circle at both ends of pipe marker, tape lapped 3".
3. Strapped-to-pipe (or insulation) application of semi-rigid type, with manufacturer's standard stainless steel bands.

F. Lettering: Manufacturer's standard pre-printed nomenclature which best describes piping system in each instance, as selected by Owner/Owner’s Representative in cases of variance with names as shown or specified.

G. Lettering: Comply with piping system nomenclature as specified, scheduled or shown, and abbreviate only as necessary for each application length.
1. Arrows: Print each pipe marker with arrows indicating direction of flow, either integrally with piping system service lettering (to accommodate both directions), or as a separate unit of plastic.

2.4 PLASTIC TAPE:

A. General: Provide manufacturer's standard color-coded pressure-sensitive (self-adhesive) vinyl tape, not less than 3 mils thick.

B. Width: Provide 1-1/2" wide tape markers on pipes with outside diameters (including insulation, if any) of less than 6", 2-1/2" wide tape for larger pipes.

C. Color: Comply with ANSI A13.1, except where another color selection is indicated.

2.5 UNDERGROUND-TYPE PLASTIC LINE MARKER:

A. General: Manufacturer's standard permanent, bright-colored, continuous-printed plastic tape, intended for direct-burial service; not less than 6" wide x 4 mils thick. Provide tape with printing which most accurately indicates the type of service of buried pipe.
   1. Provide multi-ply tape consisting of solid aluminum foil core between 2-layers of plastic tape.

2.6 VALVE TAGS:

A. Brass Valve Tags: Provide 19-gage polished brass valve tags with stamp-engraved piping system abbreviation in 1/4" high letters and sequenced valve numbers 1/2" high, and with 5/32" hole for fastener.
   1. Provide 1-1/2" diameter tags, except as otherwise indicated.
   2. Provide size and shape as specified or scheduled for each piping system.
   3. Fill tag engraving with black enamel.

B. Plastic Laminate Valve Tags: Provide manufacturer's standard 3/32" thick engraved plastic laminate valve tags, with piping system abbreviation in 1/4" high letters and sequenced valve numbers 1/2" high, and with 5/32" hole for fastener.
   1. Provide 1-1/2" sq. black tags with white lettering, except as otherwise indicated.
   2. Provide size, shape and color combination as specified or scheduled for each piping system.

C. Plastic Valve Tags: Provide manufacturer's standard solid plastic valve tags with printed enamel lettering, with piping system abbreviation in approximately 3/16" high letters and sequenced valve numbers approximately 3/8" high, and with 5/32" hole for fastener.
   1. Provide 1-1/8" sq. white tags with black lettering.
   2. Provide size, shape and color combination as specified or scheduled for each piping system.

D. Valve Tag Fasteners: Provide manufacturer's standard solid brass chain (wire link or beaded type), or solid brass S-hooks of the sizes required for proper attachment of tags to valves, and manufactured specifically for that purpose.

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

2.7 VALVE SCHEDULE FRAMES:

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

2.8 ENGRAVED PLASTIC-LAMINATE SIGNS:

A. General: Provide engraving stock melamine plastic laminate, complying with FS L-P-387, in the sizes and thicknesses indicated, engraved with engraver's standard letter style of the sizes and wording indicated, black with white core (letter color) except as otherwise indicated, punched for mechanical fastening except where adhesive mounting is necessary because of substrate.

B. Thickness: 1/16", except as otherwise indicated.

C. Thickness: 1/8", except as otherwise indicated.

D. Thickness: 1/16" for units up to 20 sq. in. or 8" length; 1/8" for larger units.

E. Fasteners: Self-tapping stainless steel screws, except contact-type permanent adhesive where screws cannot or should not penetrate the substrate.

2.9 PLASTIC EQUIPMENT MARKERS:

A. General: Provide manufacturer's standard laminated plastic, color coded equipment markers. Conform to the following color code:
1. Yellow: Heating equipment and components.
2. Blue: Equipment and components that do not meet any of the above criteria.
3. For hazardous equipment, use colors and designs recommended by ANSI A13.1.

B. Nomenclature: Include the following, matching terminology on schedules as closely as possible:
1. Name and plan number.
2. Equipment service.
3. Design capacity.
4. Other design parameters such as pressure drop, entering and leaving conditions, rpm, etc.

C. Size: Provide approximate 2-1/2" x 4" markers for control devices, dampers, and valves; and 4-1/2" x 6" for equipment.

2.10PLASTICIZED TAGS:

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

2.11LETTERING AND GRAPHICS:

A. General: Coordinate names, abbreviations and other designations used in mechanical identification work, with corresponding designations shown, specified or scheduled. Provide numbers, lettering and wording as indicated or, if not otherwise indicated, as recommended by manufacturers or as required for proper identification and operation/maintenance of mechanical systems and equipment.
   1. Multiple Systems: Where multiple systems of same generic name are shown and specified, provide identification which indicates individual system number as well as service (as examples; Boiler No. 3, Air Supply No. 1H, Standpipe F12).

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS:

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

3.2 DUCTWORK IDENTIFICATION:

A. General: Identify air supply, return, exhaust, intake and relief ductwork with duct markers; or provide stenciled signs and arrows, showing ductwork service and direction of flow, in black or white (whichever provides most contrast with ductwork color).

B. Location: In each space where ductwork is exposed, or concealed only by removable ceiling system, locate signs near points where ductwork originates or continues into concealed enclosures (shaft, underground or similar concealment), and at 50' spacings along exposed runs.

C. Access Doors: Provide duct markers or stenciled signs on each access door in ductwork and housings, indicating purpose of access (to what equipment) and other maintenance and operating instructions, and appropriate safety and procedural information.

D. Concealed Doors: Where access doors are concealed above acoustical ceilings or similar concealment, plasticized tags may be installed for identification in lieu of specified signs, at Installer's option.

3.3 PIPING SYSTEM IDENTIFICATION:

A. General: Install pipe markers of one of the following types on each system indicated to receive identification, and include arrows to show normal direction of flow:
1. Stenciled markers, including color-coded background band or rectangle, and contrasting lettering of black or white. Extend color band or rectangle 2" beyond ends of lettering.
2. Stenciled markers, with lettering color complying with ANSI A13.1.
3. Plastic pipe markers, with application system as indicated under "Materials" in this section. Install on pipe insulation segment where required for hot non-insulated pipes.
4. Stenciled markers, black or white for best contrast, wherever continuous color-coded painting of piping is provided.

B. Locate pipe markers and color bands as follows wherever piping is exposed to view in occupied spaces, machine rooms, accessible maintenance spaces (shafts, tunnels, plenums) and exterior non-concealed locations.
1. Near each valve and control device.
2. Near each branch, excluding short take-offs for fixtures and terminal units; mark each pipe at branch, where there could be question of flow pattern.
3. Near locations where pipes pass through walls or floors/ ceilings, or enter non-accessible enclosures.
4. At access doors, manholes and similar access points which permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced intermediately at maximum spacing of 50' along each piping run, except reduce spacing to 25' in congested areas of piping and equipment.
7. On piping above removable acoustical ceilings, except omit intermediately spaced markers.

3.4 UNDERGROUND PIPING IDENTIFICATION:

A. General: During back-filling/top-soiling of each exterior underground piping systems, install continuous underground-type plastic line marker, located directly over buried line at 6" to 8" below finished grade. Where multiple small lines are buried in

common trench and do not exceed overall width of 16", install single line marker. For tile fields and similar installations, mark only edge pipe lines of field.

3.5 VALVE IDENTIFICATION:

A. General: Provide valve tag on every valve, cock and control device in each piping system; exclude check valves, valves within factory-fabricated equipment units, plumbing fixture faucets, convenience and lawn-watering hose bibs, and shut-off valves at plumbing fixtures, HVAC terminal devices and similar rough-in connections of end-use fixtures and units. List each tagged valve in valve schedule for each piping system.
   1. Tagging Schedule: Comply with requirements of "Valve Tagging Schedule" at end of this section.

B. Mount valve schedule frames and schedules in machine rooms where indicated or, if not otherwise indicated, where directed by Architect/Engineer.
   1. Where more than one major machine room is shown for project, install mounted valve schedule in each major machine room, and repeat only main valves which are to be operated in conjunction with operations of more than single machine room.

3.6 MECHANICAL EQUIPMENT IDENTIFICATION:

A. General: Install engraved plastic laminate sign or plastic equipment marker on or near each major item of mechanical equipment and each operational device, as specified herein if not otherwise specified for each item or device. Provide signs for the following general categories of equipment and operational devices:
   1. Main control and operating valves, including safety devices and hazardous units such as gas outlets.
   2. Meters, gages, thermometers and similar units.
   3. Fuel-burning units including boilers, furnaces, heaters, stills and absorption units.
   4. Pumps, compressors, chillers, condensers and similar motor- driven units.
   5. Fans, blowers, primary balancing dampers and mixing boxes.
   6. Tanks and pressure vessels.
   7. Strainers, filters, humidifiers, water treatment systems and similar equipment.

B. Optional Sign Types: Where lettering larger than 1" height is needed for proper identification, because of distance from normal location of required identification, stenciled signs may be provided in lieu of engraved plastic, at Installer's option.

C. Lettering Size: Minimum 1/4" high lettering for name of unit where viewing distance is less than 2'-0", 1/2" high for distances up to 6'-0", and proportionately larger lettering for greater distances. Provide secondary lettering of 2/3 to 3/4 of size of the

principal lettering.

D. Text of Signs: In addition to name of identified unit, provide lettering to distinguish between multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.

E. Optional Use of Plasticized Tags: At Installer's option, where equipment to be identified is concealed above acoustical ceilings or similar concealment, plasticized tags may be installed within concealed space to reduce amount of text in exposed sign (outside concealment).
   1. Operational valves and similar minor equipment items located in non-occupied spaces (including machine rooms) may, at Installer's option, be identified by installation of plasticized tags in lieu of engraved plastic signs.

3.7 ADJUSTING AND CLEANING:

A. Adjusting: Relocate any mechanical identification device which has become visually blocked by work of this division or other divisions.

B. Cleaning: Clean face of identification devices, and glass frames of valve charts.

3.8 EXTRA STOCK:

A. Furnish minimum of 5% extra stock of each mechanical identification material required, including additional numbered valve tags (not less than 3) for each piping system, additional piping system identification markers, and additional plastic laminate engraving blanks of assorted sizes.

   1. Where stenciled markers are provided, clean and retain stencils after completion of stenciling and include used stencils in extra stock, along with required stock of stenciling paints and applicators.

END OF SECTION 15190

PART 1 GENERAL

1.1 SUMMARY

A. The work of this section includes but is not limited to the following:
   1. Vibration isolation elements.
   2. Equipment isolation bases.
   3. Piping flexible connections.
   4. Seismic restraints for isolated and non-isolated mechanical and electrical items.

1.2 REFERENCES

A. State of Connecticut Building Code.

B. NFPA 13 - Installation of Sprinkler Systems.

C. ASHRAE-A Practical Guide to Seismic Restraint.

D. Mason Industries, Inc. Seismic Restraint Guidelines

1.3 QUALIFICATIONS

A. Qualifications: Only firms having five years experience designing and manufacturing seismic devices shall be capable of work in this specification.

1.4 SUBMITTALS

A. The submittal material shall include copies of descriptive data for all products and materials including but not limited to the following:
   1. Descriptive Data:
      a. Catalog cuts and data sheets.
      b. An itemized list showing the items to be isolated and/or seismically restrained, product type or model number to be used and loading and deflection data.
      c. Seismic restraint calculations.
      d. (Structural or civil engineer's State of Connecticut professional engineer's seal verifying design and calculations for seismic restraining system used.)

   2. Shop Drawings:
      a. Drawings showing equipment base construction for each machine, including dimensions, structural member sizes, and support point locations.
      b. Drawings showing methods of suspension, support guides for conduit, piping and ductwork.

c. Drawings showing methods for isolation of conduits, pipes and ductwork penetrating walls and floor slabs.
d. Concrete and steel details for bases including anchor bolt locations.
e. Number location of seismic restraints and anchors for each piece of equipment.
f. Specific details of restraints including anchor bolts for mounting and maximum loading at each location, for each piece of equipment and/or pipe and duct locations.

1.5 GENERAL (MANUFACTURER) RESPONSIBILITIES

A. Design Builder shall have the following responsibilities:
1. Determine vibration isolation and seismic restraint sizes and locations per specifications.
2. Provide and install isolation systems and seismic restraints as scheduled or specified.
3. Guarantee specified isolation system deflection.
4. Provide installation instructions, drawings and field supervision to assure proper installation and performance.
5. Substitution of "Internally Isolated" mechanical equipment in lieu of the specified isolation of this section may be acceptable provided that all specified deflections and stamped seismic calculations are supplied by the equipment manufacturer.

1.6 PROJECT RECORD DOCUMENTS

A. Record actual locations and installation of vibration isolators and seismic restraints including attachment points.

PARTS 2 PRODUCTS

2.1 MANUFACTURERS

A. Mason Industries Inc. models listed below.

B. Other approved manufacturers providing equivalent products include:
1. Vibration Eliminator Co.
2. Amber/Booth Co.

2.2 SEISMIC RESTRAINT TYPES

A. General: Installations shall be designed to safely accept external forces of one-half "G" load in any direction for all rigidly supported equipment without failure and

permanent displacement of the equipment. Life safety equipment such as (fire pumps, sprinkler piping and emergency generators) shall be capable of safely accepting external forces up to one "G" load in any direction without permanent displacement of the supported equipment. Seismic restraints shall not short circuit vibration isolation systems or transmit objectionable vibration or noise.

B. Type I (spring mount): Shall comply with general characteristics of spring isolators having a minimum o.d. to o.h. of .8 to 1 and minimum runout of 50% to solid. Shall incorporate snubbing restraint in all directions. Shall be capable of supporting equipment at a fixed elevation during equipment erection. Cast housings shall be ductile iron or aluminum. System to be field bolted or welded to deck with I G acceleration capability. Mason Type SSLFH or as approved.

C. Type II (snubber): Each corner of side shall incorporate a seismic restraint having a minimum 5/8" thick resilient pad limit stops working in all directions. Restraints shall be made of plate, structural members, or square metal tubing concentric within a welded assembly incorporated resilient pads. Angle bumpers are not acceptable. System to be field bolted or welded to a deck with 1 G acceleration capability. Mason Type Z-1011 and Z-1225.

D. Type III (cable braces): Metal cable type with approved end fastening devices to equipment and structure. System to be field bolted to deck or overhead structural members using two sided beam clamps to steel or appropriately designed insert for concrete. All parts of system including cables, clamps, excluding fastenings are to be single vendor furnished to assure seismic compliance. Mason Type SCB.

E. Type IV (neoprene mount): Double deflection neoprene isolator encased in ductile iron or steel casing minimum .30 static deflection. System to be field bolted or welded to deck with 1 G acceleration capacity. Mason Type BR, RBA.

F. Type V: Non-isolated equipment to be field bolted or welded (powder shots not acceptable) to resist seismic forces unless under 100 lb. Shear force required. Mason Type SAS, SAB.

2.3 VIBRATION ISOLATION - GENERAL

A. Vibration Isolation shall control excessive noise and vibration in the building due to the operation of machinery or equipment, and/or due to interconnected piping, ductwork, or conduit. (The installation of all vibration isolation units, and associated hangers and bases, shall be under the direct supervision of the vibration isolation manufacturer's representative.)

B. All vibration isolators shall have either known non-deflected heights or calibration markings so that, after adjustment, when carrying their load, the deflection can be verified.

C. All isolators shall operate in the linear portion of their load versus deflection curve. Load versus deflection curves shall be furnished by the manufacturer and must be linear over a deflection range of not less than 50% above the design deflection.

D. The theoretical vertical natural frequency for each support point, bases upon load per isolator and isolator stiffness, shall not differ from the design objectives for the equipment as a whole by more than +/- 10%.

E. All neoprene mountings shall have a Shore hardness of 30 to 60 +/- 5, after minimum aging of 20 days or corresponding oven aging.

2.4 VIBRATION ISOLATOR TYPES:

A. Type A: Spring isolators:
1. Minimum diameter of 0.8 of the loaded operating height.
2. Corrosion resistance where exposed to corrosive environment with:
   a. Springs cadmium plated or electro-galvanized.
   b. Hardware cadmium plated.
   c. All other metal parts hot-dip galvanized.
3. Reserve deflection (from loaded to solid height) of 50% of rated deflection.
4. Minimum ¼" thick neoprene acoustical base pad on underside, unless designated otherwise.
5. Designed and installed so that ends of springs remain parallel and all springs installed with adjustment bolts.
6. Non-resonant with equipment forcing frequencies or support structure natural frequencies.
7. Mason Type SLF.
8. When used in conjunction with seismic bracing, seismic restraint Type II shall be installed.

B. Type B: Spring isolators shall be same as Type A, except:
1. Provide built-in vertical limit stops with minimum ¼" clearance under normal operation.
2. Tapped holes in top plate for bolting to equipment when subject to wind load.
3. Capable of supporting equipment at a fixed elevation during equipment erection. Installed and operating heights shall be identical.
4. Adjustable and removable spring pack with separate neoprene pad isolation.
5. Capable of accepting 1 G of acceleration.
6. Mason Type SLR.

C. Type C: Spring hanger rod isolators:
   1. Spring element seated on a steel washer within a neoprene cup incorporating a rod isolation bushing.
   2. Steel retainer box encasing the spring and neoprene cut.
   3. When used in conjunction with seismic bracing, seismic restraint Type III shall be installed.
   4. Mason Type HS.

D. Type D: Seismic Restraint, Type IV: Double deflection neoprene isolator encased in ductile iron or steel casing minimum .30 static deflection. System to be field bolted or welded to deck with 1 G acceleration capacity.
   1. Mason Type BR, RBA.

E. Type E: Elastomer hanger rod isolators:
   1. Molded unit type neoprene element with projecting bushing lining rod clearance hole.
   2. Neoprene element to be minimum 1-3/4" thick.
   3. Steel retainer box encasing neoprene mounting.
   4. Clearance between mounting hanger rod and neoprene bushing shall be minimum of 1/8".
   5. Minimum static deflection of 0.35".
   6. When used in conjunction with seismic bracing, seismic restraint Type III shall be installed.
   7. Mason Type HD.

F. Type F: Combination spring/elastomer hanger rod isolators:
   1. Spring and neoprene isolator elements in a steel box retainer. Neoprene double deflection type. Single deflection is unacceptable. Spring seated in a neoprene cup with extended rod bushing.
   2. Characteristics of spring and neoprene as described in Type A and Type E isolators.
   3. When used in conjunction with seismic bracing, seismic restraint Type III shall be installed.
   4. Mason Type DNHS.

G. Type G: Pad type elastomer mountings:
   1. ¾" Minimum thickness.
   2. 50 PSI maximum loading.
   3. Waffled design.
   4. Deflection per pad thickness.
   5. Galvanized steel plate between multiple layers or pad thickness.
   6. Suitable bearing plate to distribute load.
   7. Mason Type Super W.

H. Type H: Grommet type elastomer bushings:
   1. One piece molded bridge bearing neoprene.
   2. Washer / bushing shall surround the anchor bolt.
   3. Flat washer face to avoid metal to metal contact.
   4. Mason type HG.

I. Type K: Pipe Anchors: All-directional acoustical pipe anchor consisting of a telescopic arrangement of two sizes of steel tubing separated by a minimum one-half inch thickness of heavy-duty neoprene and duck or neoprene isolation material. Vertical restraints shall be provided by similar material arranged to prevent vertical travel in either direction.

J. Allowable loads on the isolation material travel in either direction. Allowable loads on the isolation material shall not exceed 500 psi and the design shall be balanced for equal resistance in any direction. Isolation to be bolted or welded depending on structure.
   1. Mason Type ADA.

2.5 EQUIPMENT BASES

A. Integral Structural Steel Base, Type B-1:
   1. Reinforced as required to prevent base flexure at start-up and misalignment of drive and driven units. Centrifugal fan bases complete with motor slide rails.
   2. Drills for drive and driven unit mounting template.
   3. Must be utilized with seismic restraint Type I, II, or IV.
   4. Mason Type M, WFB.

B. Concrete Inertia Base, Type B-2:
   1. Vibration isolator manufacturer shall furnish rectangular structural concrete forms for floating foundation. Bases for split case pumps shall be large enough to provide support for suction and discharge base ells. The base depth shall be a minimum of 1/10 of the longest dimension of the base but not less than 6” or greater than 14”. Forms shall include minimum concrete reinforcement consisting of ½”bars or angles welded in place in 6” centers running both ways in a layer 1-1/2” above the bottom and a top layer of reinforcing steel as above for all bases exceeding 120” in one direction. Isolators shall be set into pocket housings which are an integral partof the base construction and set at the proper height to maintain a 1” clearance below the base. Bases shall be furnished with templates and anchor bolt sleeves as part of this system.
   2. Must be utilized with seismic restraint Type I, II or IV.
   3. Mason Type K, BMK.

C. Isolated Curb, Type B-3:
   1. Curb mounted rooftop equipment shall be mounted on structural spring isolation curbs that directly sit on roof construction and are flashed and waterproofed into roof's membrane waterproofing system. Manufacturer's curb shall not be used.
   2. All spring locations shall have removable waterproof covers to allow for spring adjustment and/or removal.
   3. Curbs shall have a provision for an optional sound barrier kit
   4. All spring mounts shall be as Isolator Type A.
   5. Curbs shall have static deflection as detailed on the isolation / seismic schedule
   6. Curbs shall be rated for 1 G of acceleration and shall be wind restrained for 110 mph wind loads.
   7. Curbs shall have California OSHPD approval.
   8. Sound barrier package, SBC-3. Two layers of waterproof sheetrock shall be supplied and installed by Design Builder.
   9. Curbs to be welded to building steel or bolted to concrete decks to attain acceleration criteria.
   10. Mason Type RSC.

D. Roof Isolation Rail System, Type B-4: Rooftop fans, condensing units, exterior ducted handling units, etc., shall be installed on continuous equipment support piers which shall combine a regular equipment support and an isolation system into one assembly. The system shall be designed with 2" or 3" static deflection steel springs which are both adjustable, removable, and interchangeable after equipment has been installed. The system shall maintain the same operating and installed height both with and without the equipment load and shall be fully restrained during wind load conditions allowing no more than ¼" motion in any direction. The isolation pier shall be designed to accept the membrane waterproofing. The entire assembly shall be cold spray galvanized or plastic coated. System design permits minimum 1 G of acceleration. Curbs to be welded to building steel or bolted to concrete decks to attain acceleration criteria. Mason Industries Model RSR.

E. Non-isolated seismic roof curbs, Type B-5:
   1. Curb sections shall be either structural steel channels or 12GA. sheet metal
   2. Field assembled joints shall include a minimum of 2 rows of three bolts at each connection.
   3. Curb to have a factory installed wood nailer.
   4. System to be bolted or welded to deck.
   5. System shall be designed for minimum 1/2G. of acceleration.
   6. Mason Type RRC.

F. Dunnage steel mounted rooftop equipment. Type B-6:
   1. Rooftop equipment shall be mounted on structural tubular steel boxed rail assembly.

2. Tubular steel rails shall be attached to seismic rated spring vibration isolators.
3. Isolators shall be bolted or welded to dunnage steel to meet seismic criteria of 1/2G acceleration.
4. Entire assembly shall be hot dipped galvanized.
5. Mason Type RSLR.

2.6 FLEXIBLE CONNECTORS

A. Elastomer Type FC-1:
1. Manufactured of Kevlar reinforcement and EPDM, both molded and cured with hydraulic presses.
2. Straight connectors to have two spheres reinforced with a molded-in external ductile iron ring between spheres.
3. Elbows shall be long radius type.
4. Rated 250 psi at 170 degrees F. Dropping in a straight line to 170 psi at 250 degrees F for sizes 1-1/2" to 12" elbows. Elbows shall be rated no less than 90% of straight connections.
5. Sizes 10" to 12" to employ control cables with neoprene end fittings isolation from anchor plates by means of ½" bridge bearing neoprene bushings.
6. Minimum safety factor, 4:1 at maximum pressure ratings.
7. Systems bolted to victaulic type couplings or gate, butterfly, or check valves to have a minimum 5/8" flange spacer installed between conductor and coupling on flange.
8. Submittals to include test reports.
9. Mason Type Safeflex SFDEJ.

B. Flexible Stainless Hose, Type FC-2:
1. Type 321 stainless steel braided flexible metal hose.
2. 2" pipe size and smaller: threaded carbon steel fittings.
3. 1-1/2" pipe size and larger: Class 150 carbon steel flanges.
4. Suitable for operating pressure with 4:1 minimum safety factor.
5. Flexible Metal Hose Company type DFC and MFC.

C. Unbraided Exhaust Hose, Type FC-3:
1. Low pressure stainless steel annularly corrugated.
2. Fitted with flanged ends.
3. Maximum temperature 1,500 degrees F.
4. Mason Type SDL-RF.

PART 3 EXECUTION

3.1 GENERAL SEISMIC RESTRAINT REQUIREMENTS

A. Install seismic restraints in accordance with manufacturers recommendations.

B. Seismic restraining system Type III: Install taut for non-isolated equipment and slack with ½" cable deflection for isolated systems.

C. Seismically restrain all piping, conduit and ductwork with Type III or Type V seismic restraint in accordance with guidelines outlined below. Restraints which are to be used in conjunction with vibration isolators shall be Type III.
   1. Carbon steel piping shall be braced at maximum 40' intervals and at turns of more than 4'. Lateral bracing at maximum 80' intervals. No-hub piping to be braced at maximum 20□ intervals or maximum 40" using 1/2 G acceleration rated couplings.
   2. Ductwork shall be braced at maximum 30' and at every turn and duct run end. Lateral bracing at maximum 60'.

D. Equipment mounted on housekeeping pads: Pads shall be properly doweled or expansion shielded to deck to meet acceleration criteria. Mason Type HPA.

E. Seismic Restraints are not required for the following:
   1. Piping in boiler or mechanical rooms or penthouses less than 1-1/4" O.D. except gas piping and fire protection piping.
   2. Piping in other areas less than 2-1/2" O.D., except gas piping and fire protection piping.
   3. Ducts which have a cross sectional area less than 6 square feet.
   4. All piping suspended by individual hanger 12" or less in length from the top of the pipe to the bottom of the support for the hanger, except gas piping and fire protection piping.
   5. Fire protection feed mains and cross mains suspended by individual hangers 6" or less in length from the top of the pipe to the bottom of the support for the hanger.
   6. All top supported ducts suspended by hangers 12" or less in length from the top of the duct to the bottom of the support for the hanger.
   7. Electrical conduit less than 1-1/2" I.D.

F. (Chimneys and stacks passing through floors are to be bolted at each floor level or secured above and below each floor with riser clamps.)

G. (Chimneys and stacks running horizontally to be braced every 30' with Type III restraining system.)

H. For overhead supported equipment, over stress of the building structure must not occur. Bracing can occur from:
   1. Flanges to structural beams.
   2. Upper or lower truss chords in bar joist construction at panel points.
   3. Cast-in-place inserts or drilled and shielded inserts in concrete structures.

I. Building seismic expansion joints: Install hinged joints at piping crossing expansion joints and anchor the piping either side per the detail provided on the contract drawings. Anchors on each end are to be capable of accepting 1.5 times the operating pressure multiplied by the projected area of the pipe. Offset shall be accomplished by the annular motion of a double sphere connector (TYPE FC-1) bolted to each end of an intermediate steel pipe. Bracket each joint with hinged steel connections. Hinges shall have a pin / slot assembly on both sides. The completed assembly shall be Mason Type Safeflex SFDEJ-HE.

3.2 GENERAL VIBRATION ISOLATION REQUIREMENTS

A. Install isolators in accordance with manufacturer's recommendations. Vibration isolators shall not cause any change of position resulting in stresses or misalignment.

B. Mechanical equipment shall be isolated from the building structure by means of noise and vibration isolators.

C. Each fan and motor assembly shall be supported on a single structural steel frame (where noted on the isolation and seismic schedule). Flexible duct connections shall be provided at inlet and discharge ducts.

D. Provide pairs of horizontal limit springs (Thrust restraints) on fans with more than 6.0 inch static pressure, and on hanger supported, horizontally mounted axial fans where indicated

E. Provide resiliently mounted equipment, piping, and ductwork with seismic snubbers. Each inertia base shall have minimum of four seismic snubbers located close to isolators. Snub equipment designated for post disaster use to 0.05 inch (1.5 mm) maximum clearance. Other snubbers shall have clearance between 0.15 inch (4 mm) and 0.25 inch (7 mm).

F. Ductwork connected to rotating equipment shall be supported with Type C or Type F isolators for the first three support points.

G. Installation of piping vibration isolators:
   1. All piping, except fire protection standpipe systems, is included under this section.
   2. Vibration isolators shall be installed on all piping outside the shafts as follows:
      a. Piping in boiler or mechanical rooms.
      b. Piping where exposed on roof.
      c. Piping connected to rotating equipment and pressure reducing stations.
      d. Horizontal suspended pipe 2" and smaller and all steam piping shall be suspended by Type E isolator with a minimum 3/8" deflection. Water

pipe larger than 2" shall be supported by Type C or Type F isolator with minimum 1" whichever is greater.

e. Horizontal pipe floor supported at slab shall be supported via Type A with a minimum static deflection of 1" or same deflection as isolated equipment to which pipe connects, whichever is greater.

f. Vertical riser pipe supports under 2" diameter shall utilize Type G isolation pads.

g. Vertical riser guides, if required, shall avoid direct contact of piping with building.

h. Pipe anchors or guides, where required, shall utilize resilient pipe anchors, Mason Industries Type ADA, or equivalent, to avoid direct contact of piping with building.

i. Isolated piping which requires sway bracing shall utilize two neoprene elements, Type G to accommodate tension and compression forces.

j. Pipe extension and alignment connectors: Provide connectors at riser takeoffs, cooling and heating coils, and elsewhere as required, to accommodate thermal expansion and misalignment.

H. Pipe Isolation Schedule

PIPE SIZE - INCH (MM)	ISOLATED DISTANCE FROM EQUIPMENT
1 (25)	120 diameters (3.0m)
2 (50)	90 diameters (4.5m)
3 (80)	80 diameters (6.0m)
4 (100)	75 diameters (7.5m)
6 (150)	60 diameters (9.0m)
8 (200)	60 diameters (12.0m)
10 (250)	54 diameters (13.5m)
12 (300)	50 diameters (15.0m)
16 (400)	45 diameters (18.0m)
24 (600)	38 diameters (23.0m)

3.3 EQUIPMENT INSTALLATION

A. Requirements for installation on concrete inertia bases shall be as follows:
1. Minimum operating clearance between concrete inertia and base and housekeeping pad or floor shall be 1".
2. The equipment structural steel or concrete inertia base shall be placed in position and supported temporarily by blocks or shims, as appropriate, prior to the installation of the machine or isolators.
3. The isolators shall be installed without raising the machine and frame assembly.

4. After the entire installation is complete and under full operational load, the isolators shall be adjusted so that the load is transferred from the blocks to the isolators. When all isolators are properly adjusted, the blocks or shims shall be barely free and shall be removed.
5. Install equipment with flexibility in wiring connection.
6. Verify that all installed isolator and mounting systems permit equipment motion in all directions. Adjust or provide additional resilient restraints to flexibly limit start-up equipment lateral motion to ¼".
7. Prior to start-up, clean out all foreign matter between bases and equipment. Verify that there are no isolation short circuits in the base, isolators, or seismic restraints.

3.4 INSPECTION

A. Upon completion of the installation of all vibration isolation and seismic restraints, the manufacturer's local representative shall visit the project jobsite, visibly inspect all installations and report, in writing, any and all deficiencies from the specifications. Any additional corrective measures required to put the system in total compliance shall be the responsibility of the installing Design Builder.

Vibration Isolation and Seismic Restraint Schedule

EQUIPMENT	BASE	ISOLATOR	SEISMIC RESTRAINT	DEFLECTION
AHU-1	B-1	B	IV	2"
B-1,2	B-2		II	
ALL INLINE EXHAUST FANS		E	III	.35
ALL BASEMOUNTED PUMPS	B-2	A/FC-1	II	
ALL INLINE PUMPS		E	III	.35
ALL EXPANSION TANKS	B-2		II	
ALL UNIT HEATERS		E	III	.35
CH-1		B/H	IV	2"

END OF SECTION 15246

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. Extent of mechanical insulation required by this section is indicated by requirements of this section.

B. Types of mechanical insulation specified in this section include the following:
   1. Piping Systems Insulation:
      a. Fiberglass.
      b. Cellular Glass.
      c. Calcium Silicate.
      d. Flexible Unicellular.

   2. Ductwork System Insulation:
      a. Fiberglass.
      b. Cellular Glass.
      c. Flexible Unicellular.

   3. Equipment Insulation:
      a. Fiberglass.
      b. Calcium Silicate.
      c. Cellular.
      d. Flexible Unicellular.

C. Refer to Division-15 section "Supports and Anchors" for protection saddles, protection shields, and thermal hanger shields; not work of this section.

D. Refer to Division-15 section "Low Pressure Ductwork" for duct linings; not work of this section.

E. Refer to Division-15 section "Mechanical Identification" for installation of identification devices for piping, ductwork, and equipment; not work of this section.

1.2 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 3 years.

B. Installer's Qualifications: Firm with at least 5 years successful installation experience on projects with mechanical insulations similar to that required for this project.

C. Flame/Smoke Ratings: Provide composite mechanical insulation (insulation, jackets, coverings, sealers, mastics and adhesives) with flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E 84 (NFPA 255) method.
   1. Exception: Outdoor mechanical insulation may have flame spread index of 75 and smoke developed index of 150.
   2. Exception: Industrial mechanical insulation that will not affect life safety egress of building may have flame spread index of 75 and smoke developed index of 150.

1.3 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data and installation instructions for each type of mechanical insulation. Submit schedule showing manufacturer's product number, k-value, thickness, and furnished accessories for each mechanical system requiring insulation.

B. Maintenance Data: Submit maintenance data and replacement material lists for each type of mechanical insulation. Include this data and product data in maintenance manual.

C. Samples: Submit manufacturer's sample of each piping insulation type required, and of each duct and equipment insulation type required. Affix label to sample completely describing product.

1.4 DELIVERY, STORAGE, AND HANDLING:

A. Deliver insulation, coverings, cements, adhesives, and coatings to site in containers with manufacturer's stamp or label, affixed showing fire hazard indexes of products.

B. Protect insulation against dirt, water, and chemical and mechanical damage. Do not install damaged or wet insulation; remove from project site.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS:

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products which may be incorporated in the work include, but are not limited to, the following:

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

1. Certainteed Corp.
2. Knauf
3. Manville Products Corp.
4. Owens-Corning Fiberglas Corp.

2.2 PIPING INSULATION MATERIALS:

A. Fiberglass Piping Insulation: ASTM C 547, Class 1 unless otherwise indicated. **K-factor maximum of 0.25 ar 75 degrees F.**

B. Jackets for Piping Insulation: ASTM C 921, Type I for piping with temperatures below ambient, Type II for piping with temperatures above ambient. Type I may be used for all piping at Installers option.
   1. Encase pipe fittings insulation with one-piece premolded PVC fitting covers, fastened as per manufacturer's recommendations.
   2. Encase exterior piping insulation with aluminum jacket with weather-proof construction.

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

D. Adhesives, Sealers, and Protective Finishes: As recommended by insulation manufacturer for applications indicated.

2.3 DUCTWORK INSULATION MATERIALS:

A. Rigid Fiberglass Ductwork Insulation: ASTM C 612, Class 1.

B. Flexible Fiberglass Ductwork Insulation: ASTM C 553, Type I, Class B-4.

C. Cellular Glass Ductwork Insulation: ASTM C 552, Type I.

D. Flexible Unicellular Ductwork Insulation: ASTM C 534, Type II.

E. Jackets for Ductwork Insulation: ASTM C 921, Type I for ductwork with temperatures below ambient; Type II for ductwork with temperatures above ambient.

F. Ductwork Insulation Accessories: Provide staples, bands, wires, tape, anchors, corner angles and similar accessories as recommended by insulation manufacturer for applications indicated.

G. Ductwork Insulation Compounds: Provide cements, adhesives, coatings, sealers, protective finishes and similar compounds as recommended by insulation manufacturer for applications indicated.

2.4 EQUIPMENT INSULATION MATERIALS:

A. Rigid Fiberglass Equipment Insulation: ASTM C 612, Class 2.

B. Flexible Fiberglass Equipment Insulation: ASTM C 553, Type I, Class B-4.

C. Calcium Silicate Equipment Insulation: ASTM C 533, Type I, Block.

D. Cellular Glass Equipment Insulation: ASTM C 552, Type I.

E. Flexible Unicellular Equipment Insulation: ASTM C 534, TYPE II.

F. Jacketing Material for Equipment Insulation: Provide pre-sized glass cloth jacketing material, not less than 7.8 ounces per square yard, or metal jacket at Installer's option, except as otherwise indicated.

G. Equipment Insulation Compounds: Provide adhesives, cements, sealers, mastics and protective finishes as recommended by insulation manufacturer for applications indicated.

H. Equipment Insulation Accessories: Provide staples, bands, wire, wire netting, tape, corner angles, anchors and stud pins as recommended by insulation manufacturer for applications indicated.

PART 3 - EXECUTION

3.1 INSPECTION:

A. Examine areas and conditions under which mechanical insulation is to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 PLUMBING PIPING SYSTEM INSULATION:

A. Cold Piping:
   1. Application Requirements: Insulate the following cold plumbing piping systems:
      a. Potable cold water piping.

   2. Insulate each piping system specified above with one of the following types and thicknesses of insulation:

a. Fiberglass: 2" thickness.

B. Hot Piping:
1. Application Requirements: Insulate the following hot plumbing piping systems:
a. Potable hot water piping.
b. Potable hot water recirculating piping.

2. Insulate each piping system specified above with one of the following types and thicknesses of insulation:
a. Fiberglass: 2" thickness

3.3 HVAC PIPING SYSTEM INSULATION:

A. Cold Piping (40 degrees F (4.4 degrees C) to ambient):
1. Application Requirements: Insulate the following cold HVAC piping systems:
a. HVAC chilled water supply and return piping.
b. HVAC make-up water piping.
c. Air conditioner condensate drain piping.

2. Insulate each piping system specified above with one of the following types and thicknesses of insulation:
a. Fiberglass: 2” thickness

C. Hot Low Pressure Piping (to 250 degrees F (121 degrees C)):
1. Application Requirements: Insulate the following hot low pressure HVAC piping systems (steam piping up to 15 psi, water piping up to 250 degrees F (121 degrees C).
a. HVAC hot water supply and return piping.
b. Low pressure steam and condensate piping
c. Condenser water supply and return piping.
d. Heated fuel piping.
e. Hot gas refrigerant piping.

2. Insulate each piping system specified above with one of the following types and thicknesses of insulation:
a. Fiberglass: 2” thickness

3.4 DUCTWORK SYSTEM INSULATION:

A. Cold Ductwork (Below Ambient Temperature):
1. Application Requirements: Insulate the following cold ductwork:
a. Outdoor air intake ductwork between air entrance and fan inlet or HVAC unit inlet.

b. HVAC supply ductwork between fan discharge, or HVAC unit discharge, and room terminal outlet.

1) Insulate neck and bells of supply diffusers.

c. HVAC return ductwork between room terminal inlet and return fan inlet, or HVAC unit inlet; except omit insulation on return ductwork located in return air ceiling plenums.
d. HVAC plenums and unit housings not pre-insulated at factory or lined.

2. Insulate each ductwork system specified above with one of the following types and thicknesses of insulation:
a. Rigid Fiberglass: 1-1/2" thick, increase thickness to 2" in machine, fan and equipment rooms.
b. Flexible Fiberglass: 1-1/2" thick, application limited to concealed locations.
c. Cellular Glass: 2-1/2" thick.
d. Flexible Unicellular: 1" thick.

C. Hot Ductwork (Above Ambient Temperature):
1. Application Requirements: Insulate the following hot ductwork:
a. Hot supply and return ductwork between fan discharge, or heating unit discharge, and room terminal outlet; except omit insulation on return ductwork located in return air ceiling plenums.
b. Heating plenums and unit housings not pre-insulated at factory or lined.

2. Insulate each ductwork system specified above with one of the following types and thicknesses of insulation:
a. Rigid Fiberglass: 2" thick.
b. Flexible Fiberglass: 2" thick, application limited to concealed locations.
c. Calcium Silicate: 3" thick. Use for range and hood exhaust ductwork, in addition to other applications where indicated.

3.5 EQUIPMENT INSULATION:

A. Cold Equipment (Below Ambient Temperature):
1. Application Requirements: Insulate the following cold equipment:
a. Refrigeration equipment, including chillers, tanks and pumps.
b. Drip pans under chilled equipment.
c. Cold and chilled water pumps.

2. Insulate each item of equipment specified above with one of the following types and thicknesses of insulation:

a. Fiberglass: 2" thick for cold surfaces above 35 degrees F (2 degrees C) and 3" thick for surfaces 35 degrees F (2 degrees C) and lower.
b. Cellular Glass: 3" thick for surfaces above 35 degrees F (2 degrees C) and 4-1/2" thick for surfaces 35 degrees F (2 degrees C) and lower.

B. Hot Equipment (Above Ambient Temperature):

3 Application Requirements: Insulate the following hot equipment:
a. Boilers.
b. Hot water storage tanks.
c. Hot water expansion tanks.
d. Hot water pumps.

4 Insulate each item of equipment specified above with one of the following types and thicknesses of insulation:
a. Fiberglass: 2" thick, except 3" thick for low-pressure boilers and steam-jacketed heat exchangers.
b. Calcium Silicate: 3" thick except 4-1/2" thick for low-pressure boilers and steam-jacketed heat exchangers.

3.6 INSTALLATION OF PIPING INSULATION:

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

B. Install insulation on pipe systems subsequent to installation of heat tracing, painting, testing, and acceptance of tests.

C. Install insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full-length units of insulation, with a single cut piece to complete run. Do not use cut pieces or scraps abutting each other.

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

E. Maintain integrity of vapor-barrier jackets on pipe insulation, and protect to prevent puncture or other damage.

F. Cover valves, fittings and similar items in each piping system with equivalent thickness and composition of insulation as applied to adjoining pipe run. Install factory molded, precut or job fabricated units (at Installer's option) except where specific form or type is indicated.

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

H. Butt pipe insulation against pipe hanger insulation inserts. For hot pipes, apply 3" wide vapor barrier tape or band over the butt joints. For cold piping apply wet coat of vapor barrier lap cement on butt joints and seal joints with 3" wide vapor barrier tape or band.

3.7 INSTALLATION OF DUCTWORK INSULATION:

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

B. Install insulation materials with smooth and even surfaces.

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

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

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

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

G. Ductwork Exposed to Weather: Protect outdoor insulation from weather by installing outdoor protective finish or jacketing as recommended by manufacturer.

H. Corner Angles: Except for oven and hood exhaust duct insulation, install corner angles on external corners of insulation on ductwork in exposed finished spaces before covering with jacketing.

3.8 INSTALLATION OF EQUIPMENT INSULATION:

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

B. Install insulation materials with smooth and even surfaces and on clean and dry surfaces. Redo poorly fitted joints. Do not use mastic or joint sealer as filler for gapping joints and excessive voids resulting from poor workmanship.

C. Maintain integrity of vapor-barrier on equipment insulation and protect it to prevent puncture and other damage.

D. Do not apply insulation to equipment, breechings, or stacks while hot.

E. Apply insulation using the staggered joint method for both single and double layer construction, where feasible. Apply each layer of insulation separately.

F. Coat insulated surfaces with layer of insulating cement, troweled in workmanlike manner, leaving a smooth continuous surface. Fill in scored block, seams, chipped edges and depressions, and cover over wire netting and joints with cement of sufficient thickness to remove surface irregularities.

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

H. Do not insulate boiler manholes, handholes, cleanouts, ASME stamp, and manufacturer's nameplate. Provide neatly beveled edge at interruptions of insulation.

I. Provide removable insulation sections to cover parts of equipment which must be opened periodically for maintenance; include metal vessel covers, fasteners, flanges, frames and accessories.

J. Equipment Exposed to Weather: Protect outdoor insulation from weather by installation of weather-barrier mastic protective finish, or jacketing, as recommended by the manufacturer.

3.9 EXISTING INSULATION REPAIR:

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

3.10 PROTECTION AND REPLACEMENT:

A. Replace damaged insulation which cannot be repaired satisfactorily, including units with vapor barrier damage and moisture saturated units.

B. Protection: Insulation Installer shall advise Design Builder of required protection for insulation work during remainder of construction period, to avoid damage and deterioration.

END OF SECTION 15250

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes distribution piping systems for natural gas and manufactured gas within the building and extending from the point of delivery to the connections with gas utilization devices. Piping materials and equipment specified in this Section include:
   1. Pipes, fittings, and specialties;
   2. Special duty valves.

B. This Section does not apply to LP-gas piping; industrial gas applications using such gases as acetylene and acetylenic compounds, hydrogen, ammonia, carbon monoxide, oxygen and nitrogen; gas piping, meters, gas pressure regulators and other appurtenances used by the serving gas supplier in distribution of gas.

C. Gas pressures for systems specified in this section are limited to 5 psig.

D. Products installed but not furnished under this Section include gas meters which will be provided by the local utility company, to the site, ready for installation.

1.2 DEFINITIONS

A. Pipe sizes used in this Specification are Nominal Pipe Size (NPS).

B. Gas Distribution Piping: A pipe within the building which conveys gas from the point of delivery to the points of usage.

C. Gas Service Piping: The pipe from the gas main or other source of supply including the meter, regulating valve, or service valve to the gas distribution system of the building served.

D. Point of Delivery is the outlet of the service meter assembly, or the outlet of the service regulator (service shutoff valve when no meter is provided).

1.3 SUBMITTALS

A. Product data for each gas pipe, piping specialty and special duty valves. Include rated capacities of selected models, furnished specialties and accessories, and installation instructions.

B. Maintenance data for gas specialties and special duty valves, for inclusion in operating and maintenance manual.

C. Welders' qualification certificates, certifying that welders comply meet the quality requirements specified under "Quality Assurance" below.

D. Test reports specified in Part 3 below.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Installation and replacement of gas piping, gas utilization equipment or accessories, and repair and servicing of equipment shall be performed only by a qualified installer. The term qualified is defined as experienced in such work (experienced shall mean having a minimum of 5 previous projects similar in size and scope to this project), familiar with precautions required, and has complied with the requirements of the authority having jurisdiction. Upon request, submit evidence of such qualifications to the Engineer.

B. Qualifications for Welding Processes and Operators: Comply with the requirements of ASME Boiler and Pressure Vessel Code, "Welding and Brazing Qualification."

C. Regulatory Requirements: Comply with the requirements of the following codes:
1. NFPA 54 - National Fuel Gas Code, for gas piping materials and components, gas piping installations, and inspection, testing, and purging of gas piping systems.
2. BOCA Basic National Mechanical Code.

D. Gas Company: Contractor to coordinate all work with local gas company prior to start of construction. Contractor to provide all equipment and accessories for proposed work.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Handling Flammable Liquids: Remove and legally dispose of liquid from drips in existing gas piping and handle cautiously to avoid spillage or ignition. Notify the gas supplier. Handle flammable liquids used by the installer with proper precautions, and do not leave on the premises from the end of one working day to the beginning of the next.

1.6 SEQUENCING AND SCHEDULING

A. Notification of Interruption of Service: Except in the case of an emergency, notify all affected users when the gas supply is to be turned off.

B. Work Interruptions: When interruptions in work occur while repairs or alterations are being made to an existing piping system, leave the system in safe condition.

C. Coordinate the installation of pipe sleeves for foundation wall penetrations.

1.7 EXTRA MATERIALS

A. Valve Wrenches: Furnish to Owner, with receipt, 2 valve wrenches for each type of gas valve installed, requiring same.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering gas piping system products which may be incorporated in the work include, but are not limited to, the following:
   1. Gas Cocks:
      a. Jenkins Bros.
      b. Lunkenheimer Co.
      c. NIBCO, Inc.
      d. Powell Co.
      e. Stockham.

2.2 PIPE AND TUBING MATERIALS

A. General: Refer to Part 3, Article "PIPE APPLICATION" for identification of systems where the below specified pipe and fitting materials are used.

B. Steel Pipe: ASTM A 53, Schedule 40, seamless, black steel pipe, beveled ends.

2.3 FITTINGS

A. Malleable-Iron Threaded Fittings: ANSI B16.3, Class 150, standard pattern, for threaded joints. Threads shall conform to ANSI B1.20.1.

B. Steel Fittings: ASTM A 234, seamless or welded, for welded joints.

C. Steel Flanges and Flanged Fittings: ANSI B16.5, including bolts, nuts, and gaskets of the following material group, end connection and facing:
   1. Material Group: 1.1.
   2. End Connections: Butt Welding.
   3. Facings: Raised face.

2.4 JOINING MATERIALS

A. Gasket Material: thickness, material, and type suitable for gas to be handled, and for design temperatures and pressures.

2.5 PIPING SPECIALTIES

A. Unions: ANSI B16.39, Class 150, black malleable iron; female pattern; brass to iron seat; ground joint.

2.6 VALVES

A. General duty valves (i.e., gate, globe, check, ball, and butterfly valves) are specified in Division 15 Section "General Duty Valves." Special duty valves are specified in this Article by their generic name. Refer to Part 3 below, Article "VALVE APPLICATION" for specific uses and applications for each valve specified.

B. Gas Cocks 2 Inch and Smaller: 150 psi WOG, bronze body, straightaway pattern, square head, threaded ends.

C. Gas Cocks 2-1/2 Inch and Larger: MSS SP-78; 175 psi, lubricated plug type, semi-steel body, single gland, wrench operated, flanged ends.

2.7 METER

A. Modify existing meter and associated piping as required. Coordinate with local gas company.

PART 3 - EXECUTION

3.1 PREPARATION

A. Precautions: Before turning off the gas to the premises, or section of piping, turn off all equipment valves. Perform a leakage test as specified in "FIELD QUALITY CONTROL" below, to determine that all equipment is turned off in the piping section to be affected.

B. Conform with the requirements in NFPA 54, for the prevention of accidental ignition.

3.2 PIPE APPLICATIONS

A. Install steel pipe with threaded joints and fittings for 2 inch and smaller, and with welded joints for 2-1/2 inch and larger.

3.3 PIPING INSTALLATIONS

A. General: Conform to the requirements of NFPA 54 - National Fuel Gas Code.

B. Locations and Arrangements: Drawings (plans, schematics, and diagrams) indicate the general location and arrangement of piping systems. Design locations and arrangements of piping take into consideration pipe sizing, flow direction, slope of pipe, expansion, and other design considerations. So far as practical, install piping as indicated.

C. Install pipe sleeve and seals at foundation and basement wall penetrations, as specified in Division 15 Section "Basic Piping Materials and Methods."

D. Seal pipe penetrations of fire barriers using fire barrier penetration sealers specified in Division 7 Section "Joint Sealers."

E. Drips and Sediment Traps: Install a drip leg at points where condensate may collect, at the outlet of the gas meter, and in a location readily accessible to permit cleaning and emptying. Do not install drips where condensate is likely to freeze.
   1. Construct drips and sediment traps using a tee fitting with the bottom outlet plugged or capped. Use a minimum of 3 pipe diameters in length for the drip leg. Use same size pipe for drip leg as the connected pipe.

F. Use fittings for all changes in direction and all branch connections.

G. Install exposed piping at right angles or parallel to building walls. Diagonal runs are not permitted, unless expressly indicated.

H. Install piping free of sags or bends and with ample space between piping to permit proper insulation applications.

I. Conceal all pipe installations in walls, pipe chases, utility spaces, above ceilings, below grade or floors, unless indicated to be exposed to view.

J. Install piping tight to slabs, beams, joists, columns, walls, and other permanent elements of the building. Provide space to permit insulation applications, with 1" clearance outside the insulation. Allow sufficient space above removable ceiling panels to allow for panel removal.

K. Locate groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

L. Install gas piping at a uniform grade of 1/4 inch in 15 feet, upward to risers, and from the risers to the meter, or service regulator when meter is not provided, or the equipment.

M. Make reductions in pipe sizes using eccentric reducer fittings installed with the level side down.

N. Connect branch outlet pipes from the top or sides of horizontal lines, not from the bottom.

O. Hanger, supports, and anchors are specified in Division 15 Section "Basic Mechanical Materials and Methods." Conform to the table below for maximum spacing of supports:
1. Steel Pipe:

SIZE (NPS)	SPACING IN FEET	MIN. ROD SIZE IN
3/4 to 1-1/4	12	3/8
1-1/2 to 4 (horizontal)	12	1/2
vertical every floor level		

P. Install unions in pipes 2 inch and smaller, adjacent to each valve, at final connections each piece of equipment, and elsewhere as indicated. Unions are not required on flanged devices.

Q. Install flanges on valves, apparatus, and equipment having 2-1/2 inch and larger connections.

3.4 PIPE JOINT CONSTRUCTION

A. Welded Joints: Comply with the requirements in ASME Boiler and Pressure Vessel Code, Section IX.

B. Threaded Joints: Conform to ANSI B1.20.1, tapered pipe threads for field cut threads. Join pipe, fittings, and valves as follows:
1. Note the internal length of threads in fittings or valve ends, and proximity of internal seat or wall, to determine how far pipe should be threaded into joint. Refer to NFPA 54, for guide for number and length of threads for field threading steel pipe.
2. Align threads at point of assembly.
3. Apply appropriate tape or thread compound to the external pipe threads.
4. Assemble joint to appropriate thread depth. When using a wrench on valves place the wrench on the valve end into which the pipe is being threaded.
5. Damaged Threads: Do not use pipe with threads which are corroded, or damaged. If a weld opens during cutting or threading operations, that portion of pipe shall not be used.

C. Flanged Joints: Align flanges surfaces parallel. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly to appropriate torque specified by the bolt manufacturer.

3.5 VALVE APPLICATIONS

A. General: The Drawings indicate valve types, locations, and arrangements.

B. Shut-off duty: Use gas cocks specified in Part 2 above.

3.6 VALVE INSTALLATIONS

A. Install valves in accessible locations, protected from physical damage. Tag valves with a metal tag attached with a metal chain indicating the piping systems supplied.

B. Install a gas cock upstream of each gas pressure regulator. Where two gas pressure regulators are installed in series in a single gas line, a manual valve is not required at the second regulator.

C. Install pressure relief or pressure limiting devices so they can be readily operated to determine if the valve is free; so they can be tested to determine the pressure at which they will operate; and examined for leakage when in the closed position.

3.7 TERMINAL EQUIPMENT CONNECTIONS

A. Install gas cock upstream and within 6 feet of gas appliance. Install a union or flanged connection downstream from the gas cock to permit removal of controls.

B. Sediment Traps: Install a tee fitting with the bottom outlet plugged or capped as close to the inlet of the gas appliance as practical. Drip leg shall be a minimum of 3 pipe diameters in length.

3.8 ELECTRICAL BONDING AND GROUNDING

A. Install above ground portions of gas piping systems, upstream from equipment shutoff valves electrically continuous and bonded to a grounding electrode in accordance with NFPA 70 - "National Electrical Code."

B. Do not use gas piping as a grounding electrode.

C. Conform to NFPA 70 - "National Electrical Code," for electrical connections between wiring and electrically operated control devices.

3.9 FIELD QUALITY CONTROL

A. Piping Tests: Inspect, test, and purge natural gas systems in accordance with NFPA 54, and local utility requirements.

END OF SECTION 15488

PART 1 - GENERAL

1.1 SUMMARY

A. Scope: Extent of hydronic piping, fittings, valves and accessories is indicated on the drawings, in schedules and by the requirements of this Section.

B. Types: Types of hydronic piping systems specified in this Section include the following:
   1. Supply and return piping.

C. Related Sections: Refer to other Division 15 sections for the following:
   1. Meters and Gauges.
   2. Supports and Anchors.
   3. Mechanical Insulation.
   4. Firestopping.
   5. Testing, Adjusting, and Balancing.
   6. Valves

1.2 QUALITY ASSURANCE

A. Codes and Standards: Provide piping conforming to the requirements of the following:
   1. American National Standards Institute (ANSI):
      a. B16.3 Malleable Iron Threaded Fittings
      b. B16.5 Pipe Flanges and Flanged Fittings
      c. B16.9 Factory-Made Wrought Steel Buttwelding Fittings
      d. B16.11 Forged Steel Fittings, Socket-Welding and Threaded
      e. B16.18 Cast Copper Alloy Solder Joint Pressure Fittings
      f. B16.22 Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
      g. B16.39 Malleable Iron Threaded Pipe Unions Classes 150, 250, and 300
      h. B31 Code for Pressure Piping
      i. B31.1 Power Piping

   2. American Society of Mechanical Engineers (ASME): Installation of piping shall conform to the requirements of ANSI B31.1 "Power Piping."
   3. American Society for Testing and Materials (ASTM):
      a. A 47 Standard Specification for Ferritic Malleable Iron Castings
      b. A 53 Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded Seamless
      c. A 106 Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service

d.	A 126	Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
e.	A 183	Standard Specification for Carbon Steel Track Bolts and Nuts
f.	A 193/ A 193M	Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service
g.	A 194/ A 194M	Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure and High-Temperature Service
h.	A 307	Standard Specification for Carbon Steel Bolts and Studs, 60 000 psi Tensile Strength
i.	A 536	Standard Specifications for Ductile Iron Castings
j.	B 16	Standard Specification for Free-Cutting Brass Rod, Bar and Shapes for Use in Screw Machines
k.	B 32	Standard Specification for Solder Metal
l.	B 61	Standard Specification for Steam or Valve Bronze Castings
m.	B 62	Standard Specification for Composition Bronze or Ounce Metal Castings
n.	B 88	Standard Specification for Seamless Copper Water Tube
o.	D 2000	Standard Classification System for Rubber Products in Automotive Applications

4. American Society of Testing Materials (ASTM) Standard Specification for Crosslinked Polyethylene (PEX) Tubing B Designation: F876
5. American Society of Testing Materials (ASTM) Standard Specification for Crosslinked Polyethylene (PEX) Plastic Hot- and Cold-Water Distribution Systems B Designation: F877
6. National Sanitation Foundation (NSF) and American National Standards Institute (ANSI) Standard 14 B Plastic Piping System Components and Related Materials.
7. German Standard B Pipelines of Plastic Materials used in Warm Water Floor Heating Systems; General Requirements B Designation: DIN 4726.
8. Plastic Pipe Institute (PPI) Technical Report TR-3B Policies and Procedures for Developing Recommended Hydrostatic Design Stresses for Thermoplastic Pipe Materials.
9. Plastic Pipe Institute (PPI) Technical Report TR-4 B Recommended Hydrostatic Strength and Design Stresses for Thermoplastic Pipe and Fitting Compounds.

B. Qualification of Welders: Welders performing work under this Contract shall be certified and qualified in accordance with tests prescribed by the National Certified Welding Bureau (NCWB) or by other approved test procedures using methodology and procedures covered in the ASME Boiler and Pressure Vessel Code, Section IX, "Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators."

1. Submit for approval the names, identification, and welder's assigned number, letter or symbol of welders assigned to this project.
2. The assigned identification symbol shall be used to identify the work of each welder and shall be indelibly stamped immediately upon completion of each weld.
3. Welders shall be tested and certified for all positions.
4. Submit identifying stencilled test coupons made by each operator.
5. Any or all welders may be required to retake welding certification tests without additional expense.
6. When so requested, a welder shall not be permitted to work as a welder on this project until he has been recertified in accordance with NCWB.
7. Recertification of the welder shall be made after the welder has taken and passed the required tests.
8. Where piping 1-1/2 inches and smaller is butt or socket welded, submit 3 samples of test welds for approval.

1.3 SUBMITTALS

A. Product Data: Submit manufacturer's standard technical product data indicating conformance to the stipulated reference specifications, construction materials, construction details, and test and operating pressures. Submit manufacturer's product data on the following:
1. Pipe materials.
2. Unions and flanges.
3. Welding fittings.
4. Valves.
5. Strainers.
6. Equipment.

B. Shop Drawings: Provide piping layout drawings, drawn to a scale of not less than 1/4-inch to one foot showing the proposed layout of piping systems including valves, fittings, equipment, pumps, hangers, grading, high points, low points, drain points, anchors, expansion devices, installation details, hydraulic requirements, wiring diagrams, and control scenario. Provide shop drawings for the following locations:
1. Boiler room.
2. Mechanical mezzanine.
3. Coils.

1.4 STORAGE AND PROTECTION

A. Storage: Store piping on the project site so as to preclude the entrance of construction dirt and debris into the open ends of piping. Do not install piping fouled with construction dirt.

B. Storage of Fittings: Store fittings under cover, protected from construction dirt and rain.

C. Storage of Valves: Store valves under cover with blind or protective wood flanges secured to valve openings. Valves fouled with construction dirt shall be removed from the project site and replaced with new.

1.5 OPERATION AND MAINTENANCE DATA

A. Submit operations and maintenance data, including manufacturer's descriptive literature, installation instructions, operating instructions and maintenance and repair data.

1.6 WARRANTY

A. Brass fittings and accessories will have a 5 year warranty.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Pipe 2-1/2-inch Diameter and Smaller: Provide piping as follows:
   1. Copper, Type K or L, conforming to ASTM B 88.

B. Pipe 3 inches Diameter and Larger: Provide piping as follows:
   1. Schedule 40 black steel conforming ASTM A 53 or A 106.
   2. Use A 53 or A 106 for expansion loops, expansion bends or stresses in excess of 12,000 psig.

2.2 PIPE FITTINGS: 125 PSIG MAXIMUM WORKING PRESSURE

A. Fittings 2-inch and Smaller: Pipe fittings for piping 2 inches and smaller shall be tested and permanently stamped for 125 psig water working pressure and conform to the following:
   1. Provide threaded cast iron elbows, tees, caps and plugs conforming to ANSI B16.4, Class 125.
   2. Threaded galvanized malleable iron elbows, tees, plugs and caps conforming to ANSI B16.3, Class 150.
   3. Provide cast iron flanges conforming to ANSI B16.1, Class 125.
   4. Provide galvanized malleable iron unions, with bronze facings conforming to ANSI B16.39.
   5. Provide bolts and nuts conforming to ASTM A 307, Grade B up to 125 pounds

per square inch working pressure.

B. Fittings 2-1/2-inch Diameter and Larger: For working pressures not exceeding 125 psig water pressure provide fittings as follows:

1. Provide butt welding tees long radius pattern, long radius elbows and caps conforming to ANSI B16.9, each stamped by the manufacturer for conformance and working pressure.
2. Provide steel flanges conforming to ANSI B16.5, standard or welding neck pattern.
3. Provide cast iron flanged tees, flanged long radius elbows, flanged reducers and blank flanges conforming to ANSI B16.1, 125 psig class.

C. Fittings for Copper Pipe: Provide fittings for copper piping 2-1/2-inch diameter and smaller as follows:
1. Provide cast or wrought copper solder joint fittings conforming to ANSI B16.18 or ANSI B16.22. Solder shall be composition ASTM B 32 Grade 95TA, Tin-Antimony or ASTM B 32 95TS Silver Solder.
2. The use of lead-tin solder is not permitted.

D. Fittings
1. Fittings will be constructed from brass.
2. Fittings will be selected from the BRHC Product Catalog.
3. All fittings will meet the dimensional requirements for copper sweat and pipe threads in accordance with ASME B16.22 and B1.20.
4. Sweat fittings will be made up with solder that meets the requirements of ASTM B32-95b
5. Installation accessories will not conflict with local building codes.

2.3 SHAPED NIPPLES

A. Welded Shaped Nipples: On hydronic piping systems operating at less than 125 pounds per square inch water working pressure, factory made shaped welding nipples may be used under the following conditions:
1. Thickness of the fitting at any point shall not be less than the thickness of adjacent piping.
2. Tapping holes shall be drilled or ground smooth and of a diameter to match nipple bell.
3. Branch pipe diameter does not exceed 50 percent of the diameter of the main.
4. Field cut pipe or standard threaded coupling will not be permitted.

2.4 STRAINERS

A. Types: Provide strainers of the "Y" or basket types as indicated on the drawings or required to suit the field conditions.

B. Strainers 1-1/2-Inch Diameter and Smaller: Provide strainers with bronze bodies conforming to ASTM B 62, Grade C or cast iron bodies conforming to ASTM A 126, Class B.
   1. End connections shall be threaded.
   2. Screens shall be 18-8 stainless steel with 1/32-inch diameter perforations or openings.

C. Strainers 2-Inch and Larger: Provide strainers with cast iron bodies conforming ASTM A 126, Class B with flanged end connections.
   1. Screens shall be bronze, monel metal or 18-8 stainless steel.
   2. Sizes 2-inch to 6-inch shall have 1/16-inch diameter perforations.
   3. Sizes 8-inch to 12-inch shall have 1/8-inch diameter perforations.
   4. Sizes larger than 12-inch shall have 5/32-inch diameter perforations.

D. Design Pressure: Provide strainers designed for 125 pounds per square inch working pressure on systems less than 125 pounds per square inch.

E. Strainer Free Area: The free area of each strainer screen shall be not less than three times the area of the strainer inlet pipe.

F. Drain Valves: For each strainer 1-1/2-inch diameter and larger, provide a plugged minimum 1/2-inch diameter gate or ball valve, bronze body, working pressure to match the strainer, threaded with a plugged outlet.

2.5 BALANCING DEVICES

A. Types: Wherever "Balancing Valves", "Balancing Cocks", or similar words are used on the Contract Drawings, provide globe valves, resilient face eccentric plug valves, multi-purpose plug valves or butterfly valves for balancing purposes.

B. Butterfly Valves: Provide butterfly valves conforming to MSS SP 67 with single flange or lug type end connections which will anchor the valve body in place when either one or the adjacent flanged connection is unbolted.

C. Ball Valves: Provide ball valves conforming to MSS SP 72.
   1. Provide one piece bodies on sizes 1-inch and smaller.
   2. Provide top entry or split body type on sizes 1-1/2-inch and larger.

D. Locking Device: On each balancing valve size 1-1-2-inch and larger provide a locking device, with indicator, to secure the valve in the balanced position. If standard with the manufacturer, the locking device may be arranged so that the valve may be closed and then returned to its original balanced position.

E. Stems and Hand Operators: Design valves with stems and hand operators of sufficient length to project outside of 2-inch thick insulation. Indicators and locking devices shall be exposed.

F. Precision Plug Valve: In lieu of other balancing valves specified, at the Contractor's option precision all brass or bronze plug valves may be furnished.
1. Provide internal "O" ring or teflon seals to prevent leakage.
2. Machined orifice or low loss Venturi shall be calibrated and provided with four laminated pressure-flow charts for any valve position between fully opened and fully closed.
3. Provide a calibrated plate and pointer mounted on the valve to indicate the degree of valve opening.
4. Provide a quick disconnect gauge connection of bronze or stainless steel.

G. Balancing Fittings: On pipe sizes 3/4-inch diameter and smaller, provide balancing fittings on runouts to fan coil units, fin tube radiation, convectors and reheat coils.
1. Fittings shall be of the combination balancing and shut-off type with the balancing device positioned by an Allen set screw or other approved method which permits closing of the valves without disturbing its balanced position.
2. Bodies may be of the globe or "Y" type with contour flow plug or approved equivalent.
3. Provide a graduated dial or other device to indicate the valve setting.
4. Gland shall permit packing under pressure.
5. Materials and construction shall be as specified for water valves sizes 1-1/2-inch and smaller.
6. On sizes 3/4-inch and smaller ends may be sweat or compression type.

H. Circuit setters provide as required on drawings.

2.6 EXPANSION TANK: DIAPHRAGM PRE-PRESSURIZED TYPE

A. Type: Provide pre-pressurized diaphragm-type expansion tanks of sizes indicated on the drawings.

B. Construction: Construct tanks of steel in accordance with section 8 of the ASME Code. Test and stamp tanks for the working pressure.

C. Supports: Support tanks on 2-inch diameter steel pipe legs with cross bracing and floor plates or suspend on steel saddles with all-thread rod anchored to the structure.

D. Manufacturer's Qualifications and Warranty: The tanks shall be the product of a manufacturer who certifies that his tanks have been a standard production model for five years prior to opening bids and warrants the diaphragm material unconditionally, against failure or leakage for a period of five years from the date of project acceptance.

2.7 AIR SEPARATORS

A. Type: Provide air separators of tangential type constructed of steel and tested and stamped in accordance with section 8 of the ASME Code for a working pressure of 125 psig.
   1. Pressure drop through the separator and flow rate shall be as shown on the drawings.
   2. Provide separators on hydronic systems capable of separating not less than 80 percent of the entrained air on the first passage of water and not less than 30 percent of residual air on each subsequent passage through the separator.
   3. Provide flanged inlet and outlet connections, 3/4-inch diameter valve drain connection and 1-inch diameter top air eliminator connection.
   4. Provide 1-inch diameter pipe from the top air eliminator point to a 5 gallon, steel, ASME stamped 125 pound working pressure air receiver vessel with automatic float vent.
   5. Provide 1-inch diameter globe valve between the air separator and the air receiver.

2.8 PIPE ANCHORS

A. General: Provide pipe anchors where indicated on the drawings or where required to restrain the movement of piping systems.
   1. See Section 15140,"Supports and Anchors"
   2. Anchors shall be suitable for the location of installation and shall be designed to withstand all forces and movements acting on the anchor.
   3. Design anchors with a safety factor of four.
   4. Anchor vertical piping with steel clamps welded to the piping and secured to the wall or floor construction.

2.9 END SUCTION DIFFUSERS

A. Provide at each pump a suction diffuser of size and type noted on drawings. Units shall consist of angle type body with straightening vanes and combination diffuser-strainer-orifice cylinder with 3/16" diameter openings for pump protection. A permanent magnet shall be equipped with a disposable fine mesh for cleaning. The orifice cylinder shall be equipped with a disposable fine mesh strainer which shall be removed after system start-up. Orifice cylinder shall be designed to withstand pressure differential equal to pump shut-off head and shall have a free area equal to

five times cross section area of pump suction opening. Straightening vanes shall extend the full length of the orifice cylinder and shall be replaceable. Unit shall be provided with adjustable support foot to carry weight of suction piping.

2.10 CONTROLS

A. Controls will be approved by local codes.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Sizes: Provide piping systems of sizes indicated on the drawings. Systems shall be installed complete.

B. Codes: Install piping systems in conformance with ANSI B31.

C. Expansion: Install piping to allow for expansion and contraction of the piping systems. Provide offsets and swing joint connections at coils, pumps and other equipment to eliminate undue strain to the equipment connections.
   1. Connect flanges and tack weld piping systems in place before full circumferential welds are made.
   2. Springing of piping at equipment connections will not be permitted.
   3. The use of "cold-spring" is not permitted.

D. Branch Connections: Branch connections to up feed systems shall be made at the top or at a 45 degree angle above the centerline. Branch connections for down feed systems shall be made at the bottom or at a 45 degree angle below the centerline.

E. Pitch: Install water piping with a pitch or slope of not less than 1-inch in 40 feet.
   1. Provide 3/4-inch diameter plugged drain valves at each low point in mechanical rooms.

F. High Points: At each high point of the piping system provide a 3/8-inch diameter plugged globe valve.
   1. Where high points are located in an inaccessible position, provide a 3/8-inch diameter bleed line from the high point of the piping system and extend to an approved location, with access. Anchor bleed piping and provide 3/8-inch diameter globe valve.

G. Vibration and Flexibility: Support, anchor, and guide piping systems to preserve piping flexibility and the isolation effects of sound and vibration isolation hangers.

H. Welding: Conform to the welding and welder qualification requirements of "Quality Assurance" paragraph of this Section.
   1. Perform welding in conformance with ANSI B31.1.
   2. Perform welding in ambient temperatures above 0 degrees F.
   3. Ream and clean ends of piping.
   4. Support piping, align and tack weld making allowance for pipe pitch and insulation. Temporarily block piping at hangers.
   5. Use welding pipe clamps on piping 4-inch diameter and larger, and verify alignment before welding.

3.2 INSTALLATION OF UNDERROUND PIPING

A. Installation of piping system shall be done in accordance with the manufacturer's printed instructions.

B. Piping shall be accurately cut and shall be worked into place without force. Excessive cutting to facilitate piping installation will not be permitted. Pipe ends shall have burrs removed by reaming and shall be installed to permit free expansion and contraction without damage to joints.

C. Open ends of piping shall be properly capped or plugged during installation. Take extra care in handling of the piping during cold weather. Store pipe on a flat surface so as to support the barrel evenly.

D. Field cutting and pipe assembly shall be in strict accordance with a manufacturer's printed instructions.

3.3 HYDRONIC SPECIALTIES INSTALLATION.

A. Install manual air vents at high points in the system, and elsewhere as required for system air venting.

3.4 CLEANING

A. Pipe Exterior: Wash and wipe pipe exterior to remove construction dirt, loose scale and flux.

B. Pipe Interior: Flush pipe interior with clean water. Continue flushing until the piping system runs clean. After flushing inspect strainer screens, refrigeration machine water boxes, piping low points, and tank drains to determine the presence of construction debris. If debris is found, disassemble equipment and remove debris. Reflush the system and re-inspect.
   1. Do not operate centrifugal pumps until system has been cleaned and flushed.

3.5 TESTING

A. 125-Pound Systems: Test hydronic piping systems at not less than 150 pounds per square inch gauge or 1-1/2 times the maximum working pressure of devices connected to the piping system, whichever is greater, measured at the low point of the system.

B. Test Procedures: Test system as follows:
   1. Gauge safety valves during testing.
   2. Fill the system and remove all air.
   3. Apply test pressure when water and ambient temperature are approximately equal and constant.
   4. Maintain test pressure for one hour without adding any additional fluid to the system.
   5. If the system shows loss in pressure, determine and repair leaks and retest the system. System shall show no loss in pressure for one hour.
   6. Leaks in screw fittings shall be corrected by remaking the joints.
   7. Leaks in welded joints shall be cut out and rewelded. Caulking will not be permitted.

END OF SECTION 15510

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following types of HVAC pumps:
   1. Base-mounted, separately coupled, end-suction pumps.
   2. Inline circulator pumps.

1.2 SUBMITTALS

A. Product data including certified performance curves of selected models indicating selected pump's operating point, weights (shipping, installed, and operating), furnished specialties, and accessories.

B. Shop drawings showing layout and connections for HVAC pumps. Include setting drawings with templates, and directions for installation of foundation bolts and other anchorages.

C. Wiring diagrams detailing wiring for power, signal, and control systems, differentiating between manufacturer-installed wiring and field-installed wiring.

D. Maintenance data for HVAC pumps for inclusion in Operating and Maintenance Manual specified in Division 1 and Division 15 Section "Basic Mechanical Requirements."

1.3 QUALITY ASSURANCE

A. Hydraulic Institute Compliance: Design, manufacture, and install HVAC pumps in accordance with "Hydraulic Institute Standards."

B. National Electrical Code Compliance: Provide components complying with NFPA 70 "National Electrical Code."

C. UL Compliance: Provide HVAC pumps which are listed and labeled by UL, and comply with UL Standard 778 "Motor Operated Water Pumps."

D. NEMA Compliance: Provide electric motors and components that are listed and labeled NEMA.

E. Single Source Responsibility: Obtain HVAC pumps from a single manufacturer.

F. Design Criteria: The Drawings indicate sizes, profiles, connections, and dimensional requirements of HVAC pumps, and are based on the specific manufacturer types and models indicated. Pumps having equal performance characteristics by other manufacturers may be considered, provided deviations in dimensions and profiles and

efficiencies do not change the design concept or intended performance as judged by the Architect.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Store pumps in a dry location.

B. Retain shipping flange protective covers and protective coatings during storage.

C. Protect bearings and couplings against damage from sand, grit, and other foreign matter.

D. For storage times greater than 5 days, dry internal parts with hot air or a vacuum-producing device to avoid rusting internal parts. Upon drying, coat internal parts with a protective liquid, such as light oil, kerosene, or antifreeze. Dismantle bearings and couplings, dry and coat them with an acid-free heavy oil, and then tag and store in dry location.

E. Comply with Manufacturer's rigging instructions for handling.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Products: Subject to compliance with requirements, products which may be incorporated in the Work include, but are not limited to, the following:
1. Bell and Gossett
2. Taco
3. Armstrong

2.2 PUMPS, GENERAL

A. Pumps and Circulators: Factory-assembled and factory-tested. Fabricate casings to allow removal and replacement of impellers without necessity of disconnecting piping. Type, sizes, and capacities shall be as indicated.

B. Preparation for Shipping: After assembly and testing, clean flanges and exposed machined metal surfaces and treat with an anticorrosion compound. Protect flanges, pipe openings, and nozzles.

C. Motors: Conform to NEMA Standard MG-1, general purpose, continuous duty, Design B, except Design C where required for high starting torque; single, multiple, or variable speed with type of enclosure and electrical characteristics as indicated; have built-in thermal-overload protection, and grease-lubricated ball bearings. Select motors that are

non-overloading within the full range of the pump performance curve.

D. Efficiency: "Energy Efficient" motors shall have a minimum efficiency as indicated in accordance with IEEE Standard 112, Test Method B. If efficiency is not specified, motor shall have a higher efficiency than the "average standard industry motors," in accordance with IEEE Standard 112, Test Method B.
   1. Motor Frame: NEMA Standard 48 or 54; use pump manufacturer's standard.

E. Apply factory finish paint to assembled, tested units prior to shipping.

2.3 BASE-MOUNTED, SEPARATELY-COUPLED, END-SUCTION PUMPS

A. General Description: 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 deg F continuous water temperature.

B. Casings Construction: Cast iron, with flanged piping connections, and threaded gage tappings at inlet and outlet flange connections.

C. Impeller Construction: Statically and dynamically balanced, closed, overhung, single-suction, fabricated from cast bronze conforming to ASTM B 584, keyed to shaft and secured by a locking capscrew.

D. Wear Rings: Replaceable, bronze.

E. Pump Shaft and Sleeve Bearings: Steel shaft, with bronze sleeve.

F. Seals: Provide mechanical or stuffing box seals in strict accordance with pump manufacturer’s recommendations based on fluid temperature and PH levels, system operating pressure and fluid chemical treatment.
   1. Mechanical seals consisting of carbon steel rotating ring, stainless steel spring, ceramic seat, and EPT/Tungsen carbide seals.

   2. Seals: Stuffing box consisting of a minimum of 4 rings of graphite impregnated braided yarn with a bronze lantern ring between center 2 graphite rings, and a bronze packing gland.

G. Pump Couplings: Flexible, capable of absorbing torsional vibration and shaft misalignment; complete with metal coupling guard.

H. Mounting Frame: Factory-welded frame and cross members, fabricated of steel channels and angles conforming to ASTM B 36. Fabricate for mounting pump casing, coupler guard, and motor. Grind welds smooth prior to application of factory finish. Motor mounting holes for field-installed motors shall be field-drilled.

I. Motor: Secured to mounting frame with adjustable alignment on mounting frame.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, equipment foundations, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of HVAC pumps.

B. Examine rough-in for piping systems to verify actual locations of piping connections prior to installation.

C. Examine equipment foundations and inertia bases for suitable conditions where pumps are to be installed.

D. Do not proceed until unsatisfactory conditions have been corrected.

3.2 EQUIPMENT BASES

A. Construct concrete equipment pads as follows:
   1. Form concrete pads using steel channels conforming to ASTM A 36, size and location as indicated. Miter and weld corner and provide cross bracing. Anchor or key to floor slab.
   2. Form concrete pads using framing lumber with form release compounds. Chamfer top edge and corners of pad.
   3. Install reinforcing bars, tied to frame, and place anchor bolts and sleeves using manufacturer's installation template.
   4. Place concrete and allow to cure before installation of pumps. Use Portland Cement conforming to ASTM C150, 4,000 psi compressive strength, and normal weight aggregate.
   5. Clean exposed steel form and apply 2 coats of rust-preventative metal primer and 2 coats of exterior, gloss, alkyd enamel. Color shall be as selected by the Architect.
   6. See Section 15246 for additional requirements.

3.3 INSTALLATION

A. General: Comply with the manufacturer's written installation and alignment instructions.

B. Install pumps in locations and arranged to provide access for periodic maintenance, including removal of motors, impellers, couplings, and accessories.

C. Support pumps and piping separately so that the weight of the piping system does not rest on the pump.

D. Suspend inline pumps using althread hanger rod and vibration isolation hangers of sufficient size to support the weight of the pump independent from the piping system.

E. Set base-mounted pumps on concrete foundation. Disconnect coupling halves before setting. Do not reconnect couplings until the alignment operations have been completed.
   1. Support pump base plate on rectangular metal blocks and shims, or on metal wedges having a small taper, at points near the foundation bolts to provide a gap of 3/4 to 1-1/2 inches between the pump base and the foundation for grouting.
   2. Adjust the metal supports or wedges until the shafts of the pump and driver are level. Check the coupling faces and suction and discharge flanges of the pump to verify that they are level and plumb.

3.4 ALIGNMENT

A. 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.
   1. 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."

B. After alignment is correct, tighten the foundation bolts evenly, but not too firmly. Fill the base plate completely with nonshrink, nonmetallic grout, with metal blocks and shims or wedges in place. After grout has cured, fully tighten foundation bolts.
   1. Alignment tolerances shall meet manufacturer’s recommendations.

3.5 CONNECTIONS

A. General: Install valves that are same size as the piping connecting the pump.

B. Install suction and discharge pipe sizes equal to or greater than the diameter of the pump nozzles.

C. Install a nonslam check valve and globe valve on the discharge side of inline pumps.

D. Install a triple-duty valve on the discharge side of base-mounted, end-suction pumps.

E. Install a gate valve and strainer on the suction side of inline pumps.

F. Install a pump suction diffuser and gate valve on the suction side of base-mounted, end-suction pumps.

G. Install flexible connectors on the suction and discharge side of each base-mounted pump. Install flexible connectors between the pump casing and the discharge valves, and upstream from the pump suction diffuser.

H. Install pressure gages on the suction and discharge of each pump at the integral pressure gage tappings provided.

I. Install temperature and pressure gage connector plugs in suction and discharge piping around pump. Temperature and pressure gage connector plugs are specified in Division 15 Section "Meters and Gages."

J. Electrical wiring and connections are specified in Division 16 sections.

K. Control wiring and connections are specified in other Division 15 sections.

3.6 FIELD QUALITY CONTROL

A. Check suction lines connections for tightness to avoid drawing air into the pump.

3.7 COMMISSIONING

A. Final Checks Before Start-Up: Perform the following preventative maintenance operations and checks before start-up:
   1. Lubricate oil-lubricated bearings.
   2. Remove grease-lubricated bearing covers and flush the bearings with kerosene and thoroughly clean. Fill with new lubricant in accordance with the manufacturer's recommendations.
   3. Disconnect coupling and check motor for proper rotation. Rotation shall match direction of rotation marked on pump casing.
   4. Check that pump is free to rotate by hand. For pumps handling hot liquids, pump shall be free to rotate with the pump hot and cold. If the pump is bound or even drags slightly, do not operate the pump until the cause of the trouble is determined and corrected.

B. Starting procedure for pumps with shutoff power not exceeding the safe motor power:
   1. Prime the pump, opening the suction valve, closing the drains, and prepare the pump for operation.
   2. Open the valve in the cooling water supply to the bearings, where applicable.
   3. Start the motor.
   4. Open the discharge valve slowly.
   5. Observe the leakage from the stuffing boxes and adjust the sealing liquid valve for proper flow to ensure the lubrication of the packing. Do not tighten the gland immediately, but let the packing run in before reducing the leakage through the

stuffing boxes.

6. Check the general mechanical operation of the pump and motor.
7. Close the recirculating line valve once there is sufficient flow through the pump to prevent overheating.

C. If the pump is to be started against a closed check valve with the discharge gate valve open, the steps are the same, except that the discharge gate valve is opened some time before the motor is started.

D. Refer to Division 15 Section "Testing, Adjusting, and Balancing" for detailed requirements for testing, adjusting, and balancing hydronic systems.

END OF SECTION 15540

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. High Efficiency Condensing Boilers.

1.2 REFERENCES

A. ETL

1. ETL

B. American Society of Mechanical Engineers:

1. ASME Section IV - Boiler and Pressure Vessel Code - Heating Boilers

2. ASME CSD-1 – Controls and Safety Devices for Automatically Fired Boilers

C. Hydronics Institute:

1. BTS-2000 - Testing and Rating Standard for Heating Boilers.

D. National Fire Protection Association:

1. NFPA 54 - National Fuel Gas Code.

1.3 SUBMITTALS

A. In accordance with Contract Specifications.

B. Product Data: Submit capacities and accessories included with boiler. Include general layout, dimensions, size and location of water, fuel, electric, air inlet and vent connections, electrical characteristics, weight and mounting loads. Provide wiring diagrams that are specific to this project.

C. Manufacturer's Installation Instructions: Submit assembly, support details, connection requirements, and include start-up instructions.

1.4 WORK INCLUDED

A. Furnish and install Firetube gas fired hot water condensing boilers of the size, capacity and quantity as shown on the contract drawings. Include individual hot water circulating pumps as shown on the Plans and as Scheduled.

B. Each boiler shall have a self-contained controls and safety devices and shall be capable of independent operation.

C. Each boiler shall comply with the energy efficiency requirements of the latest edition of the ASHRAE 90.1 Standard and the minimum efficiency requirements of the latest edition of the AHRI BTS-2000 Standard as defined by the Department of Energy in 10 CFR Part *SS*431.86. The boiler shall be certified for indoor installation. All boilers shall be installed in accordance with local, State, and Federal codes.

D. Contractor shall obtain Certificate of boiler inspection after boiler installation has been completed and shall pay fees associated with such inspection. After receipt of certificate of Inspection, Installing Contractor shall furnish a suitable glass front frame in which to place said certificate. Frame, with Inspection certificate inserted therein, shall then be placed on or posted in a suitable location within the Boiler room in which the new Boilers have been installed.

E. Contractor shall obtain from Boiler Manufacturer Form H-2 Manufacturers Data Report for Firetube Boilers as required by the Provisions of the ASME Code Rules, Section IV and shall transmit to the Owner after Boiler installation for Record Purposes.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum ten (10) years of documented experience.

1.6 REGULATORY REQUIREMENTS

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. Boilers shall have been Certified in accordance with ANSI Z21.13 test standard; ASHRAE 90.1 Standard and ASHRAE 103 Standard; American National Standard /CSA Standard for Gas-Fired Low Pressure Steam and Hot Water Boilers; ANSI Z223.1 (NFPA 54-2012) for Gas-Fired Boilers; minimum efficiency requirements of the latest edition of the AHRI BTS-2000 Standard; ANSI/ASME CSD-1 and National Electrical Code (NFPA 70).

C. Commercial Boiler efficiency Certification Program AHRI Directory of Certified AHRI Certified Ratings list of Boilers that have earned the AHRI Certified mark. Boiler manufacturer shall be required to provide the Certified Reference Number and Approved Status under the previously specified performance criteria at Submittal Stage.

D. State Building Code, 780 CMR 1305.2.5 Heating System Controls; and Table 1305.3.3.(5) Standard Rating Conditions and Minimum Performance Gas and Oil fired Steam and Hot Water Boilers.

E. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

F. Emissions shall conform to South Coast Air Quality Management District specifications. Boiler shall have an independent laboratory rating for Oxides of Nitrogen (NOx) to meet the requirements of South Coast Air Quality Management District in Southern California and the requirements of Texas Commission on Environmental Quality. The Manufacturer shall verify proper operation of the burner, all controls and the heat exchanger by connection to water and venting for a factory fire test prior to shipping.

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

H. Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code.

I. Boiler shall be AHRI Certified t0 96% Thermal Efficiency, with Oxides of Nitrogen (NOx) less than 20 ppm corrected to 3% 02. Boiler shall produce less than 50 Db sound reading at 100% rate of fire. Control system shall comply with UL/CSD-1/GE-GAP criteria.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Install factory assembled packaged boiler carefully to prevent damage, breaking and scoring. Do not install damaged components; replace with new.

B. Comply with manufacturer’s rigging and moving instructions for unloading boilers, and moving them to final location.

1.8 WARRANTY

A. Leakage and Materials: Heat Exchangers on stainless fire-tube boilers have a ten (10) year limited warranty effective 60 days from the date of manufacture as determined by the serial number.

B. All equipment shall be guaranteed against defects in materials and workmanship for a period of 12 months from the date of start-up, or 18 months from the date of shipment, whichever comes first. The warranty shall include parts inly to repair or replace all defective parts and material at no charge to the owner.

C. Installation shall be guaranteed free from defective materials and workmanship for a period of (1) year from date of acceptance by the Owner. Any repairs required during guarantee period shall be done by the Contractor at his own expense.

1.9 FIELD MEASUREMENTS

A. Verify field measurements prior to installation.

1.10 START-UP OF EQUIPMENT

A. Operating and Maintenance Instructions are to be furnished with each unit.

B. The boiler shall be factory assembled and fire tested requiring only connections to the water circulating system (supply & return), fuel, electrical power, exhaust vent and air inlet (as specified/shown in contract drawings).

C. Factory-authorized representatives shall perform start-up service on each unit.

1.11 MAINTENANCE SERVICE

A. Furnish service and maintenance of boiler for one (1) year from owner’s acceptance.

B. Maintenance service shall be performed by qualified personnel under supervision of or trained by the manufacturer’s representative.

PART 2 BOILERS

2.1 MANUFACTURERS

A. Fulton Pulse

B. Thermal Solutions

C. Bryan Boilers

2.2 STAINLESS STEEL BOILER

A. Furnish and install in accordance with plans and specifications including manufacturer's recommendations, state and local codes with capacity as scheduled on the contract drawings and specifications.

B. Direct-Vent sealed combustion, Boiler shall be factory assembled and fire-tested fire-tube condensing boiler with counter-flow heat exchanger sealed pressure-tight, built on a steel base, including insulated metal jacket, flue gas vent, combustion air intake connections, water supply an return connections, condensate drain connections and controls. Multiple pressure vessels in a single enclosure are not acceptable.

C. Boiler shall require only connection to the water circulating system, fuel/electric utilities, condensate drain and flue gas vent. Heat exchanger shall be constructed of 316L stainless steel. Water-tube, Aluminum or Copper tube boilers, or Boilers with secondary heat exchangers are not equivalent and shall not be considered acceptable.

D. Boiler shall be able to operate in a full-flow system or a variable flow system using variable frequency drives on the system pumps, without requiring the use of a three-way valves or primary/secondary piping loops. Boiler heat exchanger shall be designed for a single-pass water flow to limit the water side pressure drops.

E. Boiler shall bear the ASME "H" stamp for 160 PSI working pressure and shall be National Board listed where applicable. There shall be no banding material, bolts, gaskets or "O" rings in the header configuration. Each 316L stainless steel combustion chamber shall be designed to drain condensation to the bottom of the heat exchanger assembly. the condensate collection basin shall be constructed of welded 316L stainless steel. A built-in trap shall allow condensation to drain from the collection basin.

F. Boiler shall be equipped with a variable frequency drive blower motor. Burner shall be a premix design, constructed of high temperature stainless steel with a woven metal fiber outer covering to provide full modulating firing rate with a turndown ratio of (17:1) (20:1) and discharge into a positive pressure vent. Boiler efficiency shall increase with decreasing load (output), while maintaining setpoint. Boiler shall have been BTS-2000 tested to an AHRI Certified thermal efficiency of 96%.

G. Burner shall be metal-fiber mesh covering a stainless steel body with spark ignition and flame rectification. All burner material exposed to the combustion zone shall be of stainless steel construction. There shall be no moving parts within the burner itself. Burner shall produce not more than 50-dBA sound reading at full firing rate.

H. Boiler shall be supplied with a combination gas control valve that includes dual safety

shutoff valves and a pressure regulator in a single body gas valve designed using negative pressure regulation and equipped with a pulse width modulation blower system, to precisely control the fuel/air mixture to provide modulating boiler firing rates for maximum efficiency. The Boiler shall operate in a safe condition at derated output with gas supply pressures between 4.00" lns. w.c. and 14" lns. w.c. inlet gas pressure. If inlet gas pressure exceeds 13" W.C., a 100% lock-up type gas pressure regulator of adequate size shall be installed in gas supply piping and adjusted to prevent pressure in excess of 13" W.C.

I. Boiler shall be constructed with a heavy gauge steel jacket assembly, primed and pre-painted on both sides. The combustion chamber shall be sealed and completely enclosed, independent of the outer jacket assemble, so that integrity of the outer jacket does not affect a proper seal. A flame observation pert shall be provided.

J. Each Boiler shall be equipped with: temperature/pressure gauge; a system supply water temperature sensor; tank sensor; high limit temperature control with manual reset; outlet water temperature sensor with a dual thermistor to verify accuracy; return water temperature sensor; outdoor air temperature sensor, flue temperature sensor; probe type low water cut off with manual reset and a condensate trap for the heat exchanger condensate drain; ASME certified pressure relief valve set for 80 PSI; Combustion air inlet filter and dirty filter switch.

K. Probe LWCO shall incorporate a Burner circuit test switch that, when depressed, will test out the control circuit by dropping out the Burner if the circuit is properly wired. Boiler shall fitted with either a float type or a probe type LWCO located above the lowest safe permissible water level established by the Boiler manufacturer. LWCO shall be UL listed and FM approved, suitable for commercial hydronic heating service at 80 PSI.

L. A coil type boiler or water-tube boiler with heat input greater than 200,000 BTU's/hr requiring forced circulation to prevent overheating of the coils or tubes shall have a flow sensing device installed in the outlet piping in lieu of the low water fuel cutoff required in 522 CMR 5.07 (15)(a) to automatically cut off the fuel supply when the circulating flow is interrupted.

M. This Contractor shall furnish and install a condensate neutralizing box complete with limestone granules shipped loose for field installation. Furnish and install a condensate trap assembly if a condensate collection tray is not provided by the Boiler manufacturer. The tap allows condensate to drain from sump while retaining flue gases in the boiler. The trap has factory installed overflow switch, which shuts down the boiler in the event the drain line becomes obstructed, preventing proper condensate removal. Extend drain piping from boiler to acid neutralization kit and to suitable floor drain in mechanical rooms.

N. If the point of condensate disposal is above the trap, a condensate pump shall be

required to move the condensate to the drain. If overflow from the pump would result in property damage, select a pump with an overflow switch. Wire this switch in series with installer provided external high limit, to shut off boiler, and, if desired, in series with installer supplied alarm, to trigger an alarm in the event of an overflow.

O. Gas Train

1. Gas train shall be ETL and CSD-1 compliant.

2. Pilot gas valve and pilot gas pressure regulator.

3. Main air-gas ratio valve shall have 2 safety valves in one body and also include the main gas regulator.

4. Leak test valve downstream of gas valve.

5. Low gas pressure switch.

6. Manual shut off valve upstream of burner and downstream of last gas valve.

2.3 COMPUTERIZED BOILER CONTROL

A. The factory mounted and wired control system (BMCS) shall incorporate a high resolution LED display for boiler set-up, boiler status, and boiler diagnostics. All components shall be easily accessed and serviceable from the front and top of the jacket.

B. Factory installed Boiler Management Control System (BMCS) shall be provided with password security, outdoor air reset, pump delay with freeze protection, pump exercise, ramp delay featuring six steps, domestic hot water prioritization with limiting capabilities, USB drive for simple uploading of parameters and a PC port connection for connection to a local computer for programming and trending. A secondary operating control that is field mounted or inside the appliance is not acceptable. The boiler shall have alarm contacts for any failure, runtime contacts and data logging of runtime at given modulation rates, ignition attempts and ignition failures. The boiler shall have a built-in “Cascade” with leader redundancy to sequence and rotate while maintaining modulation of up to eight boilers of different Btu inputs without utilization of an external controller. The internal “Cascade” function shall be capable of lead-lag, efficiency optimization, Hybrid plant front-end loading, and rotation of lead boiler every 24 hours. The boiler shall be capable of controlling an isolation valve during heating operation and rotation of open valves in standby operation for full flow applications. The control shall be equipped to communicate via BACnet MSTP communications. All components shall be easily accessed and serviceable from the front of the jacket.

C. The control system shall monitor both boiler lockout and limit circuits to automatically skip over those boilers that are powered down for maintenance, tripped or otherwise will not start. The control system shall be fully integrated into the Boiler Cabinet and incorporate single and multiple boiler control logic, inputs, outputs and communication interfaces. Using parameter menu selections, the control system shall allow the boiler to respond to remote system water temperature and outside air temperatures and warm weather shut down or building automation system remote start/stop commands.

D. A 0-10 VDC output signal shall control a variable speed boiler pump (pump to be offered by manufacturer) to keep a fixed delta T across the boiler regardless of the modulation rates. The boiler shall have the capability to receive 0-10 VDC input signal from a variable speed system pump to anticipate changes in system heat load in order to prevent flow related issues such as erratic temperature cycling.

2.4 ELECTRICAL REQUIREMENTS

A. All Boiler room wiring from the main disconnect switch panel to all Boiler controls, Boiler Circulators, system circulators, Limit circuit, Operating controls, gas valves and actuators, switches and additional control devices shall be furnished and installed under this section of the work by the HVAC Subcontractor and shall conform to the job standards as established by Division 16 Sections.

B. Single-Point Field Power Connection: Factory installed and wired switches, motor controller, transformers and other electrical devices necessary shall provide a single-point field power connection to boiler.

C. Boiler Circuit shall be taken from a two-wire branch circuit, one side grounded, not exceeding 150 Volts, line to line. All safety control switching shall be accomplished in the hot ungrounded conductor and through the 24V low voltage wiring provided by the Boiler manufacturer and in accordance with the manufacturer's instructions and recommendations.

D. Control system wiring shall comply with ASME CSD-1 requirements and 522 CMR 5.07 (19). Fuse protection for the control circuit shall be provided. A manually operated remote heating plant shut-down switch shall be furnished and installed just outside the Boiler room door and shall be marked for easy identification. If there is more than one (1) Boiler room door, there shall be a switch located at each door. Shutdown switches must be wired to disconnect all power to the Boiler controls.

E. Each Boiler shall be equipped with two terminal strips for electrical connections as follows:

1. A low voltage connection board with 46 connection points for safety and operating controls, i.e., Alarm Contacts, Runtime Contacts, Louver Proving Switch, Tank Thermostat, Domestic Hot Water Building Recirculation Pump Contacts, Domestic Hot Water Recirculation Temperature Sensor Contacts, Remote Enable/Disable, System Supply Temperature Sensor, Outdoor Temperature Sensor, Tank Temperature Sensor, Modbus Building Management System Signal and Cascade Control Circuit.

2. A high voltage terminal strip shall be provided for Supply voltage. Supply voltage shall be 120 volt/60 hertz/ single phase on all models. The high voltage terminal strip plus integral relays are provided for independent pump control of the System pump, the Boiler pump and the Domestic Hot Water pump.

2.5 VENTING KITS

A. Listed special Gas Vents: All products furnished under this Section shall conform to the requirement of the National Fuel Gas Code, ANSI Z223.1/NFPA-54 where applicable and shall comply with and be listed to UL 1738, the U.S. Standard for Venting Systems for Gas-Burning Appliances, Category II, III and IV and ULC-S636-95, the Canadian Standard for Type BH gas vent systems. Compnents coming in direct contact with products of combustion shall carry the appropriate UL or ULC. PVC, CPVC, PPS Polypropylene shall be ULC-S636 Certified for use as a flue gas vent system.

B. Combustion-Air Intake: the air inlet pipe may be CPVC or ABS.

C. Approved Vent: AL29-4C vent.

PART 3 EXECUTION

3.1 BOILER INSTALLATION

A. Boiler Pumps shall be installed with manufacturer’s recommendations, Contract Drawings, and reviewed submittals.

B. Pumps shall be installed so as to ensure easy accessibility for service or removal and replacement of all components such as, but not limited to, impellers, motors, drive couplings, bearings, strainers, other pump appurtenances, isolators, and flex connections.

C. Install circulator, including all valves, strainer and accessories on each boiler as may be required.

D. The Contractor shall properly protect all equipment to prevent damage from water, dirt, etc. Protection shall include temporary plastic wrap to keep equipment in original factory condition.

E. Install in accordance with NFPA 54 and NFPA 58.

F. Provide connections to the natural gas service connection in accordance with NFPA 54, AGA Z223.1 and NFPA 58. Pipe all gas train vents to the outdoors in accordance with all local and State codes. Connect gas piping to boiler gas-train inlet with union. Piping shall be at least full size of gas train connection. Provide a reducer if required.

G. Provide hydronic piping connections, valves, fittings and accessories as indicated.

H. CAT IV boilers require special gas venting. Use only the vent materials, listed manufacturers, and methods specified within the Boiler manufacturer's Installation and Operation Manual.

I. Connect each Cat-IV direct-vent appliance's flue outlet with a continuous Boiler manufacturer's approved vent system to the vent termination outside the building. The vertical vent shall be routed through the designated vertical chase. All system components shall be listed to UL or ULC standard and supplied form the same manufacturer. Maximum exposure of CAT IV vent pipe shall be limited to not more than 60" Ins. exposure to outdoor environment.

J. Pipe water relief valves to nearest floor drain.

K. Provide complete electrical connections to all boilers.

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

M. Install control wiring to filed-mounted electrical devices.

N. Pipe condensing boiler/vent condensate connections to condensate neutralization tank. Neutralization tank shall be piped to the nearest floor drain.

3.2 START-UP

A. Installing Contractor shall supervise al phases of Boiler installation, pressure testing, startup, and training of operating personnel. Installing Contractor shall also provide all installation verification inspections, system functional and safety operational test, and heating system capacity verification tests. Hydrostatic test. Repair leaks and retest until no leaks exist.

B. Installing Contractor shall include, as part of his Contract, all charges and cost for Boiler testing, start-up, checkout, adjusting, filed and State inspections, including service contracts for systems and equipment as here-in-after specified. Provide signed documentation to the Awarding Authority for completion of specified procedures.

C. The Boiler manufacturer's Representative shall provide the initial start-up, final adjusting and testing of the Boiler and controls in the presence of the Consulting Engineer, ATC/DDC start up representative and the Owners operating personnel. State Gas inspector, and gas company representative shall also be in attendance as may be required by 248 CMR 7.00. Boiler manufacturer's representative shall also provide raining of the Boilers and Controls and in boiler carte and maintenance to Owners Operating Personnel.

D. Initial start-up, testing and adjustment shall comply with all applicable Local and State Regulations and requirements. Start up and final adjustment shall be in accordance with the Boiler manufacturer's start-up instructions Test and adjust Boiler for maximum efficiency. Test and adjust combustion controls, and boiler controls for proper operation and maximum system efficiency. Check and adjust initial operating set points and high and low limit safety set points of fuel supply, water level and water temperature. Set field-adjustable switches and circuit-breaker trip ranges as indicated. Replace damaged or malfunctioning controls and equipment in accordance with the manufacturer's requirements.

E. Purging of the Boilers, and all required tests for proper venting. Start up technician shall determine the presence and proper function of draft interlock switches or spill switches as may be required by Code and in accordance with the Plumbing Engineers design.

F. At time and date of original start up, provide instruction to the Owners operating personnel in the procedures to resolve a "Lockout" condition. At this time, operating personnel shall also be instructed in the operation and routine management of the Burner and safety controls. The Owner shall arrange to have personnel who require training to be present during the oringal lgithoff. in addition, manufacturer's representative shall provide a training session for the Owners operatinbg personnel at a later date prior to Owners Final Acceptance. Installing Contractor to coordinate time and ate of additional training.

G. Boiler combustion shall be tested and adjusted utilizing electronic combustion instruments to verify that the boiler is operating within acceptable tolerances of the factory fire test report, with a print-out copy submitted to the Engineer. A written report of the start-up, including the factors of the factory fire test, and the factory of the start-up, shall also be furnished to the Engineer.

H. Final acceptance of the Heating system installed within this scope of work shall be

contingent on passing a satisfactory system pressure test, mechanical performance test and heating function test to determine that the system will perform according to the contract requirements. The above test shall be witnessed by the Engineer and the Owner at his option and acceptance will only be granted in writing by the Owner after receipt of certification from the Engineer that the design criteria have been met.

I. Installing Contractor shall guarantee the entire installation for a period of One (1) years from the date of Owner Acceptance and beneficial usage by the Owner and Date of Final Payment. Installing contractor shall, upon completion of the installation, make available to the Owner an annual service agreement covering all labor and material required to efficiently maintain the boilers for first year of operation.

END OF SECTION 15559

PART 1 GENERAL

1.1 SECTION INCLUDES

A. This section includes the following:
   1. Chiller package.
   2. Charge of refrigerant and oil.
   3. Controls and control connections.
   4. Chilled water connections.
   5. Starters.
   6. Electrical power connections.

1.2 REFERENCES

A. References shall include the following:
   1. ANSI/ARI 550/590-2003 - Standard for Water Chilling Packages using the Vapor Compression Cycle.
   2. ANSI/ASHRAE 15 - Safety Code for Mechanical Refrigeration.
   3. ANSI/ASHRAE 90.1 - Energy Efficient Design of New Buildings.
   4. ANSI/ASME SEC 8 - Boiler and Pressure Vessel Code
   5. ANSI/NEMA MG 1 - Motors and Generators.
   6. ANSI/UL 1995 - Central Cooling Air Conditioners.
   7. ANSI/UL 984 - Safety Standard for Hermetic Motor Compressors.
   8. ANSI/AFBMA 9-1978 - Load Ratings and Fatigue Life for Ball Bearings. Bearings must have life of not less than L10 200,000 hours.
   9. California Administrative Code - Title 24
   10. ASTM B117 - Standard Method of Salt Spray (Fog) Testing
   11. ASTM A123 - Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
   12. ASTM A525 - Zinc (Hot-Dip Galvanized) Coatings on Sheet Steel Products
   13. ASTM D1654 - Evaluation of Painted or Coated Specimens, Subjected to Corrosive Environments.

1.3 SUBMITTALS

A. Submit product data indicating rated capacities, weights, specialties and accessories, electrical requirements and wiring diagrams.

B. Submit manufacturer's installation instructions.

1.4 OPERATION AND MAINTENANCE DATA

A. Submit operation data.

B. Include start-up instructions, maintenance data, controls, and accessories.

C. Submit maintenance data.

1.5 REGULATORY REQUIREMENTS

A. Conform to ANSI/ARI 550/590-2003 Standard for testing and certified rating of Water Chilling Packages using the Vapor Compression Cycle.

B. Conform to ANSI/UL 1995 code for construction of water chillers. In the event the unit is not UL approved, the manufacturer shall, at his expense, provide for a field inspection by an UL representative to verify conformance to UL standards. If necessary, contractor shall perform modifications to the unit to comply with UL, as directed by the UL representative.

C. Conform to ANSI/ASME SEC 8 Boiler and Pressure Vessel Code for construction and testing of water chillers.

D. Conform to ANSI/ASHRAE 15 code for construction and operation of water chillers.

1.6 STORAGE AND HANDLING

A. Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.

B. Protect units from physical damage. Factory coil shipping covers shall be kept in place until installation.

C. Unit controls shall be capable of withstanding 203 Deg F (95 Deg C) storage temperatures in the control compartment for an indefinite period of time.

1.7 WARRANTY

A. A 1-year Parts and Labor Warranty shall be provided on each chiller and associated accessories.

1.8 MAINTENANCE SERVICE

A. Furnish service and maintenance of complete assembly for one year from Date of Substantial Completion.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers

offering products that may be incorporated in the Work include, the following:
1. Carrier
2. Trane
3. McQuay

2.2 UNIT DESCRIPTION

A. Microprocessor controlled, air-cooled liquid chiller for outdoor installation, utilizing scroll compressors, low sound fans, electronic expansion valve, optional hydronic pump system, and fluid storage tank.

B. With Greenspeed intelligence, all fans are controlled with variable speed fan drive motors. Chiller software shall be specifically developed to coordinate optimal fan speed for application conditions and provide refrigerant circuit optimization, resulting in higher part load efficiency and reduced acoustic levels.

C. Unit shall be rated in accordance with AHRI (Air- Conditioning, Heating and Refrigeration Institute) Standard 550/590, latest edition (U.S.A.) and all units shall be ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) 90.1 compliant.

D. Unit construction shall comply with ASHRAE 15 Safety Code, UL latest edition, and ASME (American Society of Mechanical Engineers) applicable codes (U.S.A. codes).

E. Unit shall be manufactured in a facility registered to ISO 9001 Manufacturing Quality Standard.

F. Unit shall be full load run tested at the factory.

2.3 CHILLER COMPONENTS

A. General:
1. Factory assembled, single-piece chassis, air-cooled liquid chiller. Contained within the unit cabinet shall be all factory wiring, piping, controls, refrigerant charge (R-410A), and special features required prior to field start-up.

B. Unit Cabinet:
1. Frame shall be of heavy-gage, galvanized steel.
2. Exterior panels shall be galvanized steel with a baked enamel powder or pre-painted finish.

3. Cabinet shall be capable of withstanding 500-hour salt spray test in accordance with the ASTM (American Society for Testing and Materials, U.S.A.) B-117

standard.

C. Fans:
1. Standard condenser fans shall be direct-driven, 9-blade airfoil cross-section, reinforced polymer construction, shrouded-axial type, and shall be statically and dynamically balanced with inherent corrosion resistance.
2. Standard condenser fans shall be direct-driven (VFD [variable frequency drive] controlled on units with Greenspeed intelligence), 9-blade airfoil cross-section, reinforced polymer construction, shrouded-axial type, and shall be statically and dynamically balanced with inherent corrosion resistance.
3. The variable speed drives for the condenser fans on 30RAP units with Greenspeed intelligence shall include a DC link reactor.
4. Fan operation shall allow reduced sound levels during scheduled unoccupied operating periods. Manufacturers without unoccupied reduced sound capability shall submit 1/3 octave band data and sound power data as measured according to AHRI 370 as confirmation of unit sound characteristics.
5. Air shall be discharged vertically upward.
6. Fans shall be protected by coated steel wire safety guards.

D. Compressor/Compressor Assembly:
1. Fully hermetic, direct-drive, scroll type compressors.
2. Compressor motors shall be cooled by refrigerant gas passing through motor windings and shall have either internal line break thermal and current overload protection or external current overload modules with compressor temperature sensors.
3. Compressors shall be mounted on rubber in shear vibration isolators.
4. Staging of compressors shall provide unloading capability. Digital compressor unloading control.

E. Cooler:
1. Cooler shall be rated for a refrigerant working-side pressure of 565 psig (3896 kPa) and shall be tested for a maximum waterside pressure of 300 psig (2068 kPa) or 150 psig (1034 kPa) when optional hydronic package is installed.
2. Shall be single-pass, ANSI (American National Standards Institute) type 316 stainless steel, brazed plate construction.

3. Shell shall be insulated with 3/4-in. (19 mm) closed-cell, polyvinyl-chloride foam with a maximum K factor of 0.28.

4. Shall incorporate 2 independent refrigerant circuits.
5. Cooler shall have optional factory-installed heater, to protect cooler from ambient temperature freeze down to –20 F (–29 C).
6. Unit shall be provided with a factory-installed flow switch.
7. All connections shall use standard Victaulic-type fittings.
8. Cooler fluid inlet line shall have a 40 mesh strainer just ahead of the cooler.

F. Condenser:
1. Coil shall be air-cooled Novation® heat exchanger technology with microchannel (MCHX) coils and shall have a series of flat tubes containing a series of multiple, parallel flow microchannels layered between the refrigerant manifolds.
2. Coils shall consist of a two-pass arrangement. Coil construction shall consist of aluminum alloys for fins, tubes, and manifolds in combination with a corrosion-resistant coating.
3. Tubes shall be cleaned, dehydrated, and sealed.
4. Assembled condenser coils shall be leak tested and pressure tested at 656 psig (4522 kPa).

G. Refrigeration Components:
1. Refrigerant circuit components shall include filter drier, moisture indicating sight glass, electronic expansion device, and complete operating charge of both refrigerant R-410A and compressor oil.

H. Controls, Safeties, and Diagnostics:
1. Unit controls shall include the following minimum components:
    a. Microprocessor with non-volatile memory. Battery backup system shall not be accepted.
    b. Separate terminal block for power and controls.
    c. Control transformer to serve all controllers, relays, and control components.
    d. ON/OFF control switch.
    e. Replaceable solid-state controllers.
    f. Pressure sensors shall be installed to measure suction and discharge pressure for each circuit. Thermistors shall be installed to measure cooler entering and leaving fluid temperatures, outdoor ambient temperature, and suction temperature. Provision for field installation of accessory sensor to measure compressor return gas temperature.

2. Unit controls shall include the following functions:
   a. Automatic circuit lead/lag for dual circuit chillers.
   b. Hermetic scroll compressors are maintenance free and protected by an auto-adaptive control that minimizes compressor wear.
   c. Capacity control based on leaving chilled fluid temperature and compensated by rate of change of return-fluid temperature with temperature set point accuracy to 0.1° F (0.06° C).
   d. Limiting the chilled fluid temperature pulldown rate at start-up to an adjustable range of 0.2° F to 2° F (0.11° C to 1.1° C) per minute to prevent excessive demand spikes at start-up.
   e. Seven-day time schedule.
   f. Leaving chilled fluid temperature reset from return fluid and outside air temperature.
   g. Chilled water pump start/stop control and primary/standby sequencing to ensure equal pump run time.
   h. Dual chiller control for parallel chiller applications without addition of hardware modules and control panels (additional thermistors and wells are required).
   i. Timed maintenance scheduling to signal maintenance activities for pumps, condenser coil cleanings, strainer maintenance and user-defined maintenance activities.
   j. Boiler enable signal to initiate system heating mode.
   k. Low ambient protection to energize cooler and hydronic system heaters.
   l. Periodic pump start to ensure pump seals are properly maintained during off-season periods.
   m. Single step demand limit control activated by remote contact closure.
   n. Nighttime sound mode to reduce the sound of the machine by a user-defined schedule.

3. Diagnostics:
   a. The control panel shall include, as standard, a scrolling marquee display capable of indicating the safety lockout condition by displaying a code for which an explanation may be scrolled at the display.
   b. Information included for display shall be:
      1. Compressor lockout.
      2. Loss of charge.
      3. Low fluid flow.
      4. Cooler freeze protection.

5. Cooler set point.
6. Chilled water reset parameters.
7. Thermistor and transducer malfunction.
8. Entering and leaving-fluid temperature.
9. Compressor suction temperature.
10. Evaporator and condenser pressure.
11. System refrigerant temperatures.
12. Chiller run hours.
13. Compressor run hours.
14. Compressor number of starts.
15. Low superheat.
16. Time of day:
    I) Display module, in conjunction with the microprocessor, must also be capable of displaying the output (results) of a service test. Service test shall verify operation of every switch, thermistor, fan, and compressor before chiller is started.
    II) Diagnostics shall include the ability to review a list of the 20 most recent alarms with clear language descriptions of the alarm event. Display of alarm codes without the ability for clear language descriptions shall be prohibited.
    III) An alarm history buffer shall allow the user to store no less than 20 alarm events with clear language descriptions, time and date stamp event entry.
    IV) The chiller controller shall include multiple connection ports for communicating with the local equipment network, the Carrier Comfort Network® (CCN) system and access to chiller control functions from any point on the chiller.
    V) The control system shall allow software upgrade without the need for new hardware modules.

4. Safeties:
    a. Unit shall be equipped with thermistors and all necessary components in conjunction with the control system to provide the unit with the following protections:
        1. Loss of refrigerant charge.
        2. Reverse rotation.
        3. Low chilled fluid temperature.

4. Thermal overload.
5. High pressure.
6. Electrical overload.

b. Factory pump motors shall have external overcurrent protection.

I. Operating Characteristics:
1. Unit shall be capable of starting and operating down to 32 F (0° C) as standard.
2. Unit shall be capable of starting and running at outdoor ambient temperatures up to 120 F (50 C) for all sizes. Unit shall additionally be able to stay online when running with a 125 F (52 C) ambient temperature.
3. Unit shall be capable of starting up with 95 F (35 C) entering fluid temperature to the cooler.

J. Fan Motors:
1. Condenser fans shall be direct-drive Aero- Acoustic™ type, discharging air vertically upward.
2. All condenser fan motors shall be totally enclosed 3-phase type with permanently lubricated ball bearings, Class F insulation and internal, automatic reset thermal overload protection or manual reset calibrated circuit breakers.
3. Shafts shall have inherent corrosion resistance.
4. Fan blades shall be statically and dynamically balanced.
5. Condenser fan openings shall be equipped with PVC coated steel wire safety guards.

K. Electrical Requirements:
1. Unit/module primary electrical power supply shall enter the unit at a single electrical box.
2. Unit shall operate on 3-phase power at the voltage shown in the equipment schedule.
3. Control points shall be accessed through terminal block.
4. Unit shall be shipped with factory control and power wiring installed.

L. Chilled Water Circuit:
1. Chilled water circuit shall be rated for 300 psig (2068 kPa) working pressure.

2. Solid-state flow monitor with integral relay shall be factory installed and wired.
3. Brass body strainer with 40 mesh screen and ball type blow down.

M. Special Features:
   1. High-Efficiency Variable Condenser Fans:
      a. All fans on the unit shall have variable speed fan motors to provide higher part load efficiency and reduced acoustic levels. Each fan circuit shall have a factory-installed, independent variable speed drive with display. Variable speed drives are rated IP-55 enclosures and UL Listed. The use of this option, with the addition of antifreeze in the cooler circuit and wind baffles, shall allow running with outdoor ambient temperatures down to –20 F (–28.9 C). This option is a standard feature on sizes 011 and 016, is not available on sizes 010, 015, and 070-150, and is not available in combination with low ambient head pressure control.

N. Energy Management Module:
   1. A factory-installed module shall provide the following energy management capabilities: 4 to 20 mA signals for leaving fluid temperature reset, cooling set point or demand limit control; 2-point demand limit control (from 15% to 100%) activated by a remote contact closure.

O. Security Grilles/Hail Guards:
   1. Unit shall be supplied with factory installed, louvered, sheet metal panels which securely fasten to the chiller and provide condenser coil protection against hail and other physical damage.

Q. Vibration Isolation:
   1. Vibration isolation pads shall be supplied for field installation at unit mounting points. Pads shall help to reduce vibration transmission into the occupied space.

R. BACnet Communication Option:
   1. Shall provide factory-installed communication capability with a BACnet MS/TP network. Allows integration with BACnet building automation system.

S. GFI Convenience Outlet:
   1. Shall be factory installed to provide the chiller with a 4 amp GFI receptacle. The receptacle shall have independent fuse protection. The convenience outlet is a 115-v female receptacle.

T. Ultra-Low Sound:
   1. Shall provide sound blankets around each compressor in conjunction with low-

sound AeroAcoustic™ fans to provide significant chiller sound reduction.

U. Digital Compressor:
   1. Shall provide a factory-installed digital compressor to provide incremental steps for tighter temperature control.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install in strict accordance with manufacturer's requirements, shop drawings, and contract documents.

B. A 20 mesh strainer shall be placed in the supply water line just prior to the inlet of the evaporator. Care shall be exercised when welding pipe or flanges to the evaporator to prevent any slag from entering the vessel.

C. Adjust and level chiller in alignment on supports.

D. Coordinate electrical installation with electrical contractor.

E. Coordinate controls with control contractor.

F. Provide all appurtenances required to insure a fully operational and functional chiller.

3.2 MANUFACTURER'S FIELD SERVICES

A. Supply service of factory trained representative for a period of one days to supervise testing, start-up, and instruction on operation and maintenance to Owner.

B. Supply initial charge of refrigerant and oil.

END OF SECTION 15685

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Proposed Air Handling Units.

1.2 RELATED SECTIONS

A. Section 15010 – Basic Mechanical Requirements.

B. Section 15050 – Basic Mechanical Materials & Methods.

C. Section 15890 – Metal Ductwork.

D. Section 15990 – Testing, Adjusting and Balancing.

E. Section 16010 – Basic Electrical Requirements.

F. Section 16050 – Basic Electrical Materials and Methods.

1.3 REFERENCES

A. AMCA 300 - Reverberant Method for Sound Testing of Fans.

B. AMCA 301 - Method for Publishing Sound Ratings for Air Moving Devices.

C. ANSI/AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings.

D. ANSI/UL 900 - Test Performance of Air Filter Units.

E. ARI 260 - Standard for Sound Rating of Ducted Air Moving and Conditioning Equipment

F. ARI 410 - Standard for Forced Circulation Air-Cooling and Air-Heating Coils.

G. ARI 430 - Standard for Central Station Air Handling Units.

H. ARI 1060 Air-To-Air Energy Recovery Ventilation Equipment

I. ASHRAE 68 - Laboratory Method of Testing In-Duct Sound Power Measurement Procedure for Fans.

J. ASTMB 117 - Standard Practice for Operation Salt Spray Apparatus

K. NEMA MG1 - Motors and Generators

L. NFPA 90 A & B - Installation of Air Conditioning and Ventilation Systems and Installation of Warm Air Heating and Air Conditioning Systems.

M. SMACNA - HVAC Duct Construction Standards.

N. UL 1995 - Heating and Cooling Equipment

1.4 QUALITY ASSURANCE

A. Air Coils: Certify capacities, pressure drops and selection procedures in accordance with current ARI 410 Standard.

B. Certify air-handling units in accordance with ARI 430.

C. ISO 9001 Certification.

1.5 SUBMITTALS

A. Submit unit performance including: capacity, nominal and operating performance.

B. Submit Mechanical Specifications for unit and accessories describing construction, components and options.

C. Submit shop drawings indicating overall dimensions as well as installation, operation and service clearances. Indicate lift points and recommendations. Indicate unit shipping split locations, and split dimensions, installation and operating weights including dimensions.

D. Provide fan curves with specified operating point clearly plotted.

E. Submit data on electrical requirements. Include safety and start-up instructions.

F. Submit sound data certified to ARI 260.

1.6 REGULATORY REQUIREMENTS

A. Unit shall be manufactured to conform to UL 1995 Standard and shall be listed by either UL/CUL or ETL. Units shall be provided with listing agency label affixed to unit. In the event the unit is not UL/CUL or ETL approved, the contractor shall, at his/her expense provide for a field inspection by a UL/CUL or ETL representative to verify conformance. If necessary, contractor shall perform modifications to the unit to comply with UL/CUL or ETL as directed by the representative, at no additional expense to the owner.

B. Certify air-handling units in accordance with ARI 430. If air-handling units are

not certified in accordance with ARI 430, contractor shall be responsible for expenses associated with testing of units after installation to verify performance of fan(s). Any costs incurred to adjust fans to meet scheduled capacities shall be the sole responsibility of the contractor.

C. Certify air-handling coils in accordance with ARI 410. If air-handling coils are not certified in accordance with ARI 410, contractor shall be responsible for expenses associated with testing of coils after installation to verify performance of coil(s). Any costs incurred to adjust coils to meet scheduled capacities shall be the sole responsibility of the contractor.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.

B. Units shall ship fully assembled up to practical shipping and rigging limitations. Units not shipped fully assembled shall have tags and airflow arrows on each section to indicate location and orientation in direction of airflow. Shipping splits shall be clearly defined on submittal drawings. Cost associated with non conformance to shop drawings shall be the responsibility of the manufacturer. Each section shall have lifting lugs or shipping skid to allow for field rigging and final placement of section.

C. Deliver units to jobsite with fan motor(s), sheave(s), and belt(s) completely assembled and mounted in units.

D. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.

1.8 START-UP AND OPERATING REQUIREMENTS

A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters in place, bearings lubricated (if applicable), condensate properly trapped, piping connections verified and leak-tested, belts aligned and tensioned, all shipping braces removed, bearing set screws torqued, and fan has been test run under observation.

1.9 WARRANTY

A. The equipment manufacturer shall provide, at no additional cost, a standard parts warranty that covers a period of one year from unit start-up or 18 months from shipment, whichever occurs first. This warrants that all products are free from defects in material and workmanship and shall meet the capacities and ratings set forth in the equipment manufacturer's catalog and bulletins.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Approved Manufacturers:

1. Carrier
2. Trane
3. York

2.2 AHU GENERAL

A. Outdoor mounted central station air-handling unit designed to provide air to a conditioned space as required to meet specified performance requirements for ventilation, heating, cooling, filtration and distribution. Unit shall be assembled for draw-thru application and shall be arranged to discharge conditioned air horizontally or vertically as shown on the contract drawings. All units shall have neoprene vibration isolation pads.

B. Units shall ship in the number of sections necessary to meet project requirements and shall ship in as many splits as specified in selection software. Split options as follows: Shipped assembled — solid base rail.

C. Unit shall be factory-supplied, factory-assembled, outdoor, curb-mounted central station air handler. The air-handling unit may consist of a fan with the following factory-installed components as indicated on the equipment schedule.

1. Mixing Box Section:
   a. with 2-in. angle filters.
2. Internal Face and Bypass Damper Section.
3. Coil Section:
   a. Chilled water coil.
   b. Hot water coil.
4. Fan Section:
   a. Horizontal blow-thru (with integral diffuser).
   b. Plenum fan:

2.3 CASING

A. Construction:

1. Unit shall be constructed of a complete frame with easily removable panels. Removal of any panel shall not affect the structural integrity of the unit.
2. All units shall be supplied with a perimeter, 14-gage or heavier, G-90 galvanized, high tensile steel base rail with a pocket to accommodate roof curb. Perimeter lifting lugs for overhead lifting shall be provided on each shipping section. Slinging units in place of lifting lugs shall not be acceptable.
3. Unit shall be thermally broken to minimize the conduction path from the inside of the casing to the outside.
4. Casing panels (top, sides, and bottom) shall be constructed of galvanized steel and shall have one of the following exterior finishes as specified:
    a. Pre-painted with a baked enamel finish passing 500-hour salt spray test (ASTM American Society of Mechanical Engineers] B-117) for pre-painted steel and 125-hour marine level 1 prohesion test (ASTM G-85.A5) for pre-painted steel.
    b. Roof shall be double-wall, pitched in four directions at a minimum roof slope of $^{1}/_{4}$-in. per foot across the width of the unit. No penetrations shall be made in pressure sensitive panels. Roof shall incorporate a standing top seam. All seams in the roof shall be gasketed and capped to prevent water infiltration into the unit.
5. Casing panels (top, sides, and bottom) shall be one piece double-wall construction with foam insulation sealed between the inner and outer panels. Panel assemblies shall not carry an R-value of less than 13.
6. Casing deflection shall not exceed an L/240 ratio when subject to an internal pressure of ±8-in. wg and shall exhibit no permanent deformation at ±9 in. wg L is defined as the longest linear panel or cabinet length (measured to AHRI 1350 Cd level 2).
7. Casing leakage rate shall be less than 1% at ±8 in. wg of nominal unit airflow or 50 cfm, whichever is greater. Leakage rate shall be tested and documented on a routine basis on random production units. Optionally, factory witness leak testing and/or test reports shall be available.
8. Side panels shall be easily removable for access to unit and shall seal against a full perimeter automotive style gasket to ensure a tight seal.
9. The panel retention system shall comply with UL 1995 which states all moving parts (for example, fan blades, blower wheels, pulleys, and belts) that, if accidentally contacted, could cause bodily injury, shall be guarded against accidental contact by an enclosure requiring tools for removal.

10. Base rail shall overhang the curb to facilitate water run-off and protection of the curb to base connection from water intrusion.

11. Accessibility options shall be as follows:

    a. Hinged, lockable double-wall access door on either side with removable access panel(s) on the other side.

    b. Hinged, lockable double-wall access doors on both sides.

    c. Removable double-wall access panels on both sides.

12. Depending on the options selected and the remaining available space inside each section, the following options may be available:

    a. Reinforced glass viewports shall be factory-installed on the access panel(s) or door(s) of this section.

    b. Marine lights shall be factory-installed with or without GCFI (ground fault circuit interrupter) convenience outlets.

13. Fan supports, structural members, panels, or flooring shall not be welded, unless aluminum, stainless steel, or other corrosion-resistant material is used. Painted welds on unit exterior steel or galvanized steel are not acceptable.

14. All coil sections shall be double-wall construction with foam insulation sealed between the inner and outer panels. Panel assemblies shall not carry an R-value of less than 13.

15. Blow-thru fan sections shall have a diffuser plate as an integral part of the fan section.

B. Access Doors:

1. Access doors shall be one piece, hinged, lockable, double-wall construction with foam insulation sealed between the inner and outer panels. Panel assemblies shall not carry an R-value of less than 13.

C. Drain Pans:

1. Drain pans shall be foam insulated stainless steel construction. The pan shall be sloped toward the drain connection. Drain pan shall have $1^{1}/_{2}$-in. MPT connection exiting through the hand side or opposite side of the casing as specified. Drain connection shall be insulated from the drain pan to the point at which it exits the casing. One drain outlet shall be supplied for each cooling coil section. Drain pan shall allow no standing water and comply with ASHRAE (American Society of Heating, Refrigerating, and Air-Conditioning Engineers) Standard 62.1-2010. Where 2 or more coils are stacked in a coil bank, intermediate drain pans shall be provided and the condensate shall be piped to the bottom drain pan. The bottom coil shall not serve as a drain path for the upper coil.

D. Hoods and Louvers:

1. Outside Air Hoods:

a. Outside air hoods shall be constructed of 20-gage galvanized G-90 steel and sized for 100% of unit nominal cfm.

b. Hoods shall include easily accessible 1-in. moisture eliminators with a maximum velocity of no more than 500 fpm.

2.4 FANS

A. General:

1. Direct drive plenum fan sections:

a. With NEMA T frame motors shall have the option of one, two, four, or six single width single inlet (SWSI) airfoil fan wheel(s). Airfoil blades shall be double thickness design continuously welded to the back plate and the front plate. Fan wheel shall be constructed of aluminum. Airfoil blades shall be aluminum extrusions and shall be top welded to the back plate and front plate of the wheel. Fan wheel shall be dynamically balanced per ISO standard 1940 quality grade G6.3.

b. With EC motors shall have the option of single or multiple SWSI backward curved fans. Fan wheel shall be constructed of aluminum. Blades shall welded to both front and back plates of the wheel. Fan assembly shall be dynamically balanced per ISO standard 1940 quality grade 6.3.

2. Isolated fan assembly vibration shall not exceed 0.248 in. per second when mounted on active isolators. Vibration shall be measured in both vertical and horizontal directions at the specified fan operating speed using specified motor. For testing purposes, accelerometers shall be mounted on the motor near the bearing locations and removed before shipment.

3. All fan sled components shall provide corrosion protection to pass 100-hour salt spray test per ASTM B-117.

4. Fan wheels for all AF, FC, belt drive PF, and direct drive PF with NEMA “T” frame motors shall be keyed to the shaft. Fan wheels for direct drive PF with EC motors shall be mounted directly to the rotor of the EC motor. All shall be designed for continuous operation at maximum rated fan speed and motor horsepower. Fan wheels and shafts shall be selected with a maximum operating speed 25% below the first critical.

5. Direct drive with EC motors shall exceed the minimum efficiency requirements of the ErP Directive for Fans, efficiency class IE4, and specify motor protection according to EN 60529. Motors shall also provide the following: locked rotor protection, phase failure detection, soft start, mains under-voltage detection, over-temperature protection of electronics/motor, and short circuit protection.

B. Performance Ratings:

1. Supply fan performance shall be rated and certified in accordance with AHRI Standard 430.

C. Sound Ratings:

1. Manufacturer shall submit first through eighth octave sound power for fan discharge and casing radiated sound. Sound ratings shall be tested in accordance with AHRI 260.

D. Mounting:

1. AF, FC, Belt-drive PF, Direct-drive PF with NEMA motor: Fan scroll, wheel, shaft, bearings, drives, and motor shall be mounted on a common base assembly. The base assembly is isolated from the outer casing with factory-installed isolators and vibration absorbent an discharge seal. A canvas style duct connection between fan discharge and cabinet is not acceptable. Units shall use 2-in. deflection spring isolators.

2. Direct drive PF with EC motor: Fan wheel, inlet plate, inlet ring, motor and motor supports shall be a common assembly. The assembly is mounted directly to panels on an internal bulkhead wall.

E. Fan Accessories:

1. Direct Drive Plenum Fans and EC Motors

a. Inlet guard

b. Control options

1) 0-10 VDC
2) 4-20 mA
3) Modbus
4) BACnet

2.5 COILS

A. All water coils shall be provided to meet the scheduled performance. All coil performance shall be certified in accordance with AHRI Standard 410. All water coils shall be tested at 450 psig air pressure. Factory-supplied $^{1}/_{2}$-in. OD coils shall be covered under the standard product one-year limited warrantyCoil epoxy coating shall be covered under a 5-year limited warranty from the date of shipment from the manufacturer.

B. General Fabrication:

1. All water and coils shall have minimum $^{1}/_{2}$-in. OD copper tubes mechanically expanded into fins to ensure high thermal performance with lower total flow and pumping requirements. Minimum tube wall thickness shall be 0.016 inches.

2. Aluminum plate fin type with belled collars. Fin type shall be sine wave construction.

3. Aluminum-finned coils shall be supplied with die-formed casing and tube sheets of mill galvanized steel or stainless steel as specified. Copper-finned coils shall be supplied with stainless steel casing and tube sheets.

4. Headers shall be constructed of steel with steel MPT connections. Headers shall have drain and vent connections accessible from the exterior of the unit.

5. Configuration: Coils shall be drainable, with non-trapping circuits. Coils will be suitable for a design working pressure of 300 psig at 200°F.

2.6 FILTER SECTIONS

A. Angle filter sections shall accept either 2-in.. filters of standard sizes, arranged in a horizontal V formation.

B. Differential Pressure Gages:

1. Housing shall be constructed of a glass filled nylon case and acrylic lens. Exterior finish shall be coated black.

2. Accuracy shall be ±5% of full scale throughout range at 70°F.

3. Pressure limits shall be 30 psig continuous to either pressure connection.

4. Temperature limits shall be 20 to 120°F.

5. Diameter of dial face shall be 2.33 in.

6. Process connections shall be barbed, $^{3}/_{16}$-in. for ID tubing.

7.

2.7 DAMPERS

A. Factory-supplied dampers shall be warranted to be free from defects in material and workmanship for a period of 12 months after being installed or placed in service, but in no instance shall the period of warranty be longer than 18 months from the date of the original shipment by the manufacturer.

Mixing boxes, filter-mixing boxes, and exhaust boxes shall have parallel or opposed blades and interconnecting outside-air and return-air dampers. Bottom damper locations shall be optionally available with a tool screen to prevent most objects from falling through a bottom damper opening.

1. Premium Dampers:

Damper blades shall be constructed of galvanized steel with a double-skin airfoil design, with blade seals and stainless steel jamb seals. Blades shall be mechanically fastened to axle rods rotating in self-lubricating synthetic bearings. Maximum leakage rate shall be 2 cfm/ft^2 at 1 in. wg differential pressure.

B. Internal Face and Bypass Dampers:

1. Internal face and bypass dampers shall be factory mounted in galvanized steel frame. Damper blades shall be constructed of galvanized steel, with high temperature blade and edge seals. Blades shall be mechanically fastened to axle rods rotating in self-lubricating synthetic bearings. To eliminate blade warping, face dampers shall be sectionalized to limit blade length to 60 in. maximum. Face

damper blades shall be opposed and arranged to match coil face with top bypass, and internal linkage.

Static mixing devices of a minimum 0.080 in. aluminum welded and mechanical fastened construction shall be in.

C. Unit with a direct-expansion cooling coil shall have the capability to be used in a refrigerant circuit in conjunction with air-cooled condensing units.

2.8 UNIT CABINET

A. Unit panels shall be constructed of 20 gage galvanized steel. Casing panels shall be removable for easy access to the unit. All panels shall be gasketed to ensure a tight seal.

B. Optional double wall construction shall be available with inner panels constructed of 20 gage steel.

C. Hinged access doors shall be double wall with 1.5 lb dual-density fiberglass between galvanized steel panels.

D. Insulation for casing panels on unit shall be 1-in. minimum thickness dual-density fiberglass insulation with a nominal density of not less than 1.5 lb per cubic foot.

E. Insulation shall be secured to casing with waterproof adhesive.

F. Condensate drain pans shall be sloped to prevent standing water and constructed of stainless steel; they shall have double wall construction with threaded drain connection.

2.9 FAN SECTION

A. Fan sections shall be constructed of galvanized steel and shall have a formed channel base for integral mounting of fan, motor, and casing panels. Fan scroll, wheel, shaft, and bearings are to be rigidly secured to the base unit.

B. Each unit shall have a single fan wheel and scroll. Fans shall be double width, double inlet type, with forward-curved blades. Wheels shall be bonderized steel with baked enamel, or galvanized steel.

C. Fan wheels shall be keyed to the shaft and shall be designed for continuous operation at the maximum rated fan speed and motor horsepower. Fan wheels and shafts shall be selected to operate at least 25% below the first critical speed, and shall be statically and dynamically balanced as an assembly.

D. Fan shafts shall be solid steel, turned, ground and polished.

E. Fan bearings shall be self-aligning, pillow-block regreasable ball type selected for an average life of 200,000 hours at design operation conditions, per ANSI Code B3.15.

F. Fan motor shall be mounted within the fan section casing on slide rails having 2 adjusting screws. Motor shall be NEMA Design B with sizes and electrical characteristics as shown on the equipment schedule.

G. Fan drive shall be designed for a 1.5 service factor and shall be factory mounted and aligned. Belt drive shall be variable or fixed-pitch type.

2.10 COIL SECTIONS

A. All coils shall have mill galvanized casings. Coils shall be factory leak tested at 450 psig air pressure.

B. Hot water coils shall have aluminum plate fins with belled collars bonded to copper tubes by mechanical expansion. Coils shall have galvanized steel casings and copper headers with threaded steel pipe connections. Working pressure shall be 175 psig at 400 F. Headers shall have drain and vent connections.

2.11 FILTER SECTIONS

A. Each filter section shall be designed and constructed to house the specific type of filter specified as Merv 8 and 13.

B. Flat filter sections shall accept filters of standard sizes. Sections shall include side access slide rails and hinged door access. Flat filter section shall be arranged with minimum depth in direction of airflow.

C. Angle filter section shall accept 2-in. filters arranged in horizontal V formation. Double walled hinged doors shall be provided.

2.12 DAMPER SECTIONS

A. Mixing boxes and filter mixing boxes shall have parallel blade, interconnecting outside-air and return-air dampers. Damper blades shall have parallel bends for stiffness and shall be welded to 1/2-in. diameter steel rods rotating in nylon bushings and mounted in rigid galvanized steel frames. Dampers shall be sectionalized to limit blade width to no more than 50-in. to minimize blade warpage and to ensure tight closure. All mixing boxes and filter mixing boxes shall have double-walled hinged access doors.

B. All dampers for mixing boxes and filter mixing boxes shall be rated as low-leakage dampers, having a leakage rate not to exceed 2% of air quantity calculated at 2000 fpm velocity through damper and 4.0-in. wg pressure difference. Damper blades shall be

gasketed and perimeter sealing strips shall be provided.

2.13 ACCESS SECTIONS

A. Access sections shall be installed where indicated on the drawings and shall be as specified on the equipment schedule.

B. Access sections shall have double-walled hinged doors.

2.14 SPECIAL FEAUTRES

A. The following unit options shall be available. The local Carrier Sales Office can provide assistance in amending the specifications.

1. Fan Section:

a. Variable inlet guide vanes.
b. High-efficiency motor.
c. Totally enclosed fan cooled (TEFC) motor for variable speed drive.

2. Coil Section:

a. Direct-expansion coil with copper plate fins and stainless steel casing.
b. Hot water (U-bend) coil with copper plate fins and stainless steel casing.

3. VFD

a. Factory mounted VFD with Bypass.
b. CO2 sensors shall monitor and track outside air as required.
c. Economizer provide interlock to exhaust fans as required.

4. Controls
a. Interconnect to proposed BAS as required.

PART 3 - EXECUTION

3.1 DELIVERY, STORAGE AND HANDLING

A. Unit shall be stored and handled in accordance with the unit manufacturer’s instructions.

B. Provide two (2) sets of belts and filters for attic stock.

END OF SECTION 15720

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. Extent of terminal unit work is indicated by drawings and schedules, and by requirements of this section.

B. Types of units required for project include the following:
   1. Fan Coils Units

C. Refer to other Division-15 sections for piping; ductwork; and testing, adjusting and balancing of terminal units; not work of this section.

D. Refer to Division-16 sections for the following work; not work of this Section.
   1. Power supply wiring from power source to power connection on terminal unit. Include starters, disconnects, and required electrical devices, except where specified as furnished, or factory-installed, by manufacturer.
   2. Interlock wiring between electrically-operated terminal units; and between terminal units and field-installed control devices.
   3. Interlock wiring specified as factory-installed is work of this section.

E. Provide the following electrical work as work of this section, complying with requirements of Division-16 sections:
   1. Control wiring between field-installed controls, indicating devices, and terminal unit control panels.
      a. Control wiring specified as work of Division-15 for Automatic Temperature Controls is work of that section.

1.2 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of terminal units, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 3 years.

B. Codes and Standards:
   1. ARI Compliance: Provide coil ratings in accordance with ARI Standard 410 "Forced-Circulation Air-Cooling and Air-Heating Coils".
   2. ASHRAE Compliance: Test coils in accordance with ASHRAE Standard 33 "Methods of Testing Forced Circulation Air Cooling and Heating Coils".

   3. UL Compliance: Provide electrical components for terminal units which have been listed and labeled by UL.

1.3 SUBMITTALS:

A. Product Data: Submit manufacturer's specifications for terminal units showing dimensions, capacities, ratings, performance characteristics, gages and finishes of materials, and installation instructions.

B. Shop Drawings: Submit assembly-type shop drawings showing unit dimensions, construction details, and field connection details.

C. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to terminal units. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

D. Samples: Submit 3 samples of each type of cabinet finish furnished.

E. Maintenance Data: Submit maintenance instructions, including lubrication instructions, filter replacement, motor and drive replacement, and spare parts lists. Include this data, product data, shop drawings in maintenance manuals; in accordance with requirements of Division 1.

1.4 DELIVERY, STORAGE, AND HANDLING:

A. Handle terminal units and components carefully to prevent damage, breaking, denting and scoring. Do not install damaged terminal units or components; replace with new.

B. Store terminal units and components in clean dry place. Protect from weather, dirt, fumes, water, construction debris, and physical damage.

C. Comply with Manufacturer's rigging and installation instructions for unloading terminal units, and moving them to final location.

PART 2 – PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Horizontal, 4-pipe room fan coil unit or with cabinet for exposed ceiling installations.

B. Factory-assembled, horizontal, blow-thru type fan coil for furred-in, exposed ceiling or ducted installations. Unit shall be complete with water coil(s), fan(s), motor(s), drain pan, and all required wiring, piping, controls and special features. Standard insulation shall be dual density fiberglass insulation.

C. Cabinet Units (42CG): Base unit with stamped discharge grille, removable bottom access panel with stamped return-air grille, filter rack and 1-in. fiberglass throwaway filter. The panel shall be fastened with tamper proof quarter-turn fasteners. The cabinet shall be coated with an Arctic White powder-coat finish.

D. Fans: Direct-driven, double-width fan wheels with forward-curved blades shall be statically and dynamically balanced. Scrolls shall be constructed of galvanized steel. Fan wheels shall be constructed of galvanized steel.

E. Coils: Standard base unit shall be equipped with a 3-row or 4-row coil for installation in a 2-pipe system. Additional coil depth and circuiting shall be provided for installation in a 4-pipe system as described in the Special Features section. All coils shall have $^{1}/_{2}$-in. copper tubes and aluminum fins (10 fins per inch) spacing. Coil fins are mechanical bonded to tube joints. The copper tubes comply with the ASTM (American Society for Testing and Materials) B-75. The fin thickness is 0.0045-in. and tube thickness is 0.016 inch. All coils shall be leak tested with air at 300 psig under water.

F. Controls and Safeties: The fan motor(s) shall be equipped with integral automatic temperature reset for motor protection.

G. Operating Characteristics: A double-circuit coil unit installed in a 4-pipe system shall be capable of providing sequenced heating and cooling.

H. Electrical Requirements: Standard unit shall operate on 115 v, single-phase, 60 Hz electric power. All internal wiring shall be in flexible conduit.

I. Special Features: Unit coil(s) shall be equipped with automatic air vents.

J. Fan motor shall be constant torque electrically commutated type, 115, 208, 220, 240, or 277-v, single phase, 50 or 60 Hz as specified on the equipment schedule. The operating sequence shall be one of the following, as specified:

- Variable Airflow for 0 to 10 VDC / 4 to 20 mA Input. Requires a 0 to 10 VDC input signal and is not compatible with a 3-speed thermostat.

- Filter track and 1" – MERV 13 filter shall be installed in the plenum.
- Drain pan shall include a second drain connection located above the main drain connection to act as an indicator that the main drain is plugged.
- Discharge-air grille with double deflection, aluminum construction with aluminum frame shall be furnished for field installation as shown on the equipment schedule. Aluminum grilles shall have a natural anodized finish.
- Double-deflection discharge-air grille with steel core assembly shall be factory installed as shown on equipment schedule. Grille shall be painted to match cabinet.
- Cabinet of unit shall be painted with the color coordinated with owner.
- A stainless steel drain pan is required.
- Factory-installed insulation options shall include foil faced fiberglass or closed cell insulation.
- Control Options:
  - Factory-installed 24-v transformer and relay board for use, with 24-v controls by others.

PART 3 – EXCUTION

3.1 INSTALLATION OF FAN-COIL UNITS:

A. General: Install fan-coil units as indicated, and in accordance with manufacturer's installation instructions.

B. Locate fan-coil units as indicated, coordinate with other trades to assure correct recess size for recessed units.

C. Install piping as indicated.

D. Protect units with protective covers during balance of construction.

3.2 ADJUSTING AND CLEANING:

A. General: After construction is completed, including painting, clean unit exposed surfaces, vacuum clean terminal coils and inside of cabinets.

B. Retouch any marred or scratched surfaces of factory-finished cabinets, using finish materials furnished by manufacturer.

C. Install new filter units for terminals requiring same.

END OF SECTION 15763

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following types of power ventilators:
   1. Exhaust Fans.

1.2 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections:
   1. Product data for selected models, including specialties, accessories, and the following:
      a. Certified fan performance curves with system operating conditions indicated.
      b. Certified fan sound power ratings.
      c. Motor ratings and electrical characteristics plus motor and fan accessories.
      d. Materials gages and finishes, including color charts.
      e. Dampers, including housings, linkages, and operators.

   2. Shop drawings from manufacturer detailing equipment assemblies and indicating dimensions, weights, required clearances, components, and location and size of field connections.
   3. Wiring diagrams that detail power, signal, and control wiring. Differentiate between manufacturer-installed wiring and field- installed wiring.
   4. Product certificates, signed by manufacturers of air-handling units, certifying that their products comply with specified requirements.
   5. Maintenance data for air-handling units, for inclusion in Operating and Maintenance Manual specified in Division 1 and Division 15 Section "Basic Mechanical Requirements."

1.3 QUALITY ASSURANCE

A. UL Compliance: Fans shall be designed, manufactured, and tested in accordance with UL 705 "Power Ventilators."

B. UL Compliance: Fans and components shall be UL listed and labeled.

C. Nationally Recognized Testing Laboratory and NEMA Compliance (NRTL): Fans and components shall be NRTL listed and labeled. The term "NRTL" shall be as defined in OSHA Regulation 1910.7.

D. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

E. Electrical Component Standard: Components and installation shall comply with NFPA 70 "National Electrical Code."

1.4 DELIVERY, STORAGE, AND HANDLING

A. Lift and support units with the manufacturer's designated lifting or supporting points.

B. Disassemble and reassemble units as required for movement into the final location following manufacturer's written instructions.

C. Deliver fan units as a factory-assembled unit to the extent allowable by shipping limitations, with protective crating and covering.

1.5 SEQUENCING AND SCHEDULING

A. Coordinate the installation of equipment supports, and penetrations specified in Division 7.

B. Coordinate the size and location of structural steel support members.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include but are not limited to, the following:
   1. Exhaust Fans:
      a. Greenheck Fan Corp.
      b. Cook (Loren) Co.
      c. Carnes Company, Inc.

2.2 SOURCE QUALITY CONTROL

A. Testing Requirements: The following factory tests are required:
   1 Sound Power Level Ratings: Comply with AMCA Standard 301 "Method for Calculating Fan Sound Ratings From Laboratory Test Data." Test fans in accordance with AMCA Standard 300 "Test Code for Sound Rating." Fans shall be licensed to bear the AMCA Certified Sound Ratings Seal.
   2 Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings in accordance with AMCA Standard 210/ASHRAE Standard 51 - Laboratory Methods of Testing Fans for Rating.

2.3 FANS, GENERAL

A. General: Provide fans that are factory fabricated and assembled, factory tested, and factory finished with indicated capacities and characteristics.

B. Fans and Shafts: Statically and dynamically balanced and designed for continuous operation at the maximum rated fan speed and motor horsepower.
   1. Fan Shaft: Turned, ground, and polished steel designed to operate at no more than 70 percent of the first critical speed at the top of the speed range of the fan's class.

C. Shaft Bearings: Provide type indicated, having a median life "Rating Life" (AFBMA (L(50)) of 200,000, calculated in accordance with AFBMA Standard 9 for ball bearings and AFBMA Standard 11 for roller bearings.

D. Factory Finish: The following finishes are required:
   1. Sheet Metal Parts: Prime coating prior to final assembly.
   2. Exterior Surfaces: Baked-enamel finish coat after assembly.

2.4 CEILING-MOUNTED VENTILATORS

A. General Description: Centrifugal fan designed for installation in ceiling, wall, or concealed inline applications.

B. Housing: Galvanized steel lined with acoustical insulation.

C. Fan Wheel: Centrifugal wheels directly mounted on motor shaft Fan shrouds, motor, and fan wheel shall be removable for service.

D. Grille: Stainless steel, louvered grille with flange on intake and thumbscrew attachment to fan housing.

E. Electrical Requirements: Junction box for electrical connection on housing and receptacle for motor plug-in.

F. Remote Fan Speed Control: Solid state, capable of controlling fan speed from full speed to approximately half speed.

G. Accessories: Manufacturer's standard, wall cap, and transition fittings as required.

2.5 DIRECT DRIVE SIDEWALL MOUNTED PROPELLER FANS

A. General Description:
   1. Fan arrangement shall be either supply or exhaust, see Fan Schedule
   2. Sidewall mounted applications

3. Performance capabilities up to 7,100 cubic feet per minute (cfm) and static pressure to 0.625 inches of water gauge
4. Fans are available in eight sizes with nominal wheel diameters ranging from 8 inches through 24 inches (8 - 24 unit sizes)
5. Maximum continuous operating temperature 130 Fahrenheit (54.4 Celsius)
6. Each fan shall bear a permanently affixed manufacture's engraved metal nameplate containing the model number and individual serial number

B. Wheel:
1. Propeller shall be aluminum blade riveted to steel hub
2. A standard square key and set screw or tapered bushing shall lock the propeller to the motor shaft
3. Statically and dynamically balanced in accordance with AMCA Standard 204-05. The propeller and fan inlet will be matched and shall have precise running tolerances for maximum performance and operating efficiency

2.6 MOTORS

A. Torque Characteristics: Sufficient to accelerate the driven loads satisfactorily.

B. Motor Sizes: Minimum sizes and electrical characteristics as indicated. If not indicated, large enough so that the driven load will not require the motor to operate in the service factor range.

C. Temperature Rating: 50 deg C maximum temperature rise at 40 deg C ambient for continuous duty at full load (Class A Insulation).

D. Service Factor: 1.15 for polyphase motors and 1.35 for single-phase motors.

E. Motor Construction: NEMA Standard MG 1, general purpose, continuous duty, Design B. Provide permanent-split capacitor classification motors for shaft-mounted fans and capacitor start classification for belted fans.
1. Bases: Adjustable.
2. Bearings: The following features are required:
   a. Ball or roller bearings with inner and outer shaft seals.
   b. Grease lubricated.
   c. Designed to resist thrust loading where belt drives or other drives produce lateral or axial thrust in motor.

3. Enclosure Type: The following features are required:
   a. Open drip-proof motors where satisfactorily housed or remotely located during operation.
   b. Guarded drip-proof motors where exposed to contact by employees or building occupants.

4. Overload protection: Built-in, automatic reset, thermal overload protection.
5. Noise rating: Quiet.
6. Efficiency: Energy-efficient motors shall have a minimum efficiency as scheduled in accordance with IEEE Standard 112, Test Method B. If efficiency not specified, motors shall have a higher efficiency than "average standard industry motors" in accordance with IEEE Standard 112, Test Method B.
7. Nameplate: Indicate the full identification of manufacturer, ratings, characteristics, construction, and special features.

F. Starters, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 16.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances, equipment supports, and other conditions affecting performance of fans.

B. Do not proceed until unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

A. Install fans level and plumb, in accordance with manufacturer's written instructions. Support units as described below, using the vibration control devices indicated. Vibration control devices are specified in Division 15 Section "Vibration Controls."
1. Support utility set fans on equipment bases and supports using neoprene pads. Secure units to anchor bolts installed in equipment base.

2. Secure units to anchor bolts installed in equipment base.

3. Suspended Units: Suspend units from structural steel support frame using threaded steel rods and vibration isolation springs.

B. Arrange installation of units to provide access space around air- handling units for service and maintenance.

3.3 CONNECTIONS

A. Duct installations and connections are specified in other Division 15 sections. Make final duct connections with flexible connections.

B. Electrical Connections: The following requirements apply:

1. Electrical power wiring is specified in Division 16.
2. Temperature control wiring and interlock wiring are specified in Division 15 Section "Electrical Control Systems."
3. Temperature control wiring and interlock wiring are specified in Division 15 Section "Pneumatic Control Systems."
4. Grounding: Connect unit components to ground in accordance with the National Electrical Code.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Inspection: Arrange and pay for a factory- authorized service representative to perform the following:
   1. Inspect the field assembly of components and installation of fans including ductwork and electrical connections.
   2. Prepare a written report on findings and recommended corrective actions.

3.5 ADJUSTING, CLEANING, AND PROTECTING

A. Adjust damper linkages for proper damper operation.

B. Clean unit cabinet interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheel and cabinet.

3.6 COMMISSIONING

A. Final Checks Before Start-Up: Perform the following operations and checks before start-up:
   1. Remove shipping blocking and bracing.
   2. Verify unit is secure on mountings and supporting devices and that connections for piping, ductwork, and electrical are complete. Verify proper thermal overload protection is installed in motors, starters, and disconnects.
   3. Perform cleaning and adjusting specified in this Section.
   4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearings operations. Reconnect fan drive system,.
   5. Lubricate bearings with factory-recommended lubricants.
   6. Verify manual and automatic volume control and that fire and smoke dampers in connected ductwork systems are in the full-open position.
   7. Disable automatic temperature control operators.

B. Starting procedures for fans:
   1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated RPM.
   2. Measure and record motor electrical values for voltage and amperage.
      a. Replace fan and motor pulleys as required to achieve design conditions.

C. Shut unit down and reconnect automatic temperature control operators.

D. Refer to Division 15 Section "Testing, Adjusting, and Balancing" for procedures for air-handling-system testing, adjusting, and balancing.

3.7 DEMONSTRATION

A. Demonstration Services: Arrange and pay for a factory-authorized service representative to train Owner's maintenance personnel on the following:
   1. Procedures and schedules related to start-up and shutdown, troubleshooting, servicing, preventative maintenance, and how to obtain replacement parts.
   2. Familiarization with contents of Operating and Maintenance Manuals specified in Division 1 Section "Project Closeout" and Division 15 Section "Basic Mechanical Requirements."

B. Schedule training with at least 7 days' advance notice.

END OF SECTION 15870

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions apply to this Section.

1.2 SUMMARY

A. This Section includes rectangular and round ducts.

1.3 QUALITY ASSURANCE

A. NFPA Compliance: Comply with the following NFPA Standards:
   1. NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems," except as indicated otherwise.

PART 2 - PRODUCTS

2.1 SHEET METAL MATERIALS

A. Galvanized Sheet Steel: Lock-forming quality, ASTM A 527, Coating Designation G 90. Provide mill phosphatized finish for exposed surfaces of ducts exposed to view.

2.2 FIRE-STOPPING

A. Refer to Division 7 Section "Firestopping" for fire-stopping.

2.3 HANGERS AND SUPPORTS

A. Building Attachments: Concrete inserts, powder actuated fasteners, or structural steel fasteners appropriate for building materials. Do not use powder actuated concrete fasteners for lightweight aggregate concretes or for slabs less than 4 inches thick.

B. Hangers: Galvanized sheet steel, or round, uncoated steel, threaded rod.
   1. Straps and Rod Sizes: Conform with Table 4-1 in SMACNA HVAC Duct Construction Standards, 1985 Edition, for sheet steel width and gage and steel rod diameters.

C. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

2.4 RECTANGULAR DUCT FABRICATION

A. General: Except as otherwise indicated, fabricate rectangular ducts with galvanized sheet steel, in accordance with SMACNA "HVAC Duct Construction Standards," Tables 1-3 through 1-19, including their associated details. Conform to the requirements in the referenced standard for metal thickness, reinforcing types and intervals, tie rod applications, and joint types and intervals.
   1. Provide materials that are free from visual imperfections such as pitting, seam marks, roller marks, stains, and discolorations.

2.5 RECTANGULAR DUCT FITTINGS

A. Fabricate elbows, transitions, offsets, branch connections, and other duct construction in accordance with SMACNA "HVAC Metal Duct Construction Standard," 1985 Edition, Figures 2-1 through 2-10.

2.6 ROUND DUCT FABRICATION

A. General: "Basic Round Diameter" as used in this article is the diameter of the size of round duct that has a circumference equal to the perimeter of a given sized of flat oval duct.

B. Round Ducts: Fabricate round supply ducts with spiral lockseam construction to elbows being pleated. Comply with SMACNA "HVAC Duct Construction Standards," Table 3-2 for galvanized steel gages.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION, GENERAL

A. Install ducts with the fewest possible joints.

B. Use fabricated fittings for all changes in directions, changes in size and shape, and connections.

C. Install couplings tight to duct wall surface with projections into duct at connections kept to a minimum.

D. Locate ducts, except as otherwise indicated, vertically and horizontally, parallel and perpendicular to building lines; avoid diagonal runs. Install duct systems in shortest

route that does not obstruct useable space or block access for servicing building and its equipment.

E. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

F. Conceal ducts from view in finished and occupied spaces by locating in mechanical shafts, hollow wall construction, or in soffits.

3.2 HANGING AND SUPPORTING

A. Install rigid round, and rectangular metal duct with support systems indicated in SMACNA "HVAC Duct Construction Standards," Tables 4-1 through 4-3 and Figures 4-1 through 4-8.

B. Support horizontal ducts within 2 feet of each elbow.

C. Support vertical ducts at each floor.

D. Upper attachments to structures shall have an allowable load not exceeding 1/4 of the failure (proof test) load but are not limited to the specific methods indicated.

E. Install powder actuated concrete fasteners after concrete is placed and completely cured.

3.3 CONNECTIONS

A. Equipment Connections: Connect equipment with flexible connectors in accordance with Division 15 Section "Duct Accessories."
B. Clean ducts systems prior to final acceptance to remove dust and debris.

END OF SECTION 15891

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. Types of ductwork accessories required for project include the following:
   1. Dampers.
      a. Low pressure manual dampers.
      b. Control dampers.
      c. Counterbalanced relief dampers.
   2. Fire and smoke dampers.
   3. Turning vanes.
   4. Duct hardware.
   5. Duct access doors.
   6. Flexible connections.

B. Refer to other Division-15 sections for testing, adjusting, and balancing of ductwork accessories; not work of this section.

1.2 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of ductwork accessories, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 3 years.

B. Codes and Standards:
   1. SMACNA Compliance: Comply with applicable portions of SMACNA "HVAC Duct Construction Standards, Metal and Flexible".
   2. Industry Standards: Comply with ASHRAE recommendations pertaining to construction of ductwork accessories, except as otherwise indicated.
   3. UL Compliance: Construct, test, and label fire dampers in accordance with UL Standard 555 "Fire Dampers and Ceiling Dampers".
   4. NFPA Compliance: Comply with applicable provisions of NFPA 90A "Air Conditioning and Ventilating Systems", pertaining to installation of ductwork accessories.

1.3 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data for each type of ductwork accessory, including dimensions, capacities, and materials of construction; and installation instructions.

B. Shop Drawings: Submit manufacturer's assembly-type shop drawings for each type of ductwork accessory showing interfacing requirements with ductwork, method of

fastening or support, and methods of assembly of components.

C. Maintenance Data: Submit manufacturer's maintenance data including parts lists for each type of duct accessory. Include this data, product data, and shop drawings in maintenance manual; in accordance with requirements of Division 1.

PART 2 - PRODUCTS

2.1 DAMPERS:

A. Low Pressure Manual Dampers: Provide dampers of single blade type or multiblade type, constructed in accordance with SMACNA "HVAC Duct Construction Standards".

B. Control Dampers: Provide dampers with parallel blades for 2- position control, or opposed blades for modulating control. Construct blades of 16-ga steel, provide heavy-duty molded self- lubricating nylon bearings, 1/2" diameter steel axles spaced on 9" centers. Construct frame of 2" x 1/2" x 1/8" steel channel for face areas 25 sq. ft. and under; 4" x 1-1/4" x 16-ga channel for face areas over 25 sq. ft. Provide galvanized steel finish with aluminum touch-up.

C. Control Dampers: Refer to Division-15 section "Control Systems" for control dampers; not work of this section.

D. Counterbalanced Relief Dampers: Provide dampers with parallel blades, counterbalanced and factory-set to relieve at indicated static pressure. Construct blades of 16-ga aluminum, provide 1/2" diameter ball bearings, 1/2" diameter steel axles spaced on 9" centers. Construct frame of 2" x 1/2" x 1/8" steel channel for face areas 25 sq. ft. and under; 4" x 1-1/4" x 16-ga channel for face areas over 25 sq. ft. Provide galvanized steel finish on frame with aluminum touch-up.

E. Available Manufacturers: Subject to compliance with requirements, manufacturers offering dampers which may be incorporated in the work include, but are not limited to, the following:
1. Air Balance, Inc.
2. Airguide Corp.
3. American Warming & Ventilating, Inc.
4. Arrow Louver and Damper; Div. of Arrow United Industries, Inc. Louvers & Dampers, Inc.
5. Penn Ventilator Co.
6. Ruskin Mfg. Co.

2.2 FIRE AND SMOKE DAMPERS:

A. Fabricated Fire Dampers: Provide dampers constructed in accordance with SMACNA "Fire Dampers and Heat Stop Guide".

B. Fire Dampers: Provide fire dampers, of types and sizes indicated. Construct casings of 11-ga galvanized steel with bonded red acrylic enamel finish. Provide fusible link rated at 160 to 165 degrees F (71 to 74 degrees C) unless otherwise indicated. Provide damper with positive lock in closed position, and with the following additional features:
1. Damper Blade Assembly: Single-blade type.
2. Damper Blade Assembly: Multi-blade type.
3. Damper Blade Assembly: Curtain type.
4. Blade Material: Steel, match casing.
5. Blade Material: Stainless steel.

C. Fire/Smoke Dampers: Provide fire/smoke dampers, of types and sizes indicated. Construct casings of 11-ga galvanized steel with bonded red acrylic enamel finish. Provide fusible link rated at 160 to 165 degrees F (71 to 74 degrees C) unless otherwise indicated. Provide additional frangible link containing explosive charge, connected in series with fusible link. Provide stainless steel spring loaded leakage seals in sides of casing, and 36" long wire leads for connecting smoke link to smoke detector, and the following additional features:
1. Damper Blade Assembly: Single-blade type.
2. Damper Blade Assembly: Multi-blade type.
3. Damper Blade Assembly: Curtain type.
4. Blade Material: Steel, matching casing.
5. Blade Material: Stainless steel.

D. Motor-Driven Fire/Smoke Dampers: Provide motor-driven fire/smoke dampers in types and sizes indicated, with casing constructed of 11-ga galvanized steel with bonded red acrylic enamel finish, fusible link 160 to 165 degrees F (71 to 74 degrees C), unless otherwise indicated, and curtain type stainless steel interlocking blades, with electric motor equipped with instant closure clutch, stainless steel cable damper blade linkage, motor mounting bracket, and 32" long wire leads for connecting to smoke detector, and with the following construction features:
1. Unit Assembly: Motor mounted outside air stream.
2. Unit Assembly: Motor mounted inside air stream.

E. Available Manufacturers: Subject to compliance with requirements, manufacturers offering fire and smoke dampers which may be incorporated in the work include, but are not limited to, the following:
1. Air Balance, Inc.
2. American Warming & Ventilating, Inc.

3. Arrow Louver and Damper; Div. of Arrow United Industries Inc.
4. Louvers and Dampers, Inc.
5. Penn Ventilator Co.
6. Phillips-Aire
7. Ruskin Mfg. Co.

2.3 TURNING VANES:

A. Fabricated Turning Vanes: Provide fabricated turning vanes and vane runners, constructed in accordance with SMACNA "HVAC Duct Construction Standards".

B. Manufactured Turning Vanes: Provide turning vanes constructed of 1-1/2" wide curved blades set at 3/4" o.c., supported with bars perpendicular to blades set at 2" o.c., and set into side strips suitable for mounting in ductwork.

C. Acoustic Turning Vanes: Provide acoustic turning vanes constructed of airfoil shaped aluminum extrusion with perforated faces and fiberglass fill.

D. Available Manufacturers: Subject to compliance with requirements, manufacturers offering turning vanes which may be incorporated in the work include, but are not limited to, the following:
1. Aero Dyne Co.
2. Airsan Corp.
3. Anemostat Products Div.; Dynamics Corp. of America.
4. Barber-Colman Co.
5. Duro Dyne Corp.
6. Environmental Elements Corp.; Subs, Koppers Co., Inc.
7. Hart & Cooley Mfg. Co.
8. Register & Grille Mfg. Co., Inc.
9. Souther, Inc.

2.4 DUCT HARDWARE:

A. General: Provide duct hardware, manufactured by one manufacturer for all items on project, for the following:
1. Test Holes: Provide in ductwork at fan inlet and outlet, and elsewhere as indicated, duct test holes, consisting of slot and cover, for instrument tests.
2. Quadrant Locks: Provide for each damper, quadrant lock device on one end of shaft; and end bearing plate on other end for damper lengths over 12". Provide extended quadrant locks and end extended bearing plates for externally insulated ductwork.

B. Available Manufacturers: Subject to compliance with requirements, manufacturers offering duct hardware which may be incorporated in the work include, but are not limited to, the following:
   1. Ventfabrics, Inc.
   2. Young Regulator Co.

2.5 DUCT ACCESS DOORS:

A. General: Provide where indicated, duct access doors of size indicated.

B. Construction: Construct of same or greater gage as ductwork served, provide insulated doors for insulated ductwork. Provide flush frames for uninsulated ductwork, extended frames for externally insulated duct. Provide one size hinged, other side with one handle-type latch for doors 12" high and smaller, 2 handle-type latches for larger doors.

C. Available Manufacturers: Subject to compliance with requirements, manufacturers offering duct access doors which may be incorporated in the work include, limited to the following:
   1. Air Balance Inc.
   2. Ruskin Mfg. Co.
   3. Ventifabrics, Inc.
   4. Zurn Industries, Inc.; Air Systems Div.

2.6 FLEXIBLE CONNECTORS:

A. General: Provide flexible duct connections wherever ductwork connects to vibration isolated equipment. Construct flexible connections of neoprene-coated flameproof fabric crimped into duct flanges for attachment to duct and equipment. Make airtight joint. Provide adequate joint flexibility to allow for thermal, axial, transverse, and torsional movement, and also capable of absorbing vibration of connected equipment.

B. Available Manufacturers: Subject to compliance with requirements, manufacturers offering flexible connections which may be incorporated in the work include, limited to the following:
   1. American/Elgen Co.; Energy Div.
   2. Flexaust (The) Co.
   3. Ventfabrics, Inc.

PART 3 - EXECUTION

3.1 INSPECTION:

A. Examine areas and conditions under which ductwork accessories will be installed. Do not

proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION OF DUCTWORK ACCESSORIES:

A. Install ductwork accessories in accordance with manufacturer's installation instructions, with applicable portions of details of construction as shown in SMACNA standards, and in accordance with recognized industry practices to ensure that products serve intended function.

B. Install turning vanes in square or rectangular 90 degree elbows in supply and exhaust air systems, and elsewhere as indicated.

C. Install access doors to open against system air pressure, with latches operable from either side, except outside only where duct is to small for person to enter.

D. Coordinate with other work, including ductwork, as necessary to interface installation of ductwork accessories properly with other work.

3.3 FIELD QUALITY CONTROL:

A. Operate installed ductwork accessories to demonstrate compliance with requirements. Test for air leakage while system is operating. Repair or replace faulty accessories, as required to obtain proper operation and leakproof performance.

3.4 ADJUSTING AND CLEANING:

A. Adjusting: Adjust ductwork accessories for proper settings, install fusible links in fire dampers and adjust for proper action.
   1. Label access doors in accordance with Division-15 section "Mechanical Identification".
   2. Final positioning of manual dampers is specified in Division- 15 section "Testing, Adjusting, and Balancing".

B. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

3.5 EXTRA STOCK:

A. Furnish extra fusible links to Owner, one link for every 10 installed of each temperature range; obtain receipt.

END OF SECTION 15910

PART 1 GENERAL

1.1 SUMMARY

A. Scope: Extent of testing, adjusting and balancing work required by this Section.

B. Systems: Testing, adjusting and balancing specified in this Section includes the following systems.
   1. Air handling systems including supply, return, outside air and exhaust.
   2. Hydronic system including heating, and chilled water.
   3. Boilers, Chiller, Pumps, Fan Coils, Radiation, ETC.
   3. Verify temperature control system operations

1.2 QUALITY ASSURANCE

A. Tester's Qualifications: A specialist certified by the National Environmental Balancing Bureau (NEBB) or Associated Air Balance Council (AABC) with at least 3 years of experience in those testing, adjusting and balancing requirements similar to those required for this project, who is not the installer of the system to be tested and is otherwise independent of the project.

B. Codes and Standards: Provide testing, adjusting and balancing conforming to American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE), American National Standards Institute (ANSI), and either NEBB or AABC the following:
   1. American National Standards Institute (ANSI): Comply with the following:
      a. S1.4 Specification For Sound Level Meters
      b. S1.11 Specification for Octave-Band and Frcational-Octave-Band Analog and Digital Filters
   2. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE): Comply with ASHRAE recommendations pertaining to measurements, instruments, and testing, adjusting, and balancing.

   3. NEBB or AABC: Comply with NEBB'S "Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems" or comply with AABC MN-1 "National Standards," as applicable to mechanical air and hydronic distribution systems, and associated equipment and apparatus.

C. Penalty: The Contractor shall submit the name of the organization he proposes to employ for approval within 45 days after contract award. If the Contractor fails to submit the name of an acceptable agency within the specified time, a firm may be selected to accomplish the work, and this selection shall be binding upon the Contractor at no additional cost.

D. Calibration of Testing Instruments: All measurement instruments used for testing, adjusting, balancing, and commissioning shall be calibrated. The time between the most recent calibration data and the final test report date shall not be over 3 years.

1.3 SUBMITTALS

A. Test Reports: Provide certified test reports, signed by the test and balance supervisor who performed the work. In addition, have the reports certified by a Professional Engineer who is familiar with testing and balancing and the project, and is registered in the jurisdiction where testing is being conducted. The final reports shall include identification and types of instruments used, and their most recent calibration date and calibration date.

B. Standards: The Contractor shall deliver a copy of either NEBB or AABC standards for testing and balancing work associated with the project. This document shall serve as specific guidance to construction engineers as to minimum requirements.

C. Maintenance Data: Include, in maintenance manuals, copies of certified test reports and identification of instruments.

D. Qualifications: The Contractor shall submit the certified individual qualifications of all persons responsible for supervising and performing the actual work, the name of the certifying engineer, and the qualifications of the independent Registered Professional Engineer certifying the report.

1.4 AGENDA

A. Agenda: A preliminary report and agenda shall be submitted and approved prior to the start of testing and balancing work.
   1. Review plans and specifications prior to installation of any of the affected systems, and submit a report indicating any deficiencies in the systems that would preclude the proper adjusting, balancing, and testing of the systems.
   2. The agenda shall include a general description of each air and water system with its associated equipment and operation cycles for heating, intermediate, and cooling.
   3. The agenda shall include a list of all air and water flow and air terminal measurements to be performed.
   4. The agenda shall incorporate the proposed selection points for sound measurements, including typical spaces as well as sound sensitive areas like conference rooms.
   5. The agenda shall also include specific test procedures and parameters for determining specified quantities (e.g. flow, drafts, sound levels) from the actual field measurements to establish compliance with contract requirements. Samples of forms showing application of procedures and calculations to typical systems shall

be submitted.

6. Specific test procedures for measuring air quantities at terminals shall specify type of instrument to be used, method of instrument application (by sketch) and factors for:
   a. Air terminal configuration.
   b. Flow direction (supply or exhaust).
   c. Velocity corrections.
   d. Effective area applicable to each size and type of air terminal.
   e. Density corrections.

7. The agenda shall include identification and types of measurement instruments to be used, and their most recent calibration date and calibration date.

1.5 JOB CONDITIONS

A. General: Do not proceed with testing, adjusting and balancing work until the following conditions have been met.
   1. Work has been completed and is operable. Ensure that there is no latent residual work yet to be completed on the tested equipment.
   2. Work scheduled for testing, adjusting and balancing is clean and free from debris, dirt and discarded building materials.
   3. All architectural openings (doors, windows, and other openings) which may affect the operation of the system to be tested, adjusted, and balanced shall at their normal states.
   4. All related mechanical systems which may affect the operation of the system to be tested, adjusted, and balanced shall be at their normal operating conditions.

PART 2 PRODUCTS

2.1 MANUFACTURERS (Not Used)

2.2 PATCHING MATERIALS

A. Material: Seal, patch and repair ductwork, piping and equipment drilled or cut for testing purposes.
   1. Plastic plugs with retainers may be used to patch drilled holes in ductwork and housings.
   2. Piping shall be capped with materials the same as the piping system.
   3. Insulation shall be neatly hemmed with metal or plastic edging, leaving test points visible for future testing.

2.3 TEST INSTRUMENTS

A. Standards: Utilize instruments and equipment of type, precision, and capacity as recommended in the following standards:
   1. NEBB "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems."
   2. AABC Manual MN-1.

B. Test Instruments: All instruments used for measurements shall be accurate and calibration histories for each instrument shall be available for examination. Each test instrument shall be calibrated by an approved laboratory or by the manufacturer. A representative has the right to request instrument recalibration, or the use of other instruments and test methodology, where accuracy of readings is questionable.

C. Additional Instruments: Permanently installed measuring instruments , such as temperature and pressure gauges, shall be checked against transfer standard instruments. Any instrument which does not meet specification requirement shall be replaced or recalibrated.

D. Cone Instruments: The Contractor shall employ manufactured enclosure type cones, capable of air volume direct readings, for all diffuser air flow measurements. The readout meters shall meet calibration requirements.

PART 3 EXECUTION

3.1 PROCEDURES AND INSTRUMENTS, GENERAL

A. Requirements: All systems and components thereof shall be adjusted to perform as required.

B. Test Duration: Operating tests of heating and cooling coils, fans, and other equipment shall be of not less than four hours duration after stabilized operating conditions have been established. Capacities shall be based on temperatures and air and water quantities measured during such tests.

C. Instrumentation: Method of application of instrumentation shall be in accordance with the approved agenda.
   1. All instruments shall be applied in accordance with the manufacturer's certified instructions.
   2. All labor, instruments, and appliances required shall be furnished by the Design Builder. Permanently installed instruments used for the tests (e.g., flow meters and Btu meters) shall not be installed until the entire system has been cleaned and ready for operation.

3. See Section 15130, "Meters and Gauges" for thermometer accuracy requirements.

3.2 AIR SYSTEMS PROCEDURES

A. Adjustments: Adjust all air handling systems to provide approximate design air quantity to or through, each component, and to maintain stable and comfortable interior temperatures, free of drafts or stagnant conditions. Adjusting and balancing of all systems shall be conducted during periods of the year approximating maximum seasonal operation.

B. Equalizers: Equalizing devices shall be adjusted to provide uniform velocity across the inlets (duct side for supply) of terminals prior to measuring flow rates.

C. Balance: Flow adjusting (volume control) devices shall be used to balance air quantities (i.e., proportion flow between various terminals comprising system) to the extent that their adjustments do not create objectionable air motion or sound (i.e., in excess of specified limits).
   1. Balancing between runs (submains, branch mains, and branches) generally shall be accomplished by flow regulating devices at, or in, the divided-flow fitting.
   2. Restriction imposed by flow regulating devices in or at terminals shall be minimal. Final measurements of air quality shall be made after the air terminal has been adjusted to provide the optimum air patterns of diffusion.

D. Fan Adjustment: Total air system quantities, generally, shall be varied by adjustment of fan speeds or axial-flow fan wheel blade pitch. Damper restriction of a system's total flow may be used only for systems with direct-connected fans (without adjustable pitch blades), provided system pressure is less than 1/2-inch W.G. and sound level criteria is met.

E. Air Measurement: Where air quantity measuring devices are specified in other sections such systems shall be used as a cross-check of portable measuring equipment.
   1. Except as specifically indicated herein, pitot tube traverses shall be made of each duct to measure air flow therein. Pitot tubes, associated instruments, traverses, and techniques shall conform to the ASHRAE "Handbook Fundamentals Inch Pound Edition."
   2. For ducts serving modular office areas with movable partitions, which are subject to change, pitot tube traverses may be omitted provided the duct serves only a single room or space and its design volume is less than 2000 cfm. In lieu of pitot tube traverses, air flow in the duct shall be determined by totalling volume of individual terminals served, measured as described herein.
   3. Where duct's design velocity and air quantity are both less than 1000 (fpm/cfm), air quantity may be determined by measurements at terminals served.

F. Test Holes: Test holes shall be in a straight duct, as far as possible downstream from elbows, bends, take-offs, and other turbulence generating devices, to optimize reliability of flow measurements.

G. Air Terminal Balancing: Generally, measurement of flow rates by means of velocity meters applied to individual terminals, with or without cones or other adapters, shall be used only for balancing. Measurement of air quantities at each type of air terminal (inlet and outlet) shall be determined by the method approved for the balancing agenda. Laboratory tests shall be conducted to prove of methodology when so directed. Such tests shall be conducted in conformance with applicable ASHRAE or American Society of Mechanical Engineers (ASME) codes and shall be made at no cost.

H. Air Motion: Air motion and distribution shall be as required. The Design Builder at no additional cost shall, in addition to air motion measurements, make smoke tests wherever requested to demonstrate the air distribution from air terminals.

3.3 WATER SYSTEM PROCEDURES

A. Adjustment: All heating and cooling water systems shall be adjusted to provide required quantity to or through each component.

B. Metering: Water quantities and pressures shall be measured with calibrated meters.
1. Venturi tubes, orifices, or other metering fittings and pressure gauges shall be used to measure water flow rates and balance systems. Systems shall be adjusted to provide the approved pressure drops through the heat transfer equipment (coils, converters, etc.) prior to the capacity testing.
2. Where flow metering fittings are not installed, in air/water type heat transfer equipment, flow balance shall be determined by measuring the air side energy differential across the heat transfer equipment. Measurement of water temperature differential shall be performed with the air system, adjusted as described herein, in operation.

C. Automatic Controls: Automatic control valves shall be positioned for full flow through the heat transfer equipment of the system during tests.

D. Flow: Flow through bypass circuits at three-way valves shall be adjusted to equal that through the supply circuit, when the valve is in the bypass position.

E. Distribution: Adjustment of distribution shall be effected by means of balancing devices (cocks, valves, and fittings) and automatic flow control valves as provided; service valves shall not be used.

1. Where automatic flow control valves are utilized in lieu of Venturi tubes, only pressure differential need be recorded, provided that the pressure is at least the minimum applicable to the tag rating.

F. Special Procedures: Where available pump capacity (as designed) is less than total flow requirements of individual heat transfer units of system served, full flow may be simulated by the temporary restriction of flow to portions of the system; specific procedures shall be delineated in the agenda.

3.4 HEAT EXCHANGER CAPACITY VERIFICATION

A. Air coil capacities shall be verified from air side measurement data. Capacities of coils shall be the difference of the energy carried by the air between the up-stream and down-stream of the coils.

B. The measured air flow rate for the fan may be used for air coil capacity calculations providing no ducted bypassing of coil is occurring.

C. Capacity verifications shall be performed after air and water systems have been balanced.

D. False load shall be applied if the upstream air or water does not meet the specified conditions at the time of test.

3.5 SOUND TEST PROCEDURES

A. Scope: Tests of sound levels shall be made at each selection point included in the agenda.

B. Timing: Sound level measurements shall be taken at times when the building is unoccupied, or when activity in surrounding areas and background noise level in areas tested are at a minimum and relatively free from sudden changes in noise levels.
1. Measurements shall be taken with all equipment turned off, except that being tested.
2. The required sound levels shall be measured at any point within a room not less than 6 feet from an air terminal or room unit, and not closer than 3 feet from any floor, wall, or ceiling surface.

C. Meters: Sound levels shall be measured with a sound meter complying with ANSI S1.4. The "A" scale shall be used to measure over all sound levels. To determine the specified octave band levels, the above sound level meter, set on "C" scale, shall be supplemented by an octave band analyzer complying with ANSI S1.11.

D. Equipment Components: The "Equipment Component" of room sound equals LPt-C. The "Equipment Component" of room sound (noise) levels shall be determined for each of eight octave bands as follows.

1. Measure room sound pressure level "LPb" with equipment to be tested shut off.
2. Measure room sound pressure level "LPt" with equipment to be tested turned on.
3. Calculate LPt-LPb; if this value is less than 1, applicable test must be rerun with lower background level (LPb) unless LPt is within sound pressure level specified for equipment.
4. Determine "c" from the table below:

LPt-LPb (db)	c (db)
1	7
2	4
3	3
4 to 4-1/2	2
5 to 5-1/2	1-1/2
6 to 7-1/2	1
8 to 12	1/2
over 12	0

3.6 CERTIFIED REPORTS

A. Submittals: Three copies of the reports described herein, covering air and water system performance, air motion (fpm), and sound pressure levels, shall be submitted prior to final tests and inspection.

B. Instrument Records: Types, serial numbers, and dates of calibration of all instruments shall be included.

C. Reports: Reports shall conspicuously identify items not conforming to contract requirements, or obvious maloperation and design deficiencies.

D. Certification: The reports shall be certified by an independent Registered Professional Engineer who is versed in the field of air and water balancing and who is not affiliated with any firm involved in the design or construction phases of the project. Certification shall include checking of adherence to agenda, of calculations, of procedures, and evaluation of final summaries.

3.7 AIR SYSTEM DATA

A. Report: The certified report shall include for each air handling system the data listed below.

1. Equipment (Fan or Factory Fabricated Station Unit):
   a. Installation data
      (a) Manufacturer and model

(b) Size
(c) Arrangement, discharge and class
(d) Motor hp, voltage, phase, cycles, and full load amps
(e) Location and local identification data

b. Design data
(a) Data.

c. Fan recorded (test) data
(a) cfm
(b) Static pressure
(c) rpm
(d) Motor operating amps motor operating bhp

2. Duct Systems:
a. Duct air quantities (maximum and minimum) - main, submains, branches, outdoor (outside) air, total air, and exhaust
(a) Duct size(s)
(b) Number of Pitot tube (pressure measurements)
(c) Sum of velocity measurements (Note: Do not add pressure measurements)
(d) Average velocity
(e) Recorded (test) cfm design cfm

b. Individual air terminals
(a) Terminal identification supply or exhaust, location and number designation
(b) Type size, manufacturer and catalog identification applicable factor for application, velocity, area, etc., and designated area
(c) Design and recorded velocities- fpm (state "core," "inlet," etc., as applicable)
(d) Design and recorded quantities -cfm deflector vane or diffusion cone settings

3.8 WATER SYSTEM DATA

A. Report: The certified report for reach water system shall include the data listed below.
1. Pumps:
a. Installation data
(a) Manufacturer and model
(b) Size
(c) Type drive
(d) Motor hp, voltage, phase, and full load amps

b. Design data
(a) gpm
(b) Head
(c) rpm, bhp, and amps

c. Recorded data
   (a) Discharge pressures (full-flow and no-flow)
   (b) Suction pressures (full-flow and no-flow) operating head
   (c) Operating gpm (from pump curves if metering is not provided) no-load amps (where possible)
   (d) Full-flow amps
   (e) No-flow amps

2. Boilers:
   a. Installation data
      (a) Manufacturer, model, and type
      (b) gpm
      (c) Inlet (entering) and outlet (leaving) temperatures
      (d) Water pressure drop

   b. Recorded data
      (a) gpm (if metered)
      (b) Entering and leaving water temperatures - system
      (c) Water pressure drop
      (d) Heating (or cooling) media (conditions) - entering and leaving water temperature
      (e) Heating (or cooling) media - flow (gpm)

3. Air Heating and Cooling Equipment:
   a. Design data
      (a) Load in Btu or MBh
      (b) gpm
      (c) Entering and leaving water temperature
      (d) Entering and leaving air conditions (DB and WB)
      (e) cfm
      (f) Water pressure drop

   b. Recorded data
      (a) Type of equipment and identification (location or number designation)
      (b) Entering and leaving air conditions (DB and WB)
      (c) Entering and leaving water temperatures
      (d) gpm (if metered) Temperature rise or drop

3.9 SOUND DATA

A. Report: The certified report shall record data on sound levels, taken at each selected location, as follows.

1. Source of sound and location
2. Diagram or description of relationship of sound source to measuring instrument
3. "A" scale readings equipment being tested turned off (ambient) equipment being tested turned on (operating conditions)
4. Readings at each specified octave band frequency equipment being tested turned off (ambient) equipment being tested turned on (operating conditions)
5. "Equipment Components" of sound (noise) levels with applicable calculations per "Sound Test Procedures"
6. Graph showing relationship between pressure levels specified and recorded readings

B. Retest: Subsequent to any correctional construction work, such as acoustic corrections, measurement shall be made to verify that associated air and water quantities, as previously measured, have not been disrupted.
1. Certified report shall record all sound data, and their locations, after final adjustments of air and water systems involves.

3.10FINAL COMMISSIONING TESTS, INSPECTIONS AND ACCEPTANCE

A. Scope: Test shall be made to demonstrate that capacities and performance of air and water systems comply with contract requirements.
1. At the time of final inspection, the Design Builder shall recheck, random selection of data (water and air quantities, air motion, and sound levels) recorded in the certified report.
2. Points and areas for recheck shall be selected by the commissioning team.
3. Measurement and test procedures shall be the same as approved for work forming basis of certified report.
4. Selections for recheck (specific plus random), in general, will not exceed 25 percent of the total number tabulated in the report, except that special air systems may require a complete recheck for safety reasons.

B. Retests: If random tests elicit a measured flow deviation of 10 percent or more from, or a sound level of 2 db or more greater than, that recorded in the certified report listings, as 10 percent or more of the rechecked selections, the report shall be automatically rejected. In the event the report is rejected, all systems shall be readjusted and tested, new data recorded, new certified reports submitted, and new inspection tests made, all at no additional cost. Retainage time shall be based on the date of the final acceptance of the certified report.

C. Marking of Settings: Following final acceptance of certified reports, the settings of all valves, splitters, dampers, and other adjustment devices shall be permanently marked by the Design Builder so that adjustment can be restored if disturbed at any time. Devices shall not be marked until after final acceptance.

END OF SECTION 15990

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this and the other sections of Division 16.

1.2 SUMMARY

A. This Section includes general administrative, procedural, and other requirements for electrical installations. The following requirements are included in this Section to expand the requirements specified in Divisions 1 through 16:
   1. Submittals.
   2. Quality control.
   3. Definitions and abbreviations.
   4. Scheduling.
   5. Coordination drawings.
   6. Record documents.
   7. Maintenance manuals.
   8. Delivery, storage, and handling.
   9. Products.
   10. Rough-ins.
   11. Electrical installations.
   12. Permits and instructions.
   13. Field quality control.
   14. Protection.
   15. Additional work.
   16. Electrical schedules.
   17. Cutting and patching.

1.3 SUBMITTALS

A. General: Follow the procedures specified in Division 1.

B. Increase, by the quantity listed below, the number of electrical related shop drawings, product data, and samples submitted, to allow for required distribution plus two copies of each submittal required, which will be retained by the Electrical Consulting Engineer.
   1. Shop Drawings - Initial Submittal: 1 additional blue- or black-line prints.
   2. Shop Drawings - Final Submittal: 1 additional blue- or black-line prints.
   3. Product Data: 1 additional copy of each item.
   4. Samples: 1 addition as set.

C. Additional copies may be required by individual sections of these Specifications.

1.4 QUALITY CONTROL

A. Functional and Operational Test Procedure:
   1. Test procedure to completely test all systems as to their functional and sequential operation.
   2. Submit two (2) draft copies for review before conducting test.
   3. Certify that the test procedure was used and testing completed, and that all systems are operational and functioning properly.
   4. Submit certified Test Procedure for review prior to the date of final inspection.
   5. Systems to be covered by test procedure:
      a. Power Distirbution
      b. Equipment shut-down requirements

B. Other Tests and Certifications for:
   1. Grounding System: As specified under Section 16452.

1.5 DEFINITIONS AND ABBREVIATIONS

A. Electrical Definitions: As defined by NEC, Article 100.

B. The term "indicated" shall mean "as shown on contract documents (specifications, drawings, and related attachments)".

C. The term "provide" shall mean "to furnish, install and connect completely".

D. The term "size" shall mean one or more of the following: "length, current and voltage rating, number of poles, NEMA size, and other similar electrical characteristics".

E. The term "space" on panelboard and switchboard schedules shall mean "provide space to install the number of poles and size of the protective device indicated with all the necessary buss and fittings to install the device at some future date".

1.6 SCHEDULING

A. Coordinate electrical work with other divisions of this project.

B. Coordinate electrical work with Owner.

C. Written requests for approval for planned shutdowns or interruption of Owner's operation or equipment shall be made 72 hours prior to the start of the requested periods.

D. Written notification for on site training of Owner's personnel shall be made 1 week prior to the start of the requested training period.

1.7 COORDINATION DRAWINGS

A. Prepare coordination drawings in accordance with Division 1 to a scale of 1/4"=1'-0" or larger; detailing major elements, components, and systems of electrical equipment and materials in relationship with other systems, installations, and building components. Indicate locations where space is limited for installation and access and where sequencing and coordination of installations are of importance to the efficient flow of the Work, including (but not necessarily limited to) the following:

1. Indicate the proposed locations of major raceway systems, equipment, and materials. Include the following:
   a. Clearances for servicing equipment, including space for equipment disassembly required for periodic maintenance.
   b. Fire-rated wall and floor penetrations.
   c. Equipment connections and support details.

2. Indicate scheduling, sequencing, movement, and positioning of large equipment into the building during construction.
3. Prepare floor plans, elevations, and details to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installations.
4. Prepare reflected ceiling plans to coordinate and integrate installations, air outlets and inlets, light fixtures, raceway systems components, Exhaust/Kitchen hoods, and other ceiling-mounted devices.

1.8 RECORD DOCUMENTS

A. Prepare record documents in accordance with the requirements in Division 1. In addition to the requirements specified in Division 1, indicate installed conditions for:

1. Major raceway systems, size and location, for both exterior and interior; locations of control devices; distribution and branch electrical circuitry; and fuse and circuit breaker size and arrangements.
2. Equipment locations (exposed and concealed), dimensioned from prominent building lines.
3. Approved substitutions, Contract Modifications, and actual equipment and materials installed.

1.9 MAINTENANCE MANUALS

A. Prepare maintenance manuals in accordance with Division 1. In addition to the requirements specified in Division 1, include the following information for equipment items:

1. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.
2. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.

3. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
4. Servicing instructions and lubrication charts and schedules.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for identification.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. As specified under other RELATED SECTIONS. Manufacturers include the following:
1. Eaton Corp.
2. General Electric
3. Siemens
4. Schneider Electric, Square D

B. As specified on Drawings.

2.2 MATERIAL

A. General:
1. Unless otherwise indicated, all raceways for service, feeders, branch and control wiring are RSC or IMC. See Section 16110.
2. Unless otherwise indicated, wiring to equipment and motors shall be installed in liquid tight flexible conduit, or in dry interior locations in flexible metal conduit, with a maximum length of six (6) feet.
3. Unless otherwise indicated, all conductors to be copper THHN/THWN-2.
4. Unless otherwise indicated, all outlet and switch boxes to be cast iron with threaded hubs.
5. In interior protected locations, where recessed in ceiling and walls, outlet and switch boxes may be stamped steel.
6. Unless otherwise indicated, provide white, heavy duty grade, 20 ampere, receptacles and switches. Plates shall be 302 stainless steel, satin finish. Plates for surface mounted interior boxes may be stamped steel. Plates exposed to weather or water to be metal, weatherproof type.

B. As specified under RELATED SECTIONS.

C. As specified on Drawings.

2.3 EQUIPMENT

A. General:

1. Unless otherwise indicated, externally operated safety switches are unfused, solid neutral, heavy duty, and selected to meet the load requirements.

B. As specified under RELATED SECTIONS.

C. As specified on Drawings.

2.4 FABRICATION

A. General:

1. Unless otherwise indicated, all enclosures are NEMA Type 1. NEMA Type 3R shall be used for all exterior locations as well as all interior wet/damp locations.

B. As specified under RELATED SECTIONS.

C. As specified on Drawings.

PART 3 EXECUTION

3.1 ROUGH-IN

A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.

B. Refer to equipment specifications in Divisions 2 through 16 for rough-in requirements.

C. Contractor is to provide connections, both power and control as noted within the Contract Documents. Division 16 shall coordinate the respective installations with the respective sub-contractor, supplier and agency as required.

3.2 ELECTRICAL INSTALLATIONS

A. General: Sequence, coordinate, and integrate the various elements of electrical systems, materials, and equipment. Comply with the following requirements:

1. Coordinate electrical systems, equipment, and materials installation with other building components. Electrical plans and details do not show all interferences and conditions, visible and/or hidden, that may exist. Before selecting material and equipment, and proceeding with work, inspect areas where material and equipment are to be installed to insure suitability, and check needed space for placements, clearances and interconnections. Before cutting or drilling into building elements inspect and layout work to avoid damaging structural elements or building utilities.

2. Electrical plans, details, and diagrams show the general location and arrangement of electrical systems. They are diagrammatic and do not show all conduit bodies, connectors, bends, fittings, hangers, and additional pull and junction boxes which the Contractor must provide to complete the electrical system.
3. Verify all dimensions by field measurements.
4. Arrange for chases, slots, and openings in other building components during progress of construction, to allow for electrical installations.
5. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components, as they are constructed.
6. Sequence, coordinate, and integrate installations of electrical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building. Verify dimensional constraints of building door openings and passageways, and the maximum floor loadings, for the movement of selected material and equipment. Order equipment and material, broken down as may be required, to meet these constraints.
7. Measurement from above finished floor (AFF) shall be taken from the finished floor surface to the top of wall receptacles and switch boxes, to the centerline of wall lighting outlet boxes, to the top of wall mounted equipment enclosures, to the centerline of top most switch handle, or to the lowest surface of ceiling lighting fixtures and other ceiling mounted equipment.
   a. Unless otherwise indicated, wall switch boxes shall be 46 inches AFF.
   b. Unless otherwise indicated, receptacle boxes shall be 18 inches AFF. Receptacle mounted above counter and at furniture locations shall be coordinated with architectural elements. Coordinate with Architect.
   c. Verify connection mounting heights with kitchen equipment.
   d. Surface raceway heights shall be coordinated with Architectural requirements.

8. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum headroom possible. Switch and receptacle heights shall meet handicap accessible code requirements.
9. Coordinate connection of electrical systems with incoming utilities and services. Comply with requirements of governing regulations, power, telephone, and data service companies, and controlling agencies. Provide required connection for each service. Provide power connection to equipment. Coordinate with other Divisions.
10. Install systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination

requirements conflict with individual system requirements, refer conflict to the Engineer.

11. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished spaces.
12. Conduit Sizing:
    a. Unless otherwise indicated, conduit size for indicated conductor shall be based on Chapter 9 of NEC.
    b. Conduit: 3/4 inch minimum size.

13. Install electrical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations. Measure and locate placement of equipment and materials in relation to building structure and surfaces, and between equipment to be installed and wired. Maintain required minimum access spacing for equipment and enclosures.
14. Install access panel or doors where units are concealed behind finished surfaces. Access panels and doors are specified elsewhere.
15. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.
16. Unless otherwise noted, individual raceway runs are required for each kitchen equipment component. Connection shall be routed down existing walls exposed, concealed in new walls, and/or under slab to the respective area as noted.

3.3 PERMITS AND INSPECTIONS

A. Obtain and pay for all required permits and arrange for all required inspections in accordance with state and local governing authorities.

B. Final Electrical Inspection Certificate from inspection agency or governing authority.

3.4 FIELD QUALITY CONTROL

A. Perform field tests as specified under other electrical sections.

B. Arrange for local Inspection Authorities to inspect work performed prior to burial, closing-in behind wall and above ceiling, or encased in concrete. Also arrange for final inspection of work and obtain Final Inspection Certificate before final inspection of work by Owner or his representative.

3.5 PROTECTION

A. Protect personnel from coming in contact with live parts.

B. During remodeling or alteration work, maintain fire ratings of walls, floors and ceilings when work is left unattended.

C. Protect from damage and theft equipment and materials provided or supplied by others in accordance with manufacturer's recommendation and warranties, and with electrical standards and practices.

3.6 ADDITIONAL WORK

A. Provide connections for power and controls to all mechanical equipment being supplied under other divisions.

B. Provide power to control systems.

C. Provide temporary power and lighting.

3.7 ELECTRICAL SCHEDULES

A. As specified in related sections or shown on drawings.

3.8 CUTTING AND PATCHING

A. General: Perform cutting and patching in accordance with Division 1. In addition to the requirements specified in Division 1, the following requirements apply:
   1. Perform cutting, fitting, and patching of electrical equipment and materials required to:
      a. Uncover Work to provide for installation of ill-timed Work.
      b. Remove and replace defective Work.
      c. Remove and replace Work not conforming to requirements of the Contract Documents.
      d. Remove samples of installed Work as specified for testing.
      e. Install equipment and materials in existing structures.
      f. Upon written instructions from the Engineer, uncover and restore Work to provide for Engineer observation of concealed Work.

   2. Cut, remove, and legally dispose of selected electrical equipment, components, and materials as indicated, including but not limited to removal of electrical items indicated to be removed and items made obsolete by the new Work.
   3. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.
   4. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.
   5. Protection of Installed Work: During cutting and patching operations, protect adjacent installations.

6. Patch existing finished surfaces and building components using new materials matching existing materials and experienced Installers. Installers' qualifications refer to the materials and methods required for the surface and building components being patched.
7. Patch finished surfaces and building components using new materials specified for the original installation and experienced Installers. Installers' qualifications refer to the materials and methods required for the surface and building components being patched.

END OF SECTION 16010

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

B. Requirements specified in other Division 16 Sections apply to this section.

1.2 SUMMARY

A. This Section includes limited scope general construction materials and methods for application with electrical installations as follows:
   1. Selective demolition including:
      a. Nondestructive removal of materials and equipment for reuse or salvage as indicated.
      b. Dismantling electrical materials and equipment made obsolete by these installations.
   2. Miscellaneous metals for support of electrical materials and equipment.
   3. Fire rated wood grounds, nailers, blocking, fasteners, and anchorage for support of electrical materials and equipment.
   4. Joint sealers for sealing around electrical materials and equipment; and for sealing penetrations in fire and smoke barriers, floors, and foundation walls.
   5. Access panels and doors in walls, ceilings, and floors for access to electrical materials and equipment.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

B. Product data for the following products:
   1. Access panels and doors.
   2. Joint sealers.

C. Shop drawings detailing fabrication and installation for metal fabrications, and wood supports and anchorage for electrical materials and equipment.

D. Coordination drawings for access panel and door locations in accordance with Division 16 Section "Basic Electrical Requirements."

E. Samples of joint sealer, consisting of strips of actual products showing full range of colors available for each product.

F. Welder certificates, signed by Contractor, certifying that welders comply with requirements specified under "Quality Assurance" article of this Section.

G. Schedules indicating proposed methods and sequence of operations for selective demolition prior to commencement of Work. Include coordination for shut-off of electrical service, and details for dust and noise control.
   1. Coordinate sequencing with construction phasing and Owner occupancy specified in Division 1.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Engage an experienced Installer for the installation and application of joint sealers, access panels, and doors.

B. Qualify welding processes and welding operators in accordance with AWS D1.1 "Structural Welding Code - Steel."
   1. Certify that each welder has satisfactorily passed AWS qualification tests for welding processes involved and, if pertinent, has undergone recertification.

C. Fire-Resistance Ratings: Where a fire-resistance classification is indicated, provide access door assembly with panel door, frame, hinge, and latch from manufacturer listed in the UL "Building Materials Directory" for rating shown.
   1. Provide UL Label on each fire-rated access door.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver joint sealer materials in original unopened containers or bundles with labels informing about 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 joint sealer materials in compliance with the manufacturers' recommendations to prevent their deterioration and damage.

1.6 PROJECT CONDITIONS

A. Conditions Affecting Selective Demolition: The following project conditions apply:
   1. Protect adjacent materials indicated to remain or in the other phases of the proposed construction. 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 electrical 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, install temporary services for affected areas.
   3. Arrange for electric service change-overs during periods when the building is not occupied. This may include week-ends and evening hours. Coordinate with Owner's representatives.

B. Environmental Conditions: Apply joint sealers under temperature and humidity conditions within the limits permitted by the joint sealer manufacturer. Do no apply joint sealers to wet substrates.

1.7 SEQUENCE AND SCHEDULING

A. Coordinate the shut-off and disconnection of electrical power with the Owner.

B. Notify the Engineer at least 5 days prior to commencing demolition operations.

C. Perform demolition in sequencing/phases as noted and as required.

PART 2 PRODUCTS

2.1 MISCELLANEOUS METALS

A. Steel plates, shapes, bars, and bar grating: ASTM A 36.

B. Cold-Formed Steel Tubing: ASTM A 500.

C. Hot-Rolled Steel Tubing: ASTM A 501.

D. Steel Pipe: ASTM A 53, Schedule 40, welded.

E. Nonshrink, Nonmetallic Grout: Premixed, factory-packaged, nonstaining, noncorrosive, nongaseous grout, recommended for interior and exterior applications.

F. Fasteners: Zinc-coated, type, grade, and class as required.

2.2 MISCELLANEOUS LUMBER

A. Framing Materials: Standard Grade, light-framing-size lumber of any species. Number 3 Common or Standard Grade boards complying with WCLIB or AWPA rules, or Number 3 boards complying with SPIB rules. Lumber shall be preservative treated in accordance with AWPB LP-2, and kiln dried to a moisture content of not more than 19 percent.

B. Construction Panels: Plywood panels; APA C-D PLUGGED INT, with exterior glue; thickness as indicated, or if not indicated, not less that 3/4 inches.

2.3 JOINT SEALER

A. General: Joint sealers, joint fillers, and other related materials compatible with each other and with joint substrates under conditions of service and application.

B. Colors: As selected by the Architect from manufacturer's standard colors.

C. Elastomeric Joint Sealers: Provide the following types:
   1. One-part, nonacid-curing, silicone sealant complying with ASTM C 920, Type S, Grade NS, Class 25, for uses in non-traffic areas for masonry, glass, aluminum, and other substrates recommended by the sealant manufacturer.
   2. One-part, mildew-resistant, silicone sealant complying with ASTM C 920, Type S, Grade NS, Class 25, for uses in non-traffic areas for glass, aluminum, and nonporous joint substrates; formulated with fungicide; intended for sealing interior joints with nonporous substrates; and subject to in-service exposure to conditions of high humidity and temperature extremes.
   3. Available Products: Subject to compliance with requirements, products which may be incorporated in the Work include, but are not limited to, the following:
      a. One-Part, Nonacid-Curing, Silicone Sealant:
         1) Bostik - "Chem-Caulk 2000"
         2) Dow Corning - "Dow Corning 790"
         3) Pecora Corp – “864NST”

      b. One-Part, Mildew-Resistant, Silicone Sealant:
         1) Dow Corning - "Dow Corning 786"
         2) GE - "SCS 1702”
         3) Pecora Corp. - "898”

D. Acrylic-Emulsion Sealants: One-part, nonsag, mildew-resistant, paintable complying with ASTM C 834 recommended for exposed applications on interior and protected exterior locations involving joint movement of not more than plus or minus 5 percent.
   1. Available Products: Subject to compliance with requirements, products which may be incorporated in the Work include, but are not limited to, the following:
      a. Bostik - "Chem-Caulk 600"
      b. Pecora Corp. - "AC-20"
      c. Tremco – “Tremflex 834”

E. Fire-Resistant Joint Sealers: Two-part, foamed-in-place, silicone sealant formulated for use in through-penetration fire-stopping around cables, conduit, pipes, and duct penetrations through fire- rated walls and floors. Sealants and accessories shall have fire- resistance ratings indicated, as established by testing identical assemblies in accordance with ASTM E 814, by Underwriters' Laboratories, Inc., or other testing and inspection agency acceptable to authorities having jurisdiction.
   1. Available Products: Subject to compliance with requirements, products which may be incorporated in the Work include, but are not limited to, the following:
      a. Dow Corning - "Dow Corning Fire Stop Foam"
      b. GE - "Pensil 851"
      c. Hilti – “CP-620 Fire Stop Foam”

2.4 ACCESS DOORS

A. Steel Access Doors and Frames: Factory-fabricated and assembled units, complete with attachment devices and fasteners ready for installation. Joints and seams shall be continuously welded steel, with welds ground smooth and flush with adjacent surfaces.

B. Frames: 16-gage steel, with a 1-inch-wide exposed perimeter flange for units installed in unit masonry, pre-cast, or cast-in-place concrete, ceramic tile, or wood paneling.
   1. For installation in masonry, concrete, ceramic tile, or wood paneling: 1 inch-wide-exposed perimeter flange and adjustable metal masonry anchors.
   2. For gypsum wallboard or plaster: perforated flanges with wallboard bead.
   3. For full-bed plaster applications: galvanized expanded metal lath and exposed casing bead, welded to perimeter of frame.

C. Flush Panel Doors: 14-gage sheet steel, with concealed spring hinges or concealed continuous piano hinge set to open 175 degrees; factory-applied prime paint.
   1. Fire-Rated Units: Insulated flush panel doors, with continuous piano hinge and self-closing mechanism.

D. Locking Devices: Flush, screwdriver-operated cam locks.

E. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products which may be incorporated in the Work include, but are not limited to, the following:
   1. Bar-Co., Inc.
   2. J.L. Industries.
   3. Karp Associates, Inc.
   4. Milcor Div. Inryco, Inc.
   5. Nystrom, Inc.

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.

3.2 PREPARATION FOR JOINT SEALER

A. Surface Cleaning for Joint Sealers: Clean surfaces of joints immediately before applying joint sealers to comply with recommendations of joint sealer manufacturer.

B. Apply joint sealer primer to substrates as recommended by joint sealer manufacturer. Protect adjacent areas from spillage and migration of primers, using masking tape. Remove tape immediately after tooling without disturbing joint seal.

3.3 ERECTION OF METAL SUPPORTS AND ANCHORAGE

A. Cut, fit, and place miscellaneous metal fabrications accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

B. Field Welding: Comply with AWS "Structural Welding Code."

3.4 ERECTION OF WOOD SUPPORTS AND ANCHORAGE

A. Cut, fit, and place wood grounds, nailers, blocking, and anchorage accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

B. Select fastener sizes that will not penetrate members where opposite side will be exposed to view or will receive finish materials. Make tight connections between members. Install fasteners without splitting wood members.

C. Attach to substrates as required to support applied loads.

D. Do not install wood materials in areas being utilized as air plenum or other spaces where a potential combustible hazard exists.

3.5 APPLICATION OF JOINT SEALERS

A. General: Comply with joint sealer manufacturers' printed application instructions applicable to products and applications indicated, except where more stringent requirements apply.
   1. Comply with recommendations of ASTM C 962 for use of elastomeric joint sealants.
   2. Comply with recommendations of ASTM C 790 for use of acrylic- emulsion joint sealants.

B. Tooling: Immediately after sealant application and prior to time shinning or curing begins, tool sealants to form smooth, uniform beads; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint. Remove excess sealants from surfaces adjacent to joint. Do not use tooling agents that discolor sealants or adjacent surfaces or are not approved by sealant manufacturer.

C. Installation of Fire-Stopping Sealant: Install sealant, including forming, packing, and other accessory materials, to fill openings around electrical services penetrating floors and walls, to provide fire-stops with fire-resistance ratings indicated for floor or wall assembly in which penetration occurs. Comply with installation requirements established by testing and inspecting agency.

3.6 INSTALLATION OF ACCESS DOORS

A. Set frames accurately in position and securely attached to supports, with face panels plumb and level in relation to adjacent finish surfaces.

B. Adjust hardware and panels after installation for proper operation.

END OF SECTION 16050

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

B. Requirements specified in other Division 16 Sections apply to this Section.

1.2 SUMMARY

A. This Section includes raceways for electrical wiring. Types of raceways in this section include the following:
   1. Rigid metal conduit.
   2. Intermediate metal conduit.
   3. Liquidtight flexible conduit.
   4. Flexible metal conduit.
   5. Electrical Metallic Tubing (EMT).
   6. Rigid nonmetallic conduit.
   7. Wireways.

B. Related Sections: The following Division 16 Sections contain requirements that relate to this Section:
   1. "Wires and Cables" for other wiring methods.
   2. "Supporting Devices" for raceway supports.
   3. "Cabinets, Boxes, and Fittings" for boxes used with conduit and tubing systems.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

B. Product Data for the following products:
   1. Raceway system.

C. Installation Instructions: Manufacturer's written installation instructions for wireway, and raceway products.

1.4 QUALITY ASSURANCE

A. Electrical Component Standard: Components and installation shall comply with NFPA 70 "National Electrical Code."

B. NEMA Compliance: Comply with applicable requirements of NEMA standards pertaining to raceways.

C. UL Compliance and Labeling: Comply with applicable requirements of UL standards pertaining to electrical raceway systems. Provide raceway products and components listed and labeled by UL, ETL, or CSA.

1.5 SEQUENCING AND SCHEDULING

A. Coordinate with other Work, including metal and concrete deck installation, as necessary to interface installation of electrical raceways and components with other Work.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:

B. Conduit Bodies:
1. Appleton Electric Co.
2. Killark Electric Mfg. Co.
3. O-Z/Gedney
4. Spring City Electrical Mfg. Co.

C. Wireways:
1. Erickson Electric Equipment Co.
2. GS Metals Corp.
3. Hoffman Engineering Co.

2.2 METAL CONDUIT AND TUBING

A. Rigid Steel Conduit: ANSI C80.1.

B. Intermediate Steel Conduit: UL 1242.

C. Electrical Metallic Tubing and Fittings: ANSI C80.3

D. Flexible Metal Conduit: UL 1, zinc-coated steel.

E. Liquid-tight Flexible Metal Conduit and Fittings: UL 360. Fittings shall be specifically approved for use with this raceway.

2.3 NONMETALLIC CONDUIT AND DUCTS

A. Rigid Nonmetallic Conduit: NEMA TC 2 and UL 651, Schedule 80 PVC.

B. PVC Conduit and Tube Fittings: TC 3; match to conduit or conduit/tube type and material.

C. Conduit, Tubing and Duct Accessories: Types, sizes and materials complying with manufacturer's published product information. Mate and ,atch to raceway.

2.4 CONDUIT BODIES

A. General: Types, shapes, and sizes as required to suit individual applications and NEC requirements. Provide matching gasketed covers secured with corrosion-resistant screws.

B. Metallic Conduit and Tubing: Use metallic conduit bodies. Use bodies with threaded hubs for threaded raceways.

C. Conduit Bodies 1 Inch and Smaller: Use bodies with compression- type threaded connectors.

2.5 WIREWAYS

A. General: Electrical wireways shall be of types, sizes, and number of channels indicated. Fittings and accessories including but not limited to couplings, offsets, elbows, expansion joints, adapeters, hold-down straps, and end caps shall match and mate with wireway as required for completed system. Where features are not indicated, select to fulfill wiring requirements and comply with applicable provisions of NEC.

B. Wireway covers to be hinged type.

PART 3 EXECUTION

3.1 WIRING METHOD

A. Outdoors: Use the following wiring methods:
   1. Exposed / Concealed: Rigid metal conduit, Intermediate metal conduit.
   2. Underground: Rigid metal conduit, Rigid nonmetallic conduit.
   3. Connection to Vibrating Equipment: Including transformers and hydraulic, pneumatic, or electric solenoid or motor-driven equipment: liquidtight flexible metal conduit. Maximum length six (6) feet.

B. Indoors: Use the following wiring methods:
   1. Connection to Vibrating Equipment: Including transformers and hydraulic, pneumatic or electric solenoid or motor-operated equipment: Flexible metal conduit. Maximum length six (6) feet.
   2. Exposed/Concealed in unfinished areas: branch circuits: EMT, unless otherwise noted.

3. Exposed/Concealed Panelboard feeders: Intermediate metal conduit, Rigid metal conduit.
4. Connection to vibrating equipment and hydraulic, pneumatic, or electric solenoid or motor-driven equipment in moist or humid location or corrosive atmosphere, or where subject to water spray or dripping oil, grease, or water: Liquidtight flexible metal conduit. Maximun length six (6) feet.
5. In finished areas where conduit cannot be concealed: Wiremold surface raceway.

3.2 INSTALLATION

A. General: Install electrical raceways in accordance with manufacturer's written installation instructions, applicable requirements of NEC, and as follows:

B. Conceal Conduit, unless indicated otherwise, within finished walls, ceilings, and floors. Keep raceways at least 6 inches away from parallel runs of flues and hot water pipes. Install raceways level and square and at proper elevations.

C. Elevation of Raceway: Where possible, install horizontal raceway runs above water and sanitary piping.

D. Complete installation of electrical raceways before starting installation of conductors within raceways.

E. Provide supports for raceways as specified elsewhere in Division 16.

F. Prevent foreign matter from entering raceways by using temporary closure protection.

G. Protect stub-ups from damage where conduits rise from floor slabs. Arrange so curved portion of bends is not visible above the finished slab.

H. Make bends and offsets so the inside diameter is not effectively reduced. Unless otherwise indicated, keep the legs of a bend in the same plane and the straight legs of offsets parallel.

I. Use raceway fittings that are of types compatible with the associated raceway and suitable for the use and location. For intermediate steel conduit, use threaded rigid steel conduit fittings except as otherwise indicated.

J. Run concealed raceways with a minimum of bends in the shortest practical distance considering the type of building construction and obstructions except as otherwise indicated.

K. Install exposed raceways parallel and perpendicular to nearby surfaces or structural members and follow the surface contours as much as practical.

L. Run exposed, parallel, or banked raceways together. Make bends in parallel or banked runs from the same center line so that the bends are parallel. Factory elbows may be used in banked runs only where they can be installed parallel. This requires that there be a change in the plane of the run such as from wall to ceiling and that the raceways be of the same size. In other cases provide field bends for parallel raceways.

M. Join raceways with fittings designed and approved for the purpose and make joints tight. Where joints cannot be made tight, use bonding jumpers to provide electrical continuity of the raceway system. Make raceway terminations tight. Where terminations are subject to vibration, use bonding bushings or wedges to assure electrical continuity. Where subject to vibration or dampness, use insulating bushings to protect conductors.

N. Tighten set screws of threadless fittings with suitable tool.

O. Terminations: Where raceways are terminated with locknuts and bushings, align the raceway to enter squarely and install the locknuts with dished part against the box. Where terminations cannot be made secure with one locknut, use two locknuts, one inside and one outside the box.

P. Where terminating in threaded hubs, screw the raceway or fitting tight into the hub so the end bears against the wire protection shoulder. Where chase nipples are used, align the raceway so the coupling is square to the box, and tighten the chase nipple so no threads are exposed.

Q. Install pull wires in empty raceways. Use no. 14 AWG zinc-coated steel or monofilament plastic line having not less than 200-lb tensile strength. Leave not less than 12 inches of slack at each end of the pull wire.

R. Install raceway sealing fittings in accordance with the manufacturer's written instructions. Locate fittings at suitable, approved, accessible locations and fill them with UL- listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points and elsewhere as indicated:
   1. Where conduits pass from warm locations to cold locations, such as the boundaries of conditioned spaces and mechanical spaces.
   2. Where required by the NEC.

S. Stub-up Connections: Extend conduits through concrete floor for connection to freestanding equipment with an adjustable top or coupling threaded inside for plugs and set flush with the finished floor. Extend conductors to equipment with rigid steel conduit; flexible metal conduit may be used 6 inches above the floor.

T. Flexible Connections: Use short length (maximum of 6 ft.) of flexible conduit for recessed and semirecessed lighting fixtures, for equipment subject to vibration, noise transmission, or movement; and for all motors. Use liquidtight flexible conduit in wet locations. Install separate ground conductor across flexible connections. Light fixture flexible connections shall not exceed 15 ft.

3.3 ADJUSTING AND CLEANING

A. Upon completion of installation of raceways, inspect interiors of raceways; clear all blockages and remove burrs, dirt, and construction debris.

B. Paint Finish: Repair damage using surface raceway manufacturer's touch-up paint.

END OF SECTION 16110

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

B. Requirements of other specified Division 16 Sections apply to this section.

1.2 SUMMARY

A. This Section includes wires, cables, and connectors for power, lighting, signal, control and related systems rated 600 volts and less.

1.3 SUBMITTALS

A. Product Data for electrical wires, cables and connectors.

1.4 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with provisions of the following code:

B. NFPA 70 "National Electrical Code."
   1. Conform to applicable codes and regulations regarding toxicity of combustion products of insulating materials.

C. UL Compliance: Provide components which are listed and labeled by UL under the following standards.
   1. UL Std. 83 Thermoplastic-Insulated Wires and Cables.
   2. UL Std. 486A Wire Connectors and Soldering Lugs for Use with Copper Conductors.
   3. UL Std. 1569 Metal Clad Cable.

D. NEMA/ICEA Compliance: Provide components which comply with the following standards:
   1. WC-5 Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.

E. IEEE Compliance: Provide components which comply with the following standard.
   1. Std. 82 Test procedures for Impulse Voltage Tests on Insulated Conductors.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products which may be incorporated in the work include, but are not limited to, the following:
   1. Wire and Cable:
      a. AFC Cable Systems
      b. General Cable
      c. Southwire Company

   2. Connectors for Wires and Cable Conductors:
      a. AMP
      b. 3M Company
      c. O-Z/Gedney Co.
      d. Square D Company.

2.2 WIRES AND CABLES

A. General: Provide wire and cable suitable for the temperature, conditions and location where installed.

B. Conductors: Provide stranded conductors for power and lighting circuits no. 10 AWG and smaller. Provide stranded conductors for sizes no. 8 AWG and larger.

C. Conductor Material: copper for all wires and cables.

D. Conductor sizes indicated are based on copper.

E. Insulation: Provide THHN/THWN-2 insulation for all conductors size 500MCM and larger, and no. 8 AWG and smaller. For all other sizes provide, THHN/THWN-2 or XHHW insulation as appropriate for the locations where installed.

F. Color Coding for phase identification in accordance with Table 1 in Part 3 below.

G. Jackets: Factory-applied nylon or PVC external jacketed wires and cables for pulls in raceways over 100-feet in length, for pulls in raceways with more than three equivalent 90 deg. bends, for pulls in conduits underground or under slabs on grade, and where indicated.

H. Cables: Provide the following type(s) of cables in NEC approved locations and applications where indicated. Provide cable UL listed for particular application:
   1. Metal-Clad Cable: Type MC - limited to lighting fixtures and outlets concealed in gypsum wall partitions.
   2. Metal clad above ceilings to be limited to five (5) feet whips.

2.3 CONNECTORS FOR CONDUCTORS

A. Provide UL-listed factory-fabricated, solderless metal connectors of sizes, ampacity ratings, materials, types and classes for applications and for services indicated. Use connectors with temperature ratings equal to or greater than those of the wires upon which used.

PART 3 EXECUTION

3.1 WIRING METHOD

A. Use the following wiring methods as indicated:
   1. Wire: install all wire in raceway.
   2. Metal Clad Cable, Type MC: where wiring concealed in gypsum wall partitions, ceilings, for connections from raceway outlet boxes to lighting fixtures, unless otherwise noted.

3.2 INSTALLATION OF WIRES AND CABLES

A. General: Install electrical cables, wires, and connectors in compliance with NEC.

B. Coordinate cable installation with other Work.

C. Pull conductors simultaneously where more than one is being installed in same raceway. Use UL listed pulling compound or lubricant, where necessary.

D. Use pulling means including, fish tape, cable, rope, and basket weave wire/cable grips which will not damage cables or raceways. Do not use rope hitches for pulling attachment to wire or cable.

E. Conceal all cable in finished spaces.

F. Keep conductor splices to minimum.

G. Install splice and tap connectors which possess equivalent or better mechanical strength and insulation rating than conductors being spliced.

H. Use splice and tap connectors which are compatible with conductor material.

I. Provide adequate length of conductors within electrical enclosures and train the conductors to terminal points with no excess. Bundle multiple conductors, with conductors larger than no 10 AWG cabled in individual circuits. Make terminations so there is no bare conductor at the terminal.

J. Tighten electrical connectors and terminals, including screws and bolts, in accordance with manufacturer's published torque tightening values. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL 486A and UL 486B.

3.3 FIELD QUALITY CONTROL

A. Prior to energizing, check installed wires and cables with megohm meter to determine insulation resistance levels to assure requirements are fulfilled.

B. Prior to energizing, test wires and cables for electrical continuity and for short-circuits.

C. Subsequent to wire and cable hook-ups, energize circuits and demonstrate proper functioning. Correct malfunctioning units, and retest to demonstrate compliance.

D. TABLE 1: Color Coding for Phase Identification:

1. Color code secondary service, feeder, and branch circuit conductors with factory applied color as follows:

208Y/120Volts	Phase
Black	A
Red	B
Blue	C
White	Neutral
Green	Ground

END OF SECTION 16120

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

B. Requirements specified in other Division 16 Sections apply to this section.

1.2 SUMMARY

A. This section includes cabinets, boxes, and fittings for electrical installations and certain types of electrical fittings not covered in other sections. Types of products specified in this Section include:
   1. Outlet and device boxes.
   2. Pull and junction boxes.
   3. Cabinets.
   4. Hinged door enclosures.

B. Conduit-body-type electrical enclosures and wiring fittings are specified in Division 16 Section "Raceways."

1.3 DEFINITIONS

A. Cabinets: An enclosure designed either for surface or for flush mounting and having a frame, or trim in which a door or doors may be mounted.

B. Device Box: An outlet box designed to house a receptacle device or a wiring box designed to house a switch.

C. Enclosure: A box, case, cabinet, or housing for electrical wiring or components.

D. Outlet Box: A wiring enclosure where current is taken from a wiring system to supply utilization equipment.

E. Wiring Box: An enclosure designed to provide access to wiring systems or for the mounting of indicating devices or of switches for controlling electrical circuits.

1.4 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections:
   1. Product data for cabinets and enclosures with classification higher than NEMA 1.
   2. Shop drawings for boxes, enclosures and cabinets that are to be shop fabricated, (nonstock items). For shop fabricated junction and pull boxes, show accurately scaled views and spatial relationships to adjacent equipment. Show box types, dimensions, and finishes.

1.5 QUALITY ASSURANCE

A. UL Listing and Labeling: Items provided under this section shall be listed and labeled by UL.

B. Nationally Recognized Testing Laboratory Listing and Labeling (NRTL): Items provided under this section shall be listed and labeled by a NRTL. The term "NRTL" shall be as defined in OSHA Regulation 1910.7.

C. National Electrical Code Compliance: Components and installation shall comply with NFPA 70 "National Electrical Code."

D. NEMA Compliance: Comply with NEMA Standard 250, "Enclosures for Electrical Equipment (1000 Volts Maximum)."

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:

1. Cabinets:
   a. Electric Panelboard, Inc.
   b. Erickson Electrical Equipment Co.
   c. Hoffman Engineering Co.
   d. Parker Electrical Mfg. Co.
   e. Spring City Electrical Mfg. Co.
   f. Square D Co.

2.2 CABINETS, BOXES, AND FITTINGS, GENERAL

A. Electrical Cabinets, Boxes, and Fittings: Of indicated types, sizes, and NEMA enclosure classes. Where not indicated, provide units of types, sizes, and classes appropriate for the use and location. Provide all items complete with covers and accessories required for the intended use. Provide gaskets for units in damp or wet locations. This applies to kitchen areas.

2.3 MATERIALS AND FINISHES

A. Sheet Steel: Flat-rolled, code-gage, galvanized steel.

B. Fasteners for General Use: Corrosion resistant screws and hardware including cadmium and zinc plated items.

C. Fasteners for Damp or Wet Locations: Stainless steel screws and hardware.

D. Cast Metal for Boxes, Enclosures, and Covers; Copper-free aluminum except as otherwise specified.

E. Exterior Finish: Gray baked enamel for items exposed in finished locations except as otherwise indicated.

F. Painted Interior Finish: Where indicated, white baked enamel.

G. Fittings for Boxes, Cabinets, and Enclosures: Conform to UL 514B. Malleable iron or zinc plated steel for conduit hubs, bushings and box connecters.

2.4 METAL OUTLET, DEVICE, AND SMALL WIRING BOXES

A. General: Conform to UL 514A, "Metallic Outlet Boxes, Electrical," and UL 514B, "Fittings for Conduit and Outlet Boxes." Boxes shall be of type, shape, size, and depth to suit each location and application.

B. Steel Boxes: Conform to NEMA OS 1, "Sheet Steel Outlet Boxes, Device Boxes, Covers, and Box Supports." Boxes shall be sheet steel with stamped knockouts, threaded screw holes and accessories suitable for each location including mounting brackets and straps, cable clamps, exterior rings and fixture studs.

C. Cast-Iron Boxes: Iron alloy, waterproof, with threaded raceway entries and features and accessories suitable for each location, including mounting ears, threaded screw holes for devices and closure plugs.

2.5 PULL OR JUNCTION BOXES

A. General: Comply with UL 50, "Electrical Cabinets and Boxes", for boxes over 100 cubic inches volume. Boxes shall have screwed or bolted on covers of material same as box and shall be of size and shape to suit application.

B. Steel Boxes: Sheet steel with welded seams. Where necessary to provide a rigid assembly, construct with internal structural steel bracing.

C. Hot-Dipped Galvanized Steel Boxes: Sheet steel with welded seams. Where necessary to provide a rigid assembly, construct with internal structural steel bracing. Hot-dip galvanized after fabrication. Cover shall be gasketed.

D. Stainless-Steel Boxes: Fabricate of stainless steel conforming to Type 302 of ASTM A 167, "Specification for Stainless and Heat Resisting Chromium-Nickel Steel Plate, Sheet, and Strip." Where necessary to provide a rigid assembly, construct with internal structural stainless steel bracing. Cover shall be gasketed.

E. Cast-Iron Boxes: Molded of cast iron alloy with gasketed cover and integral threaded conduit entrances.

2.6 CABINETS

A. Comply with UL 50, "Electrical Cabinets and Boxes."

B. Construction: Sheet steel, NEMA 4 class except as otherwise indicated. Cabinet shall consist of a box and a front consisting of a one piece frame and a hinged door. Arrange door to close against a rabbet placed all around the inside edge of the frame, with a uniformly close fit between door and frame. Provide concealed fasteners, not over 24-inches apart, to hold fronts to cabinet boxes and provide for adjustment. Provide flush or concealed door hinges not over 24-inches apart and not over 6-inches from top and bottom of door. For flush cabinets, make the front approximately 3/4 inch larger than the box all around. For surface mounted cabinets make front same height and width as box.

C. Doors: Double doors for cabinets wider than 24-inches.

D. Locks: Combination spring catch and key lock, with all locks for cabinets of the same system keyed alike. Locks may be omitted on signal, power, and lighting cabinets located within wire closets and mechanical-electrical rooms. Locks shall be of a type to permit doors to latch closed without locking.

2.7 STEEL ENCLOSURES WITH HINGED DOORS

A. Comply with UL 50, "Cabinets and Enclosures" and NEMA ICS 6,

B. "Enclosures for Industrial Controls and Systems."

C. Construction: Sheet steel, 16 gage, minimum, with continuous welded seams. NEMA class as indicated; arranged for surface mounting.

D. Doors: Hinged directly to cabinet and removable, with approximately 3/4-inch flange around all edges, shaped to cover edge of box. Provide handle operated, key locking latch. Individual door width shall be no greater than 24-inches. Provide multiple doors where required.

E. Mounting Panel: Provide painted removable internal mounting panel for component installation.

F. Enclosure: NEMA 4 except as indicated. Where door gasketing is required, provide neoprene gasket attached with oil-resistant adhesive, and held in place with steel retaining strips. For all enclosures of class higher than NEMA 1, use hubbed raceway entrances.

PART 3 EXECUTION

3.1 INSTALLATION, GENERAL

A. Locations: Install items where indicated and where required to suit code requirements and installation conditions.

B. Cap unused knockout holes where blanks have been removed and plug unused conduit hubs.

C. Support and fasten items securely in accordance with Division 16 Section "Supporting Devices."

D. Sizes shall be adequate to meet NEC volume requirements, but in no case smaller than sizes indicated.

E. Remove sharp edges where they may come in contact with wiring or personnel.

3.2 APPLICATIONS

A. Cabinets: Flush mounted, NEMA enclosure Type 1 except as otherwise indicated.

B. Hinged Door Enclosures: NEMA Type 1 enclosure except as indicated.

C. Hinged Door Enclosures Outdoors: Install drip hood, factory tailored to individual units.

D. Outlet Boxes and Fittings: Install outlet and device boxes and associated covers and fittings of materials and NEMA types suitable for each location and in conformance with the following requirements:

1. Interior Dry Locations: NEMA Type 1, sheet steel or as permitted by local code.
2. Locations Exposed to Weather, Dampness, or Wet Locations: NEMA Type 3R enclosures.

E. Pull and Junction Boxes: Install pull and junction boxes of materials and NEMA types suitable for each location except as otherwise indicated.

3.3 INSTALLATION OF OUTLET BOXES

A. Outlets at Windows and Doors: Locate close to window trim.

B. Column and Pilaster Locations: Locate outlet boxes for switches and receptacles on columns or pilasters so the centers of the columns are clear for future installation of partitions.

C. Locations in Special Finish Materials: For outlet boxes for receptacles and switches mounted in desks or furniture cabinets or in glazed tile, concrete block, marble, brick, stone or wood walls, use rectangular shaped boxes with square corners and straight sides. Install such boxes without plaster rings. Saw cut all recesses for outlet boxes in exposed masonry walls.

D. Gasketed Boxes: At the following locations use cast metal, threaded hub type boxes with gasketed weatherproof covers:
1. Exterior locations.
2. Where surface mounted on unfinished walls, columns or pilasters. (Cover gaskets may be omitted in dry locations).
3. Where exposed to moisture laden atmosphere.
4. Where indicated.
5. Kitchen Area.

E. Cast-Iron Boxes: Iron alloy, waterproof, with threaded raceway entries and features and accessories suitable for each location, including mounting ears, threaded screw holes for devices and closure plugs.

F. Mounting: Mount outlet boxes for switches with the long axis vertical or as indicated. Mount boxes for receptacles either vertically or horizontally but consistently either way. Three or more gang boxes shall be mounted with the long axis horizontal. Locate box covers or device plates so they will not span different types of building finishes either vertically or horizontally. Locate boxes for switches near doors on the side opposite the hinges and close to door trim, even though electrical floor plans may show them on hinge side.

G. Ceiling Outlets: For fixtures, where wiring is concealed, use outlet boxes 4-inches square by 1-1/2-inches deep, minimum.

H. Cover Plates for Surface Boxes: Use plates sized to box front without overlap.

I. Protect outlet boxes to prevent entrance of plaster, and debris. Thoroughly clean foreign material from boxes before conductors are installed.

3.4 INSTALLATION OF PULL OR JUNCTION BOXES

A. Box Selection: For boxes in main feeder conduit runs, use sizes not smaller than 8-inches square by 4-inches deep. Do not exceed 6 entering and 6 leaving raceways in a single box. Quantities of conductors (including equipment grounding conductors) in pull or junction box shall not exceed the following:

Size of Largest Conductors in Box	Maximum no. of Conductors in Box
No. 4/0 AWG	30
250 MCM	20
500 MCM	15
Over 500 MCM	10

1. Cable Supports: Install clamps, grids, or devices to which cables may be secured. Arrange cables so they may be readily identified. Support cable at least every 30-inches inside boxes.
2. Mount pull boxes in inaccessible ceilings with the covers flush with the finished ceiling.
3. Size: Provide pull and junction boxes for telephone, signal, and other systems at least 50 percent larger than would be required by Article 370 of NEC, or as indicated. Locate boxes strategically and provide shapes to permit easy pulling of future wires or cables of types normal for such systems.

3.5 INSTALLATION OF CABINETS AND HINGED DOOR ENCLOSURES

A. Mount with fronts straight and plumb.

B. Install with tops 78-inches above floor.

C. Set cabinets in finished spaces flush with walls.

3.6 GROUNDING

A. Electrically ground metallic cabinets, boxes, and enclosures. Where wiring to item includes a grounding conductor, provide a grounding terminal in the interior of the cabinet, box or enclosure.

3.7 CLEANING AND FINISH REPAIR

A. Upon completion of installation, inspect components. Remove burrs, dirt, and construction debris and repair damaged finish including chips, scratches, abrasions and weld marks.

B. Galvanized Finish: Repair damage using a zinc-rich paint recommended by the tray manufacturer.

C. Painted Finish: Repair damage using matching corrosion inhibiting touch-up coating.

END OF SECTION 16135

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Requirements of the following Division 16 Sections apply to this section:
   1. Basic Electrical Requirements.

1.2 SUMMARY

A. This Section includes the following:
   1. Receptacles
   2. Ground Fault Circuit Interrupter Receptacles
   3. Snap Switches
   4. Wall Plates

B. Related Sections: The following sections contain requirements that relate to this section:
   1. Division 16 Section "Circuit and Motor Disconnects" for devices other than snap switches and plug/receptacle sets used as disconnects for motors.

1.3 SUBMITTALS

A. Product data for each type of product specified.

B. Samples of those products indicated for sample submission in Architect's comments on product data submittal. Include color and finish samples of device plates and other items per Architect's request.

1.4 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with provisions of the following codes.

B. NFPA 70 "National Electrical Code".
   1. UL and NEMA Compliance: Provide wiring devices which are listed and labeled by UL and comply with applicable UL and NEMA standards.

1.5 SEQUENCE AND SCHEDULING

A. Schedule installation of finish plates after the surface upon which they are installed has received final finish.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to specifications requirements, manufacturers offering products which may be incorporated in the work include, but are not limited to, the following:
   1. Cooper Wiring Devices
   2. Hubbell Inc.
   3. Leviton
   4. Pass and Seymour Inc.

2.2 WIRING DEVICES:

A. General: Provide wiring devices, in types, characteristics, grades, colors, and electrical ratings for applications indicated which are UL listed and which comply with NEMA WD 1 and other applicable UL and NEMA standards. Provide ivory color devices and wall plates except as otherwise indicated. Verify color selections with Architect.

B. Receptacles: As scheduled in Table 1 in Part 3 below. Comply with UL 498 and NEMA WD 1.

C. Ground-Fault Interrupter (GFI) Receptacles: as indicated in Table 1 in Part 3 below; provide "feed-thru" type ground-fault circuit interrupter, with integral heavy-duty NEMA 5-20R duplex receptacles arranged to protect connected downstream receptacles on same circuit. Provide unit designed for installation in a 2-3/4 inch deep outlet box without adapter, grounding type, Class A, Group 1, per UL Standard 94.3.

D. Snap Switches: quiet type AC switches as indicated in Table 2 in Part 3 below. Comply with UL 20 and NEMA WD1.

2.3 WIRING DEVICE ACCESSORIES

A. Wall plates: single and combination, of types, sizes, and with ganging and cutouts as indicated. Provide plates which mate and match with wiring devices to which attached. Provide metal screws for securing plates to devices with screw heads colored to match finish of plates. Provide wall plate color to match wiring devices except as otherwise indicated. Provide plates possessing the following additional construction features:
   1. Material and Finish: steel plate, galvanized, for building mechanical spaces.
   2. Material and Finish: plastic, smooth, for tenant spaces, and other finished areas.

PART 3 - EXECUTION

3.1 INSTALLATION OF WIRING DEVICES AND ACCESSORIES:

A. Install wiring devices and accessories as indicated, in accordance with manufacturer's written instructions, applicable requirements of NEC and in accordance with recognized industry practices to fulfill project requirements.

B. Coordinate with other Work, including painting, electrical boxes and wiring installations, as necessary to interface installation of wiring devices with other Work.

C. Install wiring devices only in electrical boxes which are clean; free from building materials, dirt, and debris.

D. Install galvanized steel wallplates in unfinished spaces.

E. Install wiring devices after wiring work is completed.

F. Install wall plates after painting work is completed.

G. Install telephone/cable tv and power service connections in accordance with final furnishings arrangement plan, plumb, true, and secure.

H. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for wiring devices. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Standard 486. Use properly scaled torque indicating hand tool.

3.2 PROTECTION

A. Protect installed components from damage. Replace damaged items prior to final acceptance.

3.3 FIELD QUALITY CONTROL

A. Testing: Prior to energizing circuits, test wiring for electrical continuity, and for short-circuits. Ensure proper polarity of connections is maintained. Subsequent to energizing, test wiring devices and demonstrate compliance with requirements, operating each operable device at least six times.

B. Test ground fault interruptor operation with both local and remote fault simulations in accordance with manufacturer recommendations.

C. TABLE 1

RECEPTACLES

DESIGNATION (1)	CURRENT RATING AMPS	VOLTAGE RATING	SINGLE/ DUPLEX	NEMA CONFIGURATION	UL GRADE	NOTES
-	20	125	DUPLEX	5-20R	SPECIFICATION GRADE	
WP	20	125	DUPLEX	5-20R	SPECIFICATION GRADE	WEATHER-PROOF
GFCI	20	125	DUPLEX	5-20R	SPECIFICATION GRADE	INTEGRAL GFCI

NOTES
(1) Letter designations are used where symbols alone do not clearly designate on plans locations where specific receptacle types are used.

D. TABLE 2

SNAP SWITCHES

DESIGNATION (1)	TYPICAL APPLICATION	VOLTAGE LOAD RATING	RATING (AC)	POLES	UL GRADE	NOTES
S	CONTROL LIGHTS	20A	120/277	1	HEAVY DUTY	-
S3	CONTROL - LIGHTS	20A	120/277	3-way	HEAVY DUTY	
S	DISCONN. MOTOR	1HP	120/277	1	HEAVY DUTY	(2)
STOL	DISCONN. MOTOR	2HP	208/480	3	HEAVY DUTY	(2)

NOTES
(1) For snap switches, designation is the same as the symbol used on plans for the device. Type of switch is determined from plan context including type of device or circuit being controlled.
(2) With overload element in switch.

END OF SECTION 16143

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions apply to this Section.

B. Requirements specified in other Division 16 Sections apply to this section.

1.2 SUMMARY

A. This Section includes circuit and motor disconnects.

B. Related Sections: The following sections contain requirements that relate to this section:

1. Division 16 Section "Wiring Devices" for snap switches used as motor disconnects.

1.3 SUBMITTALS

A. Product data for each type of product specified.

B. Maintenance data for circuit and motor disconnects, for inclusion in Operation and Maintenance Manual specified in Division 1 and Division 16 Section "Basic Electrical Requirements."

1.4 QUALITY ASSURANCE

A. Electrical Component Standards: Provide components complying with NEC "National Electrical Code" and which are listed and labeled by UL. Comply with UL Standard 98 and NEMA Standard KS 1.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products which may be incorporated in the work include, but are not limited to, the following:

1. Appleton
2. Crouse-Hinds Co.
3. Eaton Corp.
4. General Electric Co.
5. Square D Company.

2.2 CIRCUIT AND MOTOR DISCONNECT SWITCHES

A. General: Provide circuit and motor disconnect switches in types, sizes, duties, features ratings, and enclosures as indicated. Provide NEMA 1 enclosure except for outdoor switches, and other indicated locations provide NEMA 3R enclosures with

raintight hubs. For motor and motor starter disconnects, provide units with horsepower ratings suitable to the loads.

B. Fusible Switches: Heavy duty switches, with fuses of classes and current ratings indicated. Where current limiting fuses are indicated, provide switches with non-interchangeable feature suitable only for current limiting type fuses.

C. Non-fusible Disconnects: Heavy duty switches of classes and current ratings as indicated.

D. Double-Throw Switches: Heavy duty switches of classes and current ratings as indicated.

E. Provide weatherproof, NEMA Type 3R rated enclosures at exterior locations and wet/damp indoor locations.

2.3 ACCESSORIES

A. Electrical Interlocks: Provide number and arrangement of interlock contacts in switches as indicated.

B. Captive Fuse Pullers: Provide built-in fuse pullers arranged to facilitate fuse removal.

PART 3 – EXECUTION

3.1 INSTALLATION OF CIRCUITS AND MOTOR DISCONNECTS

A. General: Provide circuit and motor disconnect switches as indicated and where required by the above Code. Comply with switch manufacturers' printed installation instructions.

3.2 FIELD QUALITY CONTROL

A. Testing: Subsequent to completion of installation of electrical disconnect switches, energize circuits and demonstrate capability and compliance with requirements. Except as otherwise indicated, do not test switches by operating them under load. However, demonstrate switch operation through six opening/closing cycles with circuit unloaded. Open each switch enclosure for inspection of interior, mechanical and electrical connections, fuse installation, and for verification of type and rating of fuses installed. Correct deficiencies then retest to demonstrate compliance. Remove and replace defective units with new units and retest.

END OF SECTION 16170

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

B. Requirements specified in other Division 16 Sections apply to this section.

1.2 SUMMARY

A. This Section includes secure support from the building structure for electrical items by means of hangers, supports, anchors, sleeves, inserts, seals, and associated fastenings.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

B. Product data for each type of product specified.
   1. Hanger and support schedule showing manufacturer's figure number, size, spacing, features, and application for each required type of hanger, support, sleeve, seal, and fastener to be used.

C. Shop drawings indicating details of fabricated products and materials.

D. Engineered Design consisting of details and engineering analysis for supports for the following items:
   1. Fastener supporting systems.

1.4 QUALITY ASSURANCE

A. Electrical Component Standard: Components and installation shall comply with NFPA 70 "National Electrical Code."

B. Electrical components shall be listed and labeled by UL, ETL, CSA, or other approved, nationally recognized testing and listing agency that provides third-party certification follow-up services.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:
   1. Slotted Metal Angle and U-Channel Systems:
      a. Allied Tube & Conduit

b. B-Line Systems, Inc.
c. GS Metals Corp.
d. Unistrut Diversified Products

2. Conduit Sealing Bushings:
a. Bridgeport Fittings, Inc.
b. Cooper Industries, Inc.
c. O-Z/Gedney
d. Producto Electric Corp.
e. Raco, Inc.
f. Spring City Electrical Mgf. Co.
g. Thomas & Betts Corp.

2.2 COATINGS

A. Coating: Supports, support hardware, and fasteners shall be protected with zinc coating or with treatment of equivalent corrosion resistance using approved alternative treatment, finish, or inherent material characteristic. Products for use outdoors shall be hot-dip galvanized.

2.3 MANUFACTURED SUPPORTING DEVICES

A. Raceway Supports: Clevis hangers, riser clamps, conduit straps, threaded C-clamps with retainers, ceiling trapeze hangers, wall brackets, and spring steel clamps.

B. Fasteners: Types, materials, and construction features as follows:
1. Expansion Anchors: Carbon steel wedge or sleeve type.
2. Toggle Bolts: All steel springhead type.

C. Conduit Sealing Bushings: Factory-fabricated watertight conduit sealing bushing assemblies suitable for sealing around conduit, or tubing passing through concrete floors and walls. Construct seals with steel sleeve, malleable iron body, neoprene sealing grommets or rings, metal pressure rings, pressure clamps, and cap screws.

D. Cable Supports for Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug for nonarmored electrical cables in riser conduits. Provide plugs with number and size of conductor gripping holes as required to suit individual risers. Construct body of malleable-iron casting with hot-dip galvanized finish.

E. U-Channel Systems: 16-gage steel channels, with 9/16-inch-diameter holes, at a minimum of 8 inches on center, in top surface. Provide fittings and accessories that mate and match with U-channel and are of the same manufacture.

2.4 FABRICATED SUPPORTING DEVICES

A. General: Shop- or field-fabricated supports or manufactured supports assembled from U-channel components.

B. Steel Brackets: Fabricated of angles, channels, and other standard structural shapes. Connect with welds and machine bolts to form rigid supports.

C. Pipe Sleeves: Provide pipe sleeves of one of the following:
   1. Sheet Metal: Fabricate from galvanized sheet metal; round tube closed with snaplock joint, welded spiral seams, or welded longitudinal joint. Fabricate sleeves from the following gage metal for sleeve diameter noted:
      a. 3-inch and smaller: 20-gage.
      b. 4-inch to 6-inch: 16-gage.
      c. over 6-inch: 14-gage.

   2. Steel Pipe: Fabricate from Schedule 40 galvanized steel pipe.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install supporting devices to fasten electrical components securely and permanently in accordance with NEC requirements.

B. Coordinate with the building structural system and with other electrical installation.

C. Raceway Supports: Comply with the NEC and the following requirements:
   1. Conform to manufacturer's recommendations for selection and installation of supports.
   2. Strength of each support shall be adequate to carry present and future load multiplied by a safety factor of at least four. Where this determination results in a safety allowance of less than 200 lbs, provide additional strength until there is a minimum of 200 lbs safety allowance in the strength of each support.
   3. Install individual and multiple (trapeze) raceway hangers and riser clamps as necessary to support raceways. Provide U-bolts, clamps, attachments, and other hardware necessary for hanger assembly and for securing hanger rods and conduits.
   4. Support parallel runs of horizontal raceways together on trapeze-type hangers.
   5. Support individual horizontal raceways by separate pipe hangers. Spring steel fasteners may be used in lieu of hangers only for 1-1/2-inch and smaller raceways serving lighting and receptacle branch circuits above suspended ceilings only. For hanger rods with spring steel fasteners, use 1/4-inch-diameter or larger threaded steel. Use spring steel fasteners that are specifically designed for supporting single conduits or tubing.

6. Space supports for raceways in accordance with Table I of this section. Space supports for raceway types not covered by the above in accordance with NEC.
7. Support exposed and concealed raceway within 1 foot of an unsupported box and access fittings. In horizontal runs, support at the box and access fittings may be omitted where box or access fittings are independently supported and raceway terminals are not made with chase nipples or threadless box connectors.
8. In vertical runs, arrange support so the load produced by the weight of the raceway and the enclosed conductors is carried entirely by the conduit supports with no weight load on raceway terminals.

D. Vertical Conductor Supports: Install simultaneously with installation of conductors.

E. Miscellaneous Supports: Support miscellaneous electrical components as required to produce the same structural safety factors as specified for raceway supports. Install metal channel racks for mounting cabinets, panelboards, disconnects, control enclosures, pull boxes, junction boxes, transformers, and other devices.

F. In open overhead spaces, cast boxes threaded to raceways need not be supported separately except where used for fixture support; support sheet metal boxes directly from the building structure or by bar hangers. Where bar hangers are used, attach the bar to raceways on opposite sides of the box and support the raceway with an approved type of fastener not more than 24 inches from the box.

G. Sleeves: Install in concrete slabs and walls and all other fire-rated floors and walls for raceways and cable installations. For sleeves through fire rated-wall or floor construction, apply UL- listed firestopping sealant in gaps between sleeves and enclosed conduits and cables in accordance with requirements specified elsewhere.

H. Conduit Seals: Install seals for conduit penetrations of slabs on grade and exterior walls below grade and where indicated. Tighten sleeve seal screws until sealing grommets have expanded to form watertight seal.

I. Fastening: Unless otherwise indicated, fasten electrical items and their supporting hardware securely to the building structure, including but not limited to conduits, raceways, cables, cable trays, busways, cabinets, panelboards, transformers, boxes, disconnect switches, and control components in accordance with the following:
1. Fasten by means of wood screws or screw-type nails on wood, toggle bolts on hollow masonry units, concrete inserts or expansion bolts on concrete or solid masonry, and machine screws, welded threaded studs, or spring-tension clamps on steel. Do not weld conduit, pipe straps, or items other than threaded studs to steel structures. In partitions of light steel construction, use sheet metal screws.
2. Holes cut to depth of more than 1-1/2 inches in reinforced concrete beams or to depth of more than 3/4 inch in concrete shall not cut the main reinforcing bars. Fill holes that are not used.

3. Ensure that the load applied to any fastener does not exceed 25 percent of the proof test load. Use vibration- and shock- resistant fasteners for attachments to concrete slabs.

J. TESTS: Test pull-out resistance of one of each type, size, and anchorage material for the following fastener types:
1. Expansion anchors.
2. Toggle bolts.

K. Provide all jacks, jigs, fixtures, and calibrated indicating scales required for reliable testing. Obtain the structural Engineer's approval before transmitting loads to the structure. Test to 90 percent of rated proof load for fastener. If fastening fails test, revise all similar fastener installations and retest until satisfactory results are achieved.

L. Conduit seals at walk-in cooler& freezer location: Install seals for conduit penetrations into cooler or freezer equipment where conduit enters the repsective conditional areas, and at slab locations.

3.2 TABLE I: SPACING FOR RACEWAY SUPPORTS

HORIZONTAL RUNS

Raceway Size (Inches)	No. of Conductors in Run	Location	RMC & IMC (1)	EMT (1)
1/2,3/4	1 or 2	Flat ceiling or wall.	5	5
1/2,3/4	1 or 2	Where it is difficult to provide supports except at intervals fixed by the building construction.	7	7
1/2,3/4	3 or more	Any location.	7	7
1/2-1	3 or more	Any location.		
1 & larger	1 or 2	Flat ceiling or wall.	6	6
1 & larger	1 or 2	Where it is difficult to provide supports except at intervals fixed by the building construction.	10	10
1 & larger	3 or more	Any location.	10	10
Any	....	Concealed.	10	10

VERTICAL RUNS

Raceway Size (Inches)	No. of Conductors in Run	Location	RMC & IMC (1,2)	EMT (1)
1/2,3/4	....	Exposed.	7	7
1,1-1/4	....	Exposed.	8	8
1-1/2 and larger	....	Exposed.	10	10
Up to 2	....	Shaftway.	14	10
2-1/2	....	Shaftway.	16	10
3 & larger	....	Shaftway.	20	10
Any	....	Concealed.	10	10

NOTES:

(1) Maximum spacing of supports (feet).
(2) Maximum spacings for IMC above apply to straight runs only. Otherwise the maximums for EMT apply.

Abbreviations: EMT Electrical metallic tubing.
IMC Intermediate metallic conduit.
RMC Rigid metallic conduit.

END OF SECTION 16190

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

B. Requirements specified in other Division 16 Sections apply to this section.

1.2 SUMMARY

A. This Section includes identification of electrical materials, equipment, and installations. It includes requirements for electrical identification components including but not limited to the following:
   1. Identification labeling for switchboards, panelboards, devices, raceways, cables, and conductors.
   2. Operational instruction signs.
   3. Warning and caution signs.
   4. Equipment labels and signs.

B. Related Sections: The following Sections contain requirements that relate to this Section:
   1. Division 16 Section "Wires and Cables" for requirements for color coding of conductors for phase identification.

C. Refer to other Division 16 sections for additional specific electrical identification associated with specific items.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

B. Product Data for each type of product specified.

C. Schedule of identification nomenclature to be used for identification signs and labels.

D. Samples of each color, lettering style, and other graphic representation required for identification materials; samples of labels and signs.

1.4 QUALITY ASSURANCE

A. Electrical Component Standard: Components and installation shall comply with NFPA 70 "National Electrical Code."

B. ANSI Compliance: Comply with requirements of ANSI Standard A13.1, "Scheme for the Identification of Piping Systems," with regard to type and size of lettering for raceway and cable labels.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:
   1. American Labelmark Co.
   2. Ideal Industries, Inc.
   3. LEM Products, Inc.
   4. Markal Corp.
   5. National Band and Tag Co.
   6. Panduit Corp.
   7. Seton Name Plate Co.

2.2 ELECTRICAL IDENTIFICATION PRODUCTS

A. Adhesive Marking Labels for Raceway and Cable: Pre-printed, flexible, self-adhesive labels with legend indicating voltage and service (Emergency, Lighting, Power, Light, Air Conditioning, Communications, Control, Fire, etc.).

B. Label Size: as follows:
   1. Raceways 1-Inch and Smaller: 1-1/8 inches high by 4 inches long.
   2. Raceways Larger than 1-Inch: 1-1/8 inches high by 8 inches long.

C. Color: Black legend on orange background.

D. Colored Adhesive Marking Tape for Raceways, Wires, and Cables: Self-adhesive vinyl tape not less than 3 mils thick by 1 inch to 2 inches in width.

E. Pretensioned Flexible Wraparound Colored Plastic Sleeves for Raceway and Cable Identification: Flexible acrylic bands sized to suit the raceway diameter and arranged to stay in place by pre- tensioned gripping action when coiled around the raceway or cable.

F. Wire/Cable Designation Tape Markers: Vinyl or vinyl-cloth, self- adhesive, wraparound, cable/conductor markers with preprinted numbers and letter.

G. Plasticized Card Stock Tags: Vinyl cloth with preprinted and field-printed legends to suit the application. Orange background, except as otherwise indicated, with Eyelet for fastener.

H. Engraved, Plastic-Laminated Labels, Signs, and Instruction Plates: Engraving stock melamine plastic laminate, 1/16-inch minimum thick for signs up to 20 square inches,

or 8 inches in length; 1/8-inch thick for larger sizes. Engraved legend in white letters on black face and punched for mechanical fasteners.

I. Baked-Enamel Warning and Caution Signs for Interior Use: Preprinted aluminum signs, punched for fasteners, with colors, legend, and size appropriate to the location.

J. Exterior Metal-Backed Butyrate Warning and Caution Signs: Weather-resistant, nonfading, preprinted cellulose acetate butyrate signs with 20-gage, galvanized steel backing, with colors, legend, and size appropriate to the location. Provide 1/4-inch grommets in corners for mounting.

K. Fasteners for Plastic-Laminated and Metal Signs: Self-tapping stainless steel screws or number 10/32 stainless steel machine screws with nuts and flat and lock washers.

L. Cable Ties: Fungus-inert, self-extinguishing, one-piece, self-locking nylon cable ties, 0.18-inch minimum width, 50-lb minimum tensile strength, and suitable for a temperature range from minus 50 deg F to 350 deg F. Provide ties in specified colors when used for color coding.

PART 3 EXECUTION

3.1 INSTALLATION

A. Lettering and Graphics: Coordinate names, abbreviations, colors, and other designations used in electrical identification work with corresponding designations specified or indicated. Install numbers, lettering, and colors as approved in submittals and as required by code.

B. Install identification devices in accordance with manufacturer's written instructions and requirements of NEC.

C. Sequence of Work: Where identification is to be applied to surfaces that require finish, install identification after completion of finish work.

D. Conduit Identification:
1. The following areas shall be identified:
   a. On wall surfaces directly external to conduits run concealed within wall.
   b. On all accessible surfaces of concrete envelope around conduits in vertical shafts, exposed at ceilings or concealed above suspended ceilings.

2. Apply identification to areas as follows:
   a. Clean surface of dust, loose material, and oily films before painting.

b. Prime surfaces: For galvanized metal, use single-component acrylic vehicle coating formulated for galvanized surfaces. For concrete masonry units, use heavy-duty acrylic resin block filler. For concrete surfaces, use clear alkali-resistant alkyd binder-type sealer.
c. Apply one intermediate and one finish coat of orange silicone alkyd enamel.
d. Apply primer and finish materials in accordance with manufacturer's instructions.

E. Identify Raceways of Certain Systems with Color Banding: Band exposed or accessible raceways of the following systems for identification. Bands shall be pretensioned, snap-around colored plastic sleeves, colored adhesive marking tape, or a combination of the two. Make each color band 2 inches wide, completely encircling conduit, and place adjacent bands of two-color markings in contact, side by side. Install bands at changes in direction, at penetrations of walls and floors, and at 40-foot maximum intervals in straight runs. Apply the following colors:
1. Fire Alarm System: Red
2. Fire Suppression Supervisory and Control System: Red
3. Mechanical and Electrical Supervisory System: Green and Blue
4. Telephone System: Green and Yellow

F. Identify Junction, Pull, and Connection Boxes: Code-required caution sign for boxes shall be pressure-sensitive, self-adhesive label indicating system voltage in black, preprinted on orange background. Install on outside of box cover. Also label box covers with identity of contained circuits. Use pressure- sensitive plastic labels at exposed locations and similar labels or plasticized card stock tags at concealed boxes.

G. Conductor Color Coding: Provide color coding for secondary service, feeder, and branch circuit conductors throughout the project secondary electrical system as follows:

208Y/120 Volts	Phase
Black	A
Red	B
Blue	C
White	Neutral
Green	Ground

H. Use conductors with color factory-applied the entire length of the conductors except as follows:

1. The following field-applied color-coding methods may be used in lieu of factory-coded wire for sizes larger than No. 10 AWG.
a. Apply colored, pressure-sensitive plastic tape in half- lapped turns for a distance of 6 inches from terminal points and in boxes where splices or taps

are made. Apply the last two laps of tape with no tension to prevent possible unwinding. Use 1-inch-wide tape in colors as specified. Do not obliterate cable identification markings by taping. Tape locations may be adjusted slightly to prevent such obliteration.

b. In lieu of pressure-sensitive tape, colored cable ties may be used for color identification. Apply three ties of specified color to each wire at each terminal or splice point starting 3 inches from the terminal and spaced 3 inches apart. Apply with a special tool or pliers, tighten for snug fit, and cut off excess length.

I. Tag or label conductors as follows:

1. Future Connections: Conductors indicated to be for future connection or connection under another contract with identification indicating source and circuit numbers.
2. Multiple Circuits: Where multiple branch circuits or control wiring or signal conductors are present in the same box or enclosure (except for three-circuit, four-wire home runs), label each conductor or cable. Provide legend indicating source, voltage, circuit number, and phase for branch circuit wiring. Phase and voltage of branch circuit wiring may be indicated by mean of coded color of conductor insulation. For control and signal wiring, use color coding or wire marking tape at terminations and at intermediate locations where conductors appear in wiring boxes, troughs, and control cabinets. Use consistent letter/number conductor designations throughout on wire marking tapes.
3. Match identification markings with designations used in panelboards shop drawings, Contract Documents, and similar previously established identification schemes for the facility's electrical installations.

J. Apply warning, caution, and instruction signs and stencils as follows:

1. Install warning, caution, or instruction signs where required by NEC, where indicated, or where reasonably required to assure safe operation and maintenance of electrical systems and of the items to which they connect. Install engraved plastic- laminated instruction signs with approved legend where instructions or explanations are needed for system or equipment operation. Install butyrate signs with metal backing for outdoor items.

K. Install equipment identification as follows:

1. Apply equipment identification labels of engraved plastic- laminate on each major unit of electrical equipment in building, including central or master unit of each electrical system. This includes alarm systems, unless unit is specified with its own self-explanatory identification. Except as otherwise indicated, provide single line of text, with 1/2-inch-high lettering on 1-1/2-inch-high label (2-inch-high where two lines are required), white lettering in black field. Text shall match terminology and numbering of the Contract Documents and shop

drawings. Apply labels for each unit of the following categories of electrical equipment.

a. Panelboards, electrical cabinets, and enclosures.
b. Access doors and panels for concealed electrical items.
c. Motor starters.
d. Contactors.
e. Control devices.
f. Transformers.

L. Apply designation labels of engraved plastic laminate for disconnect switches, breakers, pushbuttons, pilot lights, motor control centers, and similar items for power distribution and control components above, except panelboards and alarm/signal components, where labeling is specified elsewhere. For panelboards, provide framed, typed circuit schedules with explicit description and identification of items controlled by each individual breaker.

M. Install labels at locations indicated and at locations for best convenience of viewing without interference with operation and maintenance of equipment.

END OF SECTION 16195

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Requirements of the following Division 16 Sections apply to this section:
   1. Basic Electrical Requirements.

1.2 SUMMARY:

A. Types of service entrance equipment in this section include the following:
   1. Circuit breakers.
   2. Fuses.
   3. Utility company meter sockets.
   4. Switches.
   5. Customer Meter

1.3 SUBMITTALS:

A. Product Data: Submit manufacturer's data on service entrance equipment and accessories.

B. Shop Drawings: Submit dimensioned layouts of service entrance equipment, including spatial relationships to proximate electrical equipment.

C. Wiring Diagrams: Submit power, signal and control wiring diagrams for service entrance work. Differentiate between portions of wiring/cabling that are manufacturer installed and portions that are field installed.

1.4 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of service entrance equipment, of types, sizes, and ratings required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Installer's Qualifications: Firm with at least 5 years of successful installation experience with projects utilizing service entrance work similar to that required for this project.

C. Codes and Standards:
   1. Electrical Code Compliance: Comply with applicable local code requirements of the authority having jurisdiction and NEC, including Articles 230, 250, and 338, as applicable to installation, and construction of service entrances.
   2. NEMA Compliance: Comply with applicable construction and installation requirements of the following NEMA standards for service entrance equipment and accessories:

a. Stds Pub/No. KS 1: Enclosed Switches.
b. Stds Pub/No. PB 2: Deadfront Distribution Switchboards.
c. Stds Pub/No. PB 2.2: Application Guide for Ground fault Protective Devices for Equipment.

3. UL Compliance: Comply with construction and installation requirements of the following UL standards for service entrance equipment and accessories:
   a. UL 50: Electrical Cabinets and Boxes.
   b. UL 489: Molded Case Circuit Breakers and Circuit Breaker Enclosures.
   c. UL 854: Service Entrance Cables.
   d. UL 869: Electrical Service Equipment.

4. Provide service entrance equipment and accessories which are UL listed and labeled, and marked, "SUITABLE FOR USE AS SERVICE EQUIPMENT."
5. IEEE Compliance: Comply with applicable requirements of IEEE Std 241 pertaining to service entrances.

1.5 DELIVERY, STORAGE, AND HANDLING:

A. Deliver service entrance equipment components properly packaged and mounted on pallets, or skids to facilitate handling of heavy items. Utilize factory fabricated type containers or wrappings for service entrance equipment and components which protect equipment from damage. Install gravity measuring meters in containers which indicate whether container has been bumped or dropped. Return G meters to manufacturer for reuse upon delivery of switchgear. Inspect equipment to ensure that no damage has occurred during shipment.

B. Store service entrance equipment in original packaging and protect from weather and construction traffic. Wherever possible, store indoors; where necessary to store outdoors, store above grade and enclose with watertight wrapping.

C. Handle service entrance equipment carefully to prevent physical damage to equipment and components. Remove packaging, including the opening of crates and containers, avoiding the use of excessive hammering and jarring which would damage the electrical equipment contained therein. Do not install damaged equipment; remove from site and replace damaged equipment with new.

1.5 SEQUENCING AND SCHEDULING:

A. Schedule delivery of service entrance equipment which permits ready building ingress for large equipment components to their designated installation spaces. Coordinate delivery of equipment with the installation of other building components.

B. Coordinate the size and location of concrete equipment pads. Cast anchor bolt inserts into pad. Concrete, reinforcement, and formwork requirements as per code.

C. Coordinate with other electrical work including raceways, electrical boxes and fittings, and cabling/wiring work, as necessary to interface installation of service entrance work with other work.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

B. Available Manufacturers: Subject to specifications requirements, manufacturers offering products which may be incorporated in the work include, but are not limited to, the following:
   1. General Electric
   2. Eaton Corp
   3. Schneider Electric (Square D)
   4. Siemens

2.2 SERVICE ENTRANCE EQUIPMENT:

A. General: Provide service entrance equipment and accessories; of types, sizes, ratings and electrical characteristics required for electrical load in accordance with NEC, which comply with manufacturer's standard materials, design and construction in accordance with published product information, and as required for complete installation; and as herein specified.

B. Switches and Fuse Units: Provide interrupter switches and fuse units; consisting of 3 pole, single throw switch with 3 power fuses; front mounted operating handle with mechanical interlock between switch and access door to fuses; with underground cable entry and set of terminal blocks, small wiring and ground bus.
   1. Fuses: Provide fuses in accordance with the following listed electrical characteristics:
      a. Class L time delay.

C. Combination Service Entrance Units:
   1. Combination units shall be service entrance rated, UL listed, shall contain service disconnect section and current transformer compartment and be cold sequenced.
   2. Current transformer compartment shall contain provisions for installation of bar type current transformers.
   3. Service disconnect shall be circuit breaker with ratings as indicated on the drawings.
   4. Unit shall be factory assembled, free standing or wall mountable, front accessible and totally enclosed. Finish shall be baked enamel gray.

D. Utility Company Meter Sockets:
   1. General: Provide meter sockets which comply with requirements of local utility company supplying electrical power to service entrance equipment of building project.
   2. Available Manufacturers: Subject to compliance with requirements, manufacturers offering meter sockets which may be incorporated in the work include, but are not limited to, the following:
      a. Cooper B line
      b. Milbank
      c. Schneider Electric (Square D)
      d. Siemens

E. Cables/Wires:
   1. General: Provide cables/wires complying with Division 16 “Wires and Cables".

F. Raceways:
   1. General: Provide raceways complying with Division 16 “Raceways”.

2.3 SERVICE ENTRANCE ACCESSORIES:

A. Wall and Floor Seals: Provide wall and floor seals complying with Division 16 “Basic Electrical Requirements” and “Basic Electrical Materials and Methods”.

2.4 CUSTOMER METERING:

B. General: Provide power and energy meter for customer power monitoring of facilities electrical service. Meter shall be class 1 accurancy and be connected to buildings management system to allow for remote monitoring.

B. The meter shall be capable of the following measurements:
   1. Apparent power min/max, total
   2. Active & Reactive power min/max, total
   3. Current min/max, avg
   4. Voltage min/max, avg
   5. Frequency min/max, avg
   6. Total current and voltage harmonic distortion THD per phase
   7. Powerfactor min/max, avg
   8. Apparent energy total
   9. Active and reactive energy total

C. Measurement accuracy shall be as follows:
   1. Apparent power +/- 1%
   2. Active energy +/- 1%
   3. Reactive energy +/- 1%
   4. Active power +/- 1%
   5. Voltage +/- 0.5%

6. Current +/- 0.5%
7. Frequency +/- 0.05%
8. Power factor +/- 0.01%

D. The meter shall utilize a red LED display which indicates demand current (past and present values), demand voltage (past and present values), voltage, current, frequency, energy consumption, harmonic distortion, power factor, active power, apparent power, reactive power and unbalance in %. Display shall utilize a 3 buttion control.

E. Meter coomunication port protocol shall be Modbus RTU 4800 bps, 9600 bps, 19200 bps, 38.4 kbps even/odd or none – 2 wires 2500V. Meter coomunication port support shall be screw terminal block RS485 and shall allow for remote monitoring. Cybersecurity shall consist of enable/disable communication ports.

G. Meter data recording shall be capable of of time stamping and min/max for eight (8) parameters

PART 3 - EXECUTION

3.1 EXAMINATION:

A. Examine areas and conditions under which service entrance equipment and components are to be installed, and notify Architect/Engineer in writing of conditions detrimental to proper completion of the work. Do not proceed with the work until satisfactory conditions have been corrected in a manner that is acceptable.

3.2 INSTALLATION OF SERVICE ENTRANCE EQUIPMENT:

A. Install service entrance equipment as indicated, in accordance with equipment manufacturer's written instructions, and with recognized industry practices, to ensure that service entrance equipment fulfills requirements. Comply with applicable installation requirements of NEC and NEMA standards.

B. Install fuses, in service entrance equipment.

C. Install ground fault protection devices complying with electrical winding polarities as required.

D. Install units on vibration isolators in accordance with Division 15; and comply with manufacturer's indicated method of installation.

E. Set field adjustable GFP devices and circuit breakers for pickup and time current sensitivity ranges as required, subsequent to installation of devices and CB's.

F. Install fuses, of size required, in each switchgear.

G. Tighten electrical connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Stds 486A and B, and the National Electrical Code.

3.3 FIELD QUALITY CONTROL:

A. Prior to energization of service entrance equipment, check accessible connections for compliance to manufacturer's torque tightening specifications.

B. Prior to energization of service entrance equipment, check with ground resistance tester, phase to phase and phase to ground insulation resistance levels to ensure requirements are fulfilled.

C. Prior to energization, check circuitry for electrical continuity, and for short circuits.

3.4 GROUNDING:

A. Provide equipment grounding connections for service entrance equipment as indicated. Tighten connections to comply with tightening torques specified in UL Std 486A to assure permanent and effective grounding.

3.5 ADJUSTING AND CLEANING:

A. Adjust operating mechanisms for free mechanical movement.

B. Touch up scratched or marred enclosure surfaces to match original finishes.

3.6 DEMONSTRATION:

A. Upon completion of installation of service entrance equipment and electrical circuitry, energized circuitry and demonstrate capability and compliance with requirements. Where possible, correct malfunctioning units at site, then retest to demonstrate compliance; otherwise, remove and replace with new units, and retest to demonstrate compliance.

END OF SECTION 16420

PART 1 GENERAL

1.1 SUMMARY

A. This Section includes solid grounding of electrical systems and equipment. It includes basic requirements for grounding for protection of life, equipment, circuits, and systems. Grounding requirements specified in this Section may be supplemented in other sections of these Specifications.

B. Related Sections: The following sections contain requirements that relate to this Section:
   1. Division 16 Section "Wires and Cables."

1.2 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

B. Product data for ground rods, connectors and connection materials, and grounding fittings.

C. Field-testing organization certificate, signed by the Contractor, certifying that the organization performing field tests complies with the requirements specified in Quality Assurance below.

D. Report of field tests and observations certified by the testing organization.

1.3 QUALITY ASSURANCE

A. Listing and Labeling: Provide products specified in this Section that are listed and labeled. The terms "listed" and "labeled" shall be defined as they are in the National Electrical Code, Article 100.
   1. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.

B. Field-Testing Organization Qualifications: To qualify for acceptance, the independent testing organization must demonstrate, based on evaluation of organization-submitted criteria conforming to ASTM E 699, that it has the experience and capability to conduct satisfactorily the testing indicated.

C. Electrical Component Standard: Components and installation shall comply with NFPA 70, "National Electrical Code" (NEC).

D. UL Standard: Comply with UL 467, "Grounding and Bonding Equipment."

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:

1. Anixter Bros., Inc.
2. Bashlin Industries, Inc.
3. Buckingham Mfg. Co.
4. A.B. Chance Co.
5. Erico Products, Inc.
6. GB Electrical, Inc.
7. Ideal Industries, Inc.
8. O-Z/Gedney Co.
9. Raco, Inc.
10. Thomas & Betts Corp.
12. W.H. Salisbury & Co.
13. Utilco Co.

2.2 GROUNDING AND BONDING PRODUCTS

A. Products: Of types indicated and of sizes and ratings to comply with NEC. Where types, sizes, ratings, and quantities indicated are in excess of NEC requirements, the more stringent requirements and the greater size, rating, and quantity indications govern.

B. Conductor Materials: Copper.

2.3 WIRE AND CABLE CONDUCTORS

A. General: Comply with Division 16 Section "Wires and Cables." Conform to NEC Table
8, except as otherwise indicated, for conductor properties, including stranding.

B. Equipment Grounding Conductor: Green insulated.

C. Grounding Electrode Conductor: Stranded cable.

D. Bare Copper Conductors: Conform to the following:

1. Assembly of Stranded Conductors: ASTM B-8.

2.4 MISCELLANEOUS CONDUCTORS

A. Ground Bus: Bare annealed copper bars of rectangular cross section.

B. Braided Bonding Jumpers: Copper tape, braided No. 30 gage bare copper wire, terminated with copper ferrules.

C. Bonding Strap Conductor/Connectors: Soft copper, 0.05 inch thick and 2 inches wide, except as indicated.

2.5 CONNECTOR PRODUCTS

A. General: Listed and labeled as grounding connectors for the materials used.

B. Pressure Connectors: High-conductivity-plated units.

C. Bolted Clamps: Heavy-duty units listed for the application.

D. Exothermic Welded Connections: Provided in kit form and selected for the specific types, sizes, and combinations of conductors and other items to be connected.

E. Aluminum-To-Copper Connections: Bimetallic type, conforming to UL 96, "Lighting Protection Components," or UL 467.

PART 3 EXECUTION

3.1 APPLICATIONS

A. Equipment Grounding Conductor Application: Comply with NEC Article 250 for sizes and quantities of equipment grounding conductors, except where larger sizes or more conductors are indicated.

1. Install separate insulated equipment grounding conductors with circuit conductors for the following in addition to those locations where required by Code:
   a. Lighting circuits.
   b. Feeders and branch circuits.
   c. Receptacle Circuits.
   d. Single-phase motor or appliance circuits.
   e. Three-phase motor or appliance branch circuits.

3.2 INSTALLATION

A. General: Ground electrical systems and equipment in accordance with NEC requirements except where the Drawings or Specifications exceed NEC requirements.

B. Braided-Type Bonding Jumpers: Install to connect ground clamps on water meter piping to bypass water meters electrically. Use elsewhere for flexible bonding and grounding connections.

C. Route grounding conductors along the shortest and straightest paths possible without obstructing access or placing conductors where they may be subjected to strain, impact, or damage, except as indicated.

D. Bond interior metal piping systems and metal air ducts to equipment ground conductors of pumps, fans, electric heaters, and air cleaners serving individual systems.

3.3 CONNECTIONS

A. General: Make connections in such a manner as to minimize possibility of galvanic action or electrolysis. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.
   1. Use electroplated or hot-tin-coated materials to assure high conductivity and make contact points closer in order of galvanic series.
   2. Make connections with clean bare metal at points of contact.
   3. Aluminum to steel connections shall be with stainless steel separators and mechanical clamps.
   4. Aluminum to galvanized steel connections shall be with tin-plated copper jumpers and mechanical clamps.
   5. Coat and seal connections involving dissimilar metals with inert material such as red lead paint to prevent future penetration of moisture to contact surfaces.

B. Terminate insulated equipment grounding conductors for feeders and branch circuits with pressure-type grounding lugs. Where metallic raceways terminate at metallic housings without mechanical and electrical connection to the housing, terminate each conduit with a grounding bushing. Connect grounding bushings with a bare grounding conductor to the ground bus in the housing. Bond electrically noncontinuous conduits at both entrances and exits with grounding bushings and bare grounding conductors.

C. Tighten grounding and bonding connectors and terminals, including screws and bolts, in accordance with manufacturer's published torque tightening values for connectors and bolts. Where manufacturer's torquing requirements are not indicated, tighten connections to comply with torque tightening values specified in UL 486A and UL 486B.

D. Compression-Type Connections: Use hydraulic compression tools to provide the correct circumferential pressure for compression connectors. Use tools and dies recommended by the manufacturer of the connectors. Provide embossing die code or other standard method to make a visible indication that a connector has been adequately compressed on the ground conductor.

E. Moisture Protection: Where insulated ground conductors are connected to ground rods or ground buses, insulate the entire area of the connection and seal against moisture penetration of the insulation and cable.

3.4 FIELD QUALITY CONTROL

A. Independent Testing Organization: Arrange and pay for the services of a qualified independent electrical testing organization to perform tests described below.

B. Tests: Subject the completed grounding system to a megger test at each location where a maximum ground resistance level is specified, at service disconnect enclosure ground terminal, and at ground test wells. Measure ground resistance without the soil being moistened by any means other than natural precipitation or natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance. Perform tests by the 2-point method in accordance with Section 9.03 of IEEE 81, "Guide for Measuring Earth Resistivity, Ground Impedance and Earth Surface Potentials of a Grounding System."

C. Deficiencies: Where ground resistances exceed specified values, and if directed, modify the grounding system to reduce resistance values. Where measures are directed that exceed those indicated the provisions of the Contract, covering changes will apply.

D. Report: Prepare test reports, certified by the testing organization, of the ground resistance at each test location. Include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

END OF SECTION 16452

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions apply to this Section.

B. Requirements specified in other Division 16 Sections apply to this section.

1.2 SUMMARY

A. This Section includes lighting and power panelboards and associated auxiliary equipment rated 600 V or less.

B. Related Sections: The following Division 16 Sections contain requirements that relate to this Section:
   1. "Overcurrent Protective Devices" for circuit breakers, fusible switches, fuses, and other devices used in panelboards.

1.3 DEFINITIONS

A. Overcurrent Protective Device (OCPD): A device operative on excessive current that causes and maintains the interruption of power in the circuit it protects.

1.4 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

B. Product data for each type panelboard, accessory item, and component specified.

C. Shop drawings from manufacturers of panelboards including dimensioned plans, sections, and elevations. Show tabulations of installed devices, major features, and voltage rating. Include the following:
   1. Enclosure type with details for types other than NEMA Type 1.
   2. Bus configuration and current ratings.
   3. Short circuit current rating of panelboard.
   4. Features, characteristics, ratings, and factory settings of individual protective devices and auxiliary components.

D. Wiring diagrams detailing schematic diagram including control wiring, and differentiating between manufacturer installed and field installed wiring.

E. Qualification data for field testing organization certificates, signed by the Contractor, certifying that the organization complies with the requirements specified in Quality Assurance below. Include list of completed projects with project names, addresses, and names of Architect and Owner plus basic organization qualifications data.

F. Report of field tests and observations certified by the testing organization.

G. Panel schedules for installation in panelboards. Submit final versions after load balancing.

H. Maintenance data for panelboard components, for inclusion in Operating and Maintenance Manual specified in Division 1 and in Division 16 Section "Basic Electrical Requirements." Include instructions for testing circuit breakers.

1.5 QUALITY ASSURANCE

A. Listing and Labeling: Provide products specified in this Section that are listed and labeled.
   1. The terms "listed" and "labeled" shall be defined as they are in the National Electrical Code, Article 100.
   2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.

B. Field Testing Organization Qualifications: To qualify for acceptance, the independent testing organization must demonstrate, based on evaluation of organization submitted criteria conforming to ASTM E 699, that it has the experience and capability to conduct satisfactorily the testing indicated.

C. Electrical Component Standard: Components and installation shall comply with NFPA 70, "National Electrical Code."

D. NEMA Standard: Comply with NEMA PB1, "Panelboards."

E. UL Standards: Comply with UL 61, "Panelboards," and UL 50, "Cabinets and Boxes."

1.6 EXTRA MATERIALS

A. Keys: Furnish six spares of each type for panelboard cabinet locks.

B. Touch up Paint for surface mounted panelboards: One half pint container.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include the following:
   1. Eaton Corp.
   2. General Electric Co.
   3. Siemens

4. Schneider Electric, Square D

2.2 PANELBOARDS, GENERAL REQUIREMENTS

A. Overcurrent Protective Devices (OCPDs): Provide type, rating, and features as indicated. Comply with Division 16 Section "Overcurrent Protective Devices," with OCPDs adapted to panelboard installation. Tandem circuit breakers shall not be used. Multipole breakers shall have common trip.

B. Enclosures: Cabinets, flush or surface mounted as indicted. NEMA Type 1 enclosure, except where the following enclosure requirements are indicated.
   1. NEMA 3R: Raintight.

C. Front: Hinged front covers.

D. Directory Frame: Metal, mounted inside each panel door.

E. Bus: Hard drawn copper of 98 percent conductivity.

F. Main and Neutral Lugs: Compression type.

G. Equipment Ground Bus: Adequate for feeder and branch circuit equipment ground conductors. Bonded to box.

H. Service Equipment Approval: Listed for use as service equipment for panelboards having main service disconnect.

I. Provision for Future Devices: Equip with mounting brackets, bus connections, and necessary appurtenances, for the OCPD ampere ratings indicated for future installation of devices.

J. Special Features: Provide the following features for panelboards as indicated.
   1. Isolated Equipment Ground Bus: Adequate for branch circuit equipment ground conductors; insulated from box.
   2. Hinged Front Cover: Entire front trim hinged to box with standard door within hinged trim cover.
   3. Split Bus: Vertical bus of indicated panels divided into two vertical sections with connections as indicated.
   4. Skirt For Surface Mounted Panels: Same gage and finish as panel front with flanges for attachment to panel, wall, and floor.
   5. Extra Gutter Space: Dimensions and arrangement as indicated.
   6. Gutter Barrier: Arranged to isolate section of gutter as indicated.
   7. Column Type Panelboard Configuration: Narrow cabinet extended as wireway to overhead junction box equipped with ground and neutral terminal buses.
   8. Subfeed: OCPD or lug provision as indicated.

K. Feed Through Lugs: Sized to accommodate feeders indicated.

L. Ratings: All panelboards shall be fully rated.

2.3 LIGHTING AND APPLIANCE BRANCH CIRCUIT PANELBOARDS

A. Branch OCPDs: Bolt on circuit breakers, replaceable without disturbing adjacent units.

B. Double Width Panels: Where more than 42 poles are indicated or where otherwise indicated, provide two panelboards under single front.

C. Doors: In panel front, with concealed hinges. Secure with flush catch and tumbler lock, all keyed alike.

2.4 DISTRIBUTION PANELBOARDS

A. Doors: In panel front, omit single panelboard door in cabinet front for fusible switch panelboards except as indicated. Secure with vault type with tumbler lock, all keyed alike.

B. Branch Circuit Breakers: Where OCPDs are indicated to be circuit breakers, use bolt on breakers except circuit breakers 225 ampere frame size and greater may be plug in type where individual positive locking device requires mechanical release for removal.

C. Motor Starter Branches: Provide units equipped for panelboard mounting. Include the following accessories and pilot devices as indicated:
1. Individual control power transformers.
2. Fuses for control power transformers.
3. Pilot lights.
4. Extra interlock contacts.
5. Pushbuttons.
6. Selector switches.

D. Motor Starter Disconnects: Include overcurrent protection as indicated. Mount integral with or, in same panelboard, adjacent to motor starter. Mechanically interlock starter door with disconnect device. Provide auxiliary contacts on disconnect to deenergize control connections to starter.

2.5 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items as required for overcurrent protective device test, inspection, maintenance, and operation.

B. Portable Test Set: Arranged to permit testing of functions of solid state trip devices without removal from panelboard.

2.6 IDENTIFICATION

A. Panelboard Nameplates: Engraved laminated plastic or metal nameplate for each panelboard mounted with epoxy or industrial cement or industrial adhesive.

PART 3 EXECUTION

3.1 INSTALLATION

A. General: Install panelboards and accessory items in accordance with NEMA PB 1.1, "General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less" and manufacturers' written installation instructions.

B. Mounting Heights: Top of trim 6' 2" above finished floor, except as indicated, or required to fit existing wall cavity.

C. Mounting: Plumb and rigid without distortion of box. Mount flush panels uniformly flush with wall finish.

D. Circuit Directory: Typed and reflective of final circuit changes required to balance panel loads. Obtain approval before installing.

E. Install filler plates in unused spaces.

F. Provision for Future Circuits at Flush Panelboards: Stub four 1 inch empty conduits from panel into accessible ceiling space or space designated to be ceiling space in future. Stub four 1 inch empty conduits into raised floor space or below slab other than slabs on grade.

G. Auxiliary Gutter: Install where a panel is tapped to a riser at an intermediate location.

H. Wiring in Panel Gutters: Train conductors neatly in groups, bundle, and wrap with wire ties after completion of load balancing.

3.2 IDENTIFICATION

A. Identify field installed wiring and components and provide warning signs in accordance with Division 16 Section "Electrical Identification."

3.3 GROUNDING

A. Connections: Make equipment grounding connections for panelboards as indicated.

B. Provide ground continuity to main electrical ground bus indicated.

3.4 CONNECTIONS

A. Tighten electrical connectors and terminals, including grounding connections, in accordance with manufacturer's published torque tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.5 FIELD QUALITY CONTROL

A. Independent Testing Organization: Arrange and pay for the services of an independent electrical testing organization in to perform tests on low voltage power panelboards and accessories.

B. Pretesting: Upon completing installation of the system, perform the following preparations for independent tests:
   1. Make insulation resistance tests of panelboard buses, components, and connecting supply, feeder, and control circuits.
   2. Make continuity tests of circuits.
   3. Provide set of Contract Documents to test organization. Include full updating on final system configuration and parameters where they supplement or differ from those indicated in original Contract Documents.

C. Quality Control Program: Conform to the following:
   1. Procedures: Make field tests and inspections and prepare panelboard for satisfactory operation in accordance with manufacturer's recommendations and these specifications.
   2. Schedule tests with at least one week in advance notification.
   3. Reports by Testing Organization: Report written reports of tests and observations. Report defective materials and workmanship and unsatisfactory test results. Include records of repairs and adjustments made.
   4. Labeling: Upon satisfactory completion of tests and related effort, apply a label to tested components indicating results of tests and inspections, responsible organization and person, and date.
   5. Protective Device Ratings and Settings: Verify indicated ratings and settings to be appropriate for final system configuration and parameters. Where discrepancies are found, recommend final protective device ratings and settings. Use accepted ratings or settings to make the final system adjustments.

D. Visual and Mechanical Inspection: Include the following inspections and related work:
   1. Inspect for defects and physical damage, labeling, and nameplate compliance with requirements of up to date drawings and panelboard schedules.
   2. Exercise and perform of operational tests of all mechanical components and other operable devices in accordance with manufacturer's instruction manual.

3. Check panelboard mounting, area clearances, and alignment and fit of components.
4. Check tightness of bolted electrical connections with calibrated torque wrench. Refer to manufacturer's instructions for proper torque values.
5. Perform visual and mechanical inspection and related work for overcurrent protective devices as specified in Division 26 Section "Overcurrent Protective Devices."

E. Electrical tests: Include the following items performed in accordance with manufacturer's instruction:
1. Insulation resistance test of buses and portions of control wiring that disconnected from solid state devices. Insulation resistance less than 100 megohms is not acceptable.
2. Ground resistance test on system and equipment ground connections.
3. Test main and subfeed overcurrent protective devices in accordance with Section "Overcurrent Protective Devices."

F. Retest: Correct deficiencies identified by tests and observations and provide retesting of panelboards by testing organization. Verify by the system tests that the total assembly meets specified requirements.

3.6 CLEANING

A. Upon completion of installation, inspect interior and exterior of panelboards. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish.

3.7 COMMISSIONING

A. Balancing Loads: After Substantial Completion, but not more than two months after Final Acceptance, conduct load balancing measurements and circuit changes as follows:
1. Perform measurements during period of normal working load as advised by the Owner.
2. Perform load balancing circuit changes outside the normal occupancy/working schedule of the facility. Make special arrangements with Owner to avoid disrupting critical 24 hour services such as servers and on line data processing, computing, transmitting, and receiving equipment.
3. Recheck loads after circuit changes during normal load period. Record all load readings before and after changes and submit test records.
4. Tolerance: Difference between phase loads exceeding 20 percent at any one panelboard is not acceptable. Rebalance and recheck as required to meet this minimum requirement.

B. Infrared Scanning: After Substantial Completion, but not more than two months after Final Acceptance, perform an infrared scan of each panelboard. Remove fronts to make joints and connections accessible to a portable scanner.

C. Follow up Infrared Scanning: Perform one additional follow up infrared scan of each panelboard 11 months after the date of Substantial Completion.

D. Instrument: Use an approved infrared scanning device designed to measure temperature or detect significant deviations from normal values. Provide calibration record for device used.

E. Record of Infrared Scanning: Prepare a certified report identifying panelboards checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

END OF SECTION 16470

PART 1 GENERAL

1.1 SUMMARY

A. This Section includes overcurrent protective devices (OCPDs) rated 600 V and below and switching devices commonly used with them.

B. Panelboards: Application, installation, and other related requirements for overcurrent protective device installations in distribution equipment are specified in other Division 16 sections.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:

1. Cartridge Fuses:
   a. Bussmann Div., Cooper Industries, Inc.
   b. Gould Inc.
   c. Littelfuse Inc.

2. Fusible Switches:
   a. Allen-Bradley Co.
   b. Crouse-Hinds Distribution Equipment.
   c. Eaton Corp.
   d. General Electric Co.
   e. Siemens
   f. Square D

3. Molded-Case Circuit Breakers:
   a. Eaton Corp.
   b. General Electric Co.
   c. Siemens
   d. Square D

2.2 OVERCURRENT PROTECTIVE DEVICES (OCPDs), GENERAL

A. General: Provide OCPDs in indicated types, as integral components of panelboards and also as individually enclosed and mounted single units.

B. General: Provide OCPDs in indicated types, as integral components of panelboards, switchboards, and motor control centers; and also as individually enclosed and mounted single units.

C. Enclosures: NEMA 250 "Enclosures for Electrical Equipment (1,000 Volts Maximum)."

2.3 CARTRIDGE FUSES

A. General: NEMA Standard FU1, "Low-Voltage Cartridge Fuses." Unless indicated otherwise, provide nonrenewable cartridge fuses of indicated types, classes, and current ratings that have voltage ratings consistent with the circuits on which used.

B. Class J Fuses: UL 198C, "High-Interrupting Capacity Fuses, Current-Limiting Type."

C. Class L Fuses: UL 198C, "High-Interrupting Capacity Fuses, Current-Limiting Type."

D. Class RK1 and RK5 Dual Element Time-Delay Fuses: UL 198E, "Class R Fuses."

E. Class RK1 Fast-Acting Fuses: UL 198E, "Class R Fuses."

2.4 FUSIBLE SWITCHES

A. General: UL 98 "Enclosed and Dead Front Switches" and NEMA KS 1 "Enclosed Switches," quick-make, quick-break heavy-duty units.

B. Rating: Load-breaking capacity in excess of the normal horsepower rating for the switch.

C. Withstand Capability: In excess of the let-through current permitted by its fuse when subject to faults up to 100,000 RMS symmetrical amperes.

D. Operation: By means of external handle.

E. Interlock: Prevents access to switch interior except when in "off" position.

F. Fuse Clips: Rejection type.

G. Padlocking Provisions: For 2 padlocks, whether open or closed.

H. Enclosure for Independent Mounting: NEMA Type 1 enclosure except as otherwise indicated or required to suit environment where located.

2.5 MOLDED-CASE CIRCUIT BREAKERS

A. General: UL 489, "Molded Case Circuit Breakers and Circuit Breaker Enclosures," and NEMA AB 1, "Molded Case Circuit Breakers."

B. Construction: Bolt-in type, except breakers 225-ampere frame size and larger may be plug-in type if held in place by positive locking device requiring mechanical release for removal.

C. Construction: Bolt-in type, except breakers in load-center-type panelboards and breakers 225-ampere frame size and larger may be plug-in type if held in place by positive locking device requiring mechanical release for removal.

D. Characteristics: Indicated frame size, trip rating, number of poles, and a short-circuit interrupting capacity rating of 10,000 amperes symmetrical, unless a greater rating is indicated.

E. Tripping Device: Quick-make, quick-break toggle mechanism with inverse-time delay and instantaneous overcurrent trip protection for each pole.

F. Enclosure for Panelboard Mounting: Suitable for panel mounting in switchboard or panelboards where indicated.

G. Enclosure for Independent Mounting: NEMA Type 1 enclosure, except as otherwise indicated or required to suit environment where located.

PART 3 EXECUTION

3.1 INSTALLATION

A. Independently Mounted OCPDs: Locate as indicated and install in accordance with manufacturer's written installation instructions.

B. OCPDs in distribution equipment shall be factory installed.

3.2 IDENTIFICATION

A. Identify components in accordance with Division 16 Section "Electrical Identification."

3.3 CONTROL WIRING INSTALLATION

A. Install wiring between OCPDs and control/indication devices as specified in Division 16 Section "Wires and Cables" for hard wired connections.

3.4 CONNECTIONS

A. Check connectors, terminals, bus joints, and mountings for tightness. Tighten field-connected connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL 486A and UL 486B.

3.5 GROUNDING

A. Provide equipment grounding connections for individually mounted OCPD units as indicated and as required by NEC. Tighten connectors to comply with tightening torques specified in UL Standard 486A to assure permanent and effective grounding.

3.6 FIELD QUALITY CONTROL

A. Independent Testing Organization: Arrange and pay for the services of an independent electrical testing organization to perform tests and observations on OCPDs.

B. Reports: Prepare written reports certified by testing organization on tests and observations. Report defective materials and workmanship and unsatisfactory test results. Include complete records of repairs and adjustments made.

C. Labeling: Upon satisfactory completion of tests and related effort, apply a label to tested components indicating test results, date, and responsible organization and person.

D. Schedule visual and mechanical inspections and electrical tests with at least one week's advance notification.

E. Pretesting: Upon completing installation of the system, perform the following preparations for independent tests:
   1. Make insulation resistance tests of OCPD buses, components, and connecting supply, feeder, and control circuits.
   2. Make continuity tests of circuits.
   3. Provide set of Contract Documents to test personnel. Include full updating on final system configuration and parameters where they supplement or differ from those indicated in original Contract Documents.
   4. Provide manufacturer's instructions for installation and testing of OCPDs to test personnel.

F. Visual and mechanical inspection: Include the following inspections and related work.
   1. Overcurrent-Protective-Device Ratings and Settings: Verify indicated ratings and settings to be appropriate for final system arrangement and parameters. Where discrepancies are found, test organization shall recommend final protective device ratings and settings. Use accepted revised ratings or settings to make the final system adjustments.

2. Inspect for defects and physical damage, NRTL labeling, and nameplate compliance with current single line diagram.
3. Exercise and perform operational tests of all mechanical components and other operable devices in accordance with manufacturer's instruction manual.
4. Check tightness of electrical connections of OCPDs with calibrated torque wrench. Refer to manufacturer's instructions for proper torque values.
5. Clean OCPDs using manufacturer's approved methods and materials.
6. Verify installation of proper fuse types and ratings in fusible OCPDs.

G. Electrical Tests: Include the following items performed in accordance with manufacturer's instructions:
1. Insulation resistance test of OCPD conducting parts. Insulation resistance less than 100 megohms is not acceptable.
2. Contact resistance test or measurement of millivolt drop across contacts of drawout circuit breakers and fused power circuit devices at rated current. Compare contact resistance or millivolt drop values of adjacent poles and of similar breakers. Deviations of more than 50 percent are not acceptable.
3. Insulation resistance test of fused power circuit devices and insulated-case and molded-case circuit breakers over 600-ampere frame size at 1000 V d.c. for one minute from pole to pole and from each pole to ground with breaker closed and across open contacts of each phase. Insulation resistance less than 100 megohms is not acceptable.
4. Use primary current injection to check performance characteristics of trip units of molded-case breakers over 600-ampere frame size. Trip characteristics not falling within manufacturer's published time-current characteristic tolerance bands when adjusted to approved parameters are not acceptable. Perform the following tests:
   a. Determine minimum pickup current acceptable per manufacturer's instructions.
   b. Determine long-time delay at 300 percent pickup current.
   c. Determine short-time-pickup current and corresponding delay time.
   d. Determine ground-fault current pickup and corresponding delay time.
   e. Determine instantaneous pickup current value.
5. Make adjustments for final settings of adjustable-trip devices.
6. Activate auxiliary protective devices such as ground fault or undervoltage relays, to verify operation of shunt-trip devices.
7. Check operation of electrically operated OCPDs in accordance with manufacturer's instructions.

H. Retest: Correct deficiencies identified by tests and observations and provide retesting of OCPDs by testing organization. Verify by the system tests that specified requirements are met.

3.7 CLEANING

A. Upon completion of installation, inspect OCPDs. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish.

3.8 DEMONSTRATION

A. Training: Arrange and pay for the services of factory-authorized service representatives to demonstrate OCPDs and train Owner's maintenance personnel.

B. Conduct a minimum of one half day of training in operation and maintenance as specified under "Instructions to Owner Employees" in the "Project Closeout" Section of these specifications. Include both classroom training and hands-on equipment operation and maintenance procedures.

C. Schedule training with at least seven days' advance notification.

3.9 COMMISSIONING

A. Infrared Scanning: After Substantial Completion, but not more than 2 months after Final Acceptance, perform an infrared scan of OCPDs including their line and load connections, fuses, and fuse clips. Also scan OCPD contact structures where accessible to a portable scanner. Include individual OCPDs and those installed in switchboards, panelboards, and motor control centers.

B. Follow-up Infrared Scanning: Perform two additional follow-up infrared scans of the same devices: one four months after Substantial Completion, and one 11 months after Substantial Completion.

C. Instrument: Use an infrared scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.

D. Record of Infrared Scanning: Prepare a certified report identifying all OCPDs checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and rescanning observations after remedial action.

END OF SECTION 16475