SPECIFICATIONS FOR

REROOFING AND HVAC REPAIR & REPLACEMENT AT

GLENDALE TERRACE
3243 GLENDALE AVENUE
TOLEDO, OHIO

85 years
LUCAS
METROPOLITAN HOUSING AUTHORITY

prepared by

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DESIGN GROUP, INC.

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GLENDALE TERRACE
3243 GLENDALE AVENUE
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February 24, 2021

prepared by:

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REROOFING AND HVAC REPAIR & REPLACEMENT
GLENDALE TERRACE
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TOLEDO, OHIO

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TOLEDO, OHIO

Glendale Terrace

DIVISION 01 - GENERAL REQUIREMENTS

SECTION 01010 - SUMMARY OF WORK

1.0 GENERAL CONDITIONS

1.01 GENERAL

The General Conditions for Construction Contracts - Public Housing Programs, Special Conditions and all portions of DIVISION 01 - GENERAL REQUIREMENTS shall govern this work wherein they apply.

1.02 WORK COVERED BY CONTRACT DOCUMENTS

The project consists of the following:

a. Project Location

Glendale Terrace
3230 Glendale Avenue
Toledo, Ohio

b. Owner

Lucas Metropolitan Housing Authority
Modernization Department
201 Belmont Avenue
Toledo, Ohio 43604

c. Contract Documents Prepared By:

Rossi Associates, LLC
Architecture
1821 Spencer Street
Toledo, Ohio 43609

d. Project Architect

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1.0 GENERAL CONDITIONS (continued)

1.02 WORK COVERED BY CONTRACT DOCUMENTS (continued)

Major items of work will consist of the following:

a. New TPO Roofing

b. New HVAC & RTU, Curbs (by others - separate contract)

End of Section

DIVISION 01 - GENERAL REQUIREMENTS

SECTION 01011 - SPECIAL CONDITIONS

1.0 GENERAL CONDITIONS

1.01 GENERAL

The Specifications and Special Conditions shall have precedence over the General Conditions where and to the extent that any conflict may occur.

1.02 SCOPE OF WORK

The work includes the furnishing of all supervision, labor, materials, equipment, transportation, site and building layout, verification of existing conditions, etc., as required and shall be in compliance with these Specifications and accompanying Drawings and shall include all roofing, deck replacement, deck fastening, removals and all other construction items necessary to complete the project, as herein specified and/or required to complete the work.

1.03 GENERAL PROVISIONS

Reference to any written permission, throughout this Specification, shall mean from the Architect.

Where industry standards and Specifications are referred to in this Specification, the Specifications and standards shall always be of the latest issue. In cases of conflict between the referenced Specifications or standards, the one having the more stringent requirements shall govern.

The Contracting Officer of LMHA shall be the only authority that may make changes or alterations to the Contract Drawings or Specifications.

There shall be no burning of trash or other open fires on the site. All trash, debris, etc., shall be removed from the building site.

Reference in the Specifications to any article, device, product, material, fixture, form or type of construction by name or catalog number shall be interpreted as establishing a standard of quality only and shall not be construed as limiting competition and the Contractor in such cases, may at his option, use any article, device, product, material, fixture, form or type of construction which in the judgment of the Architect is equal to that specified. The Base Bid Proposal must be compiled from costs using all standards herein specified.

Each Contractor shall be responsible for all permits, fees, regulations and taxes as required and shall include the costs of same as part of the Base Bid.

Each Contractor shall comply with all local and state codes and regulations, and all federal regulations, particularly Occupational Safety and Health Standards and National Consensus Standards. All Contractors and all construction must conform to the above mentioned regulations as they apply to this project.

2.0 JOB REQUIREMENTS

2.01 BUILDING SECURITY

The Contractor shall maintain fences and gates, if so required, so as to provide complete sealing off of all access to the construction area at the termination of work each day.

2.02 TEMPORARY SCAFFOLDS, STAGING AND SAFETY DEVICES

Provide, erect, maintain and remove as required, all scaffolding, staging, platforms, temporary runways, temporary flooring, guards, railings, fencing, stairs, etc., as required by local and state codes, or laws for the protection of workmen and the public.

The construction, inspection and maintenance of the above items shall comply with all safety codes and regulations as applicable to the project, in particular the requirements of the Occupational Safety and Health Act.

2.03 PROPERTY AND MATERIALS PROTECTION

It is required that the property and all materials be protected during the construction period. It shall be the responsibility of the Contractor to provide security measures as required to protect the property from all damage and losses up until the time the project is accepted by the Owner.

2.04 TEMPORARY TOILET FACILITIES

The Contractor shall provide and maintain an adequate number of temporary toilets with proper enclosures as necessary for the use of all *workmen of all Contractors*. Keep toilets clean and comply with all local and state health requirements and sanitary requirements. Take precautions to prevent freezing.

Toilets are to be of the chemical type and shall be kept in service throughout the entire construction period. Unless otherwise approved by the Owner, use of permanent toilet facilities will not be permitted.

2.05 LIFTING DEVICES AND HOISTING FACILITIES

Each Contractor shall provide cranes, hoists, towers and other lifting devices necessary for the proper and efficient movement of materials; provide operating personnel for equipment as required. Equipment shall be provided with proper guys, bracing and other safety devices as required by local or state codes.

Remove towers and hoisting equipment when they are no longer needed, or as directed by the Architect.

All work shall be executed by craftsmen of the particular trade and shall be performed in a first class workmanlike manner.

Use of any existing or new elevators for construction purposes will not be permitted, unless authorized by the Owner, in writing.

2.0 JOB REQUIREMENTS (continued)

2.06 OWNER-CONTRACTOR RELATIONSHIP

The following definitions shall exist throughout the length of this work:

a. Where the term "Owner" is used in reference to the legal Owner of the proposed building project, it shall mean the Lucas Metropolitan Housing Authority.

b. The project title shall be known as:

Reroofing and HVAC Repair & Replacement
Glendale Terrace
Lucas Metropolitan Housing Authority
Toledo, Ohio

c. The location of the project is at

Glendale Terrace
3243 Glendale Avenue
Toledo, Ohio

d. Where the term "Architect" is used, it shall mean the firm of Rossi Associates, LLC, Architects, 1821 Spencer Street, Toledo, Ohio 43609. Where the term "MEP Engineer" is used, it shall mean the firm of Vision Design Group, Inc., 3450 W. Central Avenue, Suite 330, Toledo, Ohio 43606.

e. Where the term "The Contractor" is used, it shall mean a person, firm or corporation holding a direct Contract with the Owner for the work.

f. "The Work", as used herein, shall mean work to be performed, including work normally done, at the location of the building.

g. "The Drawings", as used herein, shall mean the Architectural and Mechanical Drawings on which the work is shown.

h. "The Specifications" shall mean the Contract Documents and detailed description of the work.

2.07 TEMPORARY FIRE PROTECTION

During construction, the Contractor shall provide two and one-half gallon hand anti-freeze fire extinguishers, as required throughout the construction area.

2.08 SERVICE REQUIRED

The Contractor will definitely be required to furnish services as follows:

a. Safe, approved temporary stairs, ladders, ramps, etc., will be maintained for workmen during construction for ingress and egress to the building site. *Coordination and cooperation shall be maintained by the Contractor between all Contractors.*

2.0 JOB REQUIREMENTS (continued)

2.09 MAINTENANCE OF JOB SITE

Each Contractor, under the direction of the Contractor, shall be responsible for removal of rubbish, debris and trash from the building which results from his work. All rubbish, debris and trash shall be deposited in containers located on the site; said containers shall be furnished by the Contractor, unless otherwise hereinafter specified.

2.10 ROAD LOAD LIMIT

It is the responsibility of the Contractors to obtain and observe all load limits on all roads and highways while engaged in the construction of this project.

2.11 SIGNED CONTRACT DOCUMENTS

Immediately upon signing the Contract for the construction of the project, each Contractor is required to sign and file with the Contractor, a complete set of Drawings and Specifications, listed by numbers and dates, as evidence of his understanding of the work required. Documents shall include all modifications made before the signing of the Contract.

2.12 CONTRACTORS' RESPONSIBILITIES

Each Contractor shall be responsible for:

a. The proper laying out of his own work and for any damage which may accrue to the work of any other branch by reason of his inaccuracy.

b. The safety and good condition of all work and materials embraced in or affected by his Contract, until the completion of his Contract as an entirety.

c. The accuracy of any layout work which may be done by the Architect shall be verified by the Contractor. In no case shall the Architect assume responsibility as to the accuracy of all work laid out. The Contractors shall be furnished reference lines, which shall be the responsibility of each Contractor.

d. All additional lines, measurements and elevations which may be necessary to the proper construction of the work shall be the responsibility of each Contractor.

e. Each Contractor shall protect his work from damage at all times in a proper manner, or as the Contractor may direct. Erect all necessary barriers, furnish and keep lighted the required danger signals at night, employ watchmen as necessary, and take every precaution to prevent injury to persons or property.

f. Each Contractor shall be responsible for any damage which may accrue to the property of any other Contractor connected with the work, or to adjacent private or public properties, or to any portion of the structure which in any way results from the acts or neglect of his employees.

g. Each Contractor shall afford other Contractors reasonable opportunity for the introduction or storage of their materials, and the execution of their work, and shall properly connect and coordinate his work with theirs.

2.0 JOB REQUIREMENTS (continued)

2.12 CONTRACTORS' RESPONSIBILITIES (continued)

h. If any part of a Contractor's work is preceded by the work of any other Contractor, he shall inspect such other work and report to the Contractor any defects which render it unsuitable as related to his work. Failure to make such inspection and report shall constitute his acceptance of the other Contractor's work as fit and proper for the reception of his work, except as to defects which may develop in the other Contractor's work at a later date.

i. To insure the proper execution of his subsequent work, each Contractor shall measure work already in place and shall at once report to the Contractor any discrepancy between the executed work and the Drawings.

j. It shall be the responsibility of each trade to cooperate and coordinate with the Contractor and other Contractors in a timely manner, the location and dimensions of all pipes, sleeves and openings as shown or implied on the Drawings for the completed structure.

k. It shall be the responsibility of the Contractor to make provisions for such and/or allow reasonable and sufficient time for such installation as the case may be, before covering or closing in the work.

l. It shall be the responsibility of each Contractor to protect existing pavements that are not to be removed, from damage of any kind. Where trailers and equipment are parked on existing pavements, wheels and dollies shall be set on plywood pads and blocking large enough to prevent marking or sinking into the pavement. Likewise, material stored on existing pavements shall be placed on blocking and raised adequately so as not to block surface drainage.

2.13 DISCRIMINATION

Contractors shall comply with the state code and agree to the following:

a. That in the hiring of employees for the performance of work under this Contract or any Subcontract, no Contractor, Subcontractor, or any person acting on his behalf, shall, by reason of race, creed or color, discriminate against any citizen of the state in the employment of labor or worker who is qualified and available to perform the work to which the employment relates.

b. That no Contractor, Subcontractor, nor any person on his behalf shall, in any manner, discriminate against or intimidate any employee hired for the performance of work under this Contract on account of race, creed or color.

2.14 COORDINATION AND COOPERATION OF CONTRACTORS

The Mechanical Work will be awarded as part of the Base Bid Costs under separate Contract and the Mechanical Contractor shall coordinate his work with the Roofing Contractor.

2.0 JOB REQUIREMENTS (continued)

2.14 COORDINATION AND COOPERATION OF CONTRACTORS (continued)

All Contractors and Subcontractors shall be responsible to cooperate with the Contractor, coordinate and complete their work, so that the entire project will be accomplished according to the progress schedule.

It shall be the duty of each Contractor to notify their Subcontractors when their presence is required on the job, expedite the flow of materials and secure all necessary inspections. Each Contractor shall require that all Subcontractors have a competent supervisor on the site whenever his work is being performed.

Each Contractor shall give reasonable notice to the Contractor when his or the Architect's presence is required for special consultations, examinations or decisions.

It shall be the responsibility of each Contractor to cooperate with the Architect, the Owner and all other Contractors engaged in this project.

The entire work shall be carried forward harmoniously and erected in the proper sequence and without unnecessarily interfering with or delaying the work of any other Contractor. The work of each Contractor shall properly mesh with and conform to the work of the Contractors.

Each Contractor shall consult with the Architect and the other Contractors to advise and assist them in checking and verifying measurements, correcting errors and reconciling the Drawings.

The work of each Contractor shall be erected in its various stages with due respect to the convenience of other Contractors, where work must be erected first or carried forward simultaneously.

Any dispute arising between the Contractors in regard to the sequence in which the various portions of the work are to be erected or the right of the Contractors to the use of the premises and all other questions where the rights of the Contractors appear to conflict shall be referred to the Architect. The decisions shall be accepted by all parties concerned without the right to appeal.

When it becomes necessary at any time during the construction of this roofing, in order to accelerate the work, each Contractor and Subcontractor, when ordered and directed by the Contractor, shall cease work at any point and transfer his men and equipment to such points and execute such portions of the work as may be required to enable others to properly carry on their work.

No Contractor shall erect any portion of his work where it is necessary that the work of other Contractors shall be erected first or carried forward simultaneously without having first given the Contractor notice, in writing, of his intentions. Should any Contractor, after such notices, fail to have his work in readiness, the Contractor's directions shall be followed.

2.0 JOB REQUIREMENTS (continued)

2.15 MATERIALS

Contractors shall place orders for materials and equipment to be employed in the work as soon as possible after the award of the Contracts.

All Contractors shall keep the Architect informed as to the availability of all specified materials and equipment and of such materials and equipment as may not be obtainable for purposes of the Contract, whether due to conditions of the market or other limiting and governing factors.

Each Contractor shall submit to the Contractor each month, on forms furnished by the Contractor, the "material status" for his portion of the project.

All materials delivered to the job in finished condition, installed in finished condition, or installed and finished before completion of the work, shall be protected from damage until acceptance of the work. All finished materials which are damaged either before or after installation shall be replaced with new and perfect material, without cost to the Owner.

2.16 WORKING HOURS

The normal job working hours shall be those established by local standards and/or as directed by the Contractor.

During established working hours, it shall be the responsibility of all Contractors, and their Subcontractors, to provide all necessary skilled craftsmen as to cause no delays to any phase of construction work.

2.17 COMPLIANCE WITH LAWS

Each Contractor shall ascertain that all completed installations comply with state laws and local ordinances and regulations relating to the performance of the work and the protection of adjacent property. The maintenance of exits and fences are the responsibility of the Contractor.

2.18 OPERATING INSTRUCTIONS

Except as otherwise set forth in the detailed Specifications, each Contractor shall furnish and deliver to the Architect, two complete sets of instructions, technical bulletins, parts list and other printed matter.

2.19 SAFETY REGULATIONS

Contractors shall take all necessary precautions for the safety of employees on the site, and shall comply with all applicable provisions of federal, state and municipal safety laws and building codes to prevent accidents or injury to persons on, about or adjacent to the premises where the work is being performed.

In an emergency affecting the safety of life or of the work or of adjoining property, the Contractor, without special instruction or authorization from the Architect, is hereby permitted to act at his discretion, to prevent such threatened loss or injury, and he shall so act, without appeal.

2.0 JOB REQUIREMENTS (continued)

2.19 SAFETY REGULATIONS (continued)

Protection shall be afforded to all adjacent buildings, roads, walks, and all other adjacent property. Any portion of building or other property injured during construction operations shall be properly and thoroughly repaired and replaced by the party responsible therefore, without cost to the Owner.

Each Contractor, alone, shall be responsible for the safety, efficiency, and adequacy of his plant, appliances, and methods, and for any damage which may result from their failure or their improper construction, maintenance or operation.

It is required that each Contractor furnish his employees with proper safety equipment such as hard hats and necessary protective clothing.

No metal ladders are permitted on the premises at any time. All ladders are to be equipped with safety spikes or shoes. All scaffolds are to have safety railings.

All welders must be equipped with approved fire extinguishers. Vaporizing liquid type extinguishers containing carbon tetrachloride are not permitted.

All hoisting equipment must be in good state of repair and operated by an experienced operator. Operator must be licensed as required by law.

Pneumatic impact breakers, spades and similar equipment must be equipped with approved, manufacture-identified, conductive-type air hose.

Cans for storage of flammable liquids, fire extinguishers, fire resistant tarpaulins, etc., must be provided.

2.20 FIRE PREVENTION

All flammable liquids must be stored and transported in approved containers. Do not pour flammable solvents, thinners, etc., into drains and sewers. Paint, paint thinners, gasoline, oil, roofing materials or other flammable materials shall be stored 50'-0" outside of all buildings, marked as to contents and properly protected.

2.21 STANDARDS

Reference to recognized Standard Specifications such as Federal, State, Technical Society or Institute, Manufacturers or Trade Organization, shall mean the latest or current edition of such Standard Specifications, including revisions thereof, adopted, published and in effect thirty days prior to the date for receiving Bids, and shall govern the work.

Such Standard Specifications are made a part of these Specifications as referenced and applicable to the work.

Reference to technical society, organization or body is made in the Specifications in accordance with the following abbreviations:

AA	Aluminum Association
AABC	Associated Air Balance Council

2.0 JOB REQUIREMENTS (continued)

2.21 STANDARDS (continued)

AAMA	Architectural Aluminum Manufacturers Association
ABMA	American Boiler Manufacturer's Association
AAN	American Association of Nurserymen
AASHTO	American Association of State Highway and Transportation Officials
ACI	American Concrete Institute
ADA	The Americans with Disabilities Act
ADC	Air Diffusion Council
AGA	American Gas Association
AI	Asphalt Institute
AIA	The American Institute of Architects
AISC	American Institute of Steel Construction
AISI	American Iron and Steel Institute
AITC	American Institute of Timber Construction
AMCA	Air Movement and Control Association
ANSI	American National Standards Institute
APA	The Engineered Wood Association
ARI	Air Conditioning and Refrigeration Institute
ASCE	American Society of Civil Engineers (ASCE latest edition)
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing Materials
AWI	Architectural Woodwork Institute
AWPA	American Wood Preservers Association
AWS	American Welding Society

2.0 JOB REQUIREMENTS (continued)

2.21 STANDARDS (continued)

BIA	Brick Institute of America
BOCA	Building Officials and Code Administrators International
CAGI	Compressed Air and Gas Institute
CMAA	Crane Manufacturer's Association of America
CPSC	Consumer Product Safety Commission
CRSI	Concrete Reinforcing Steel Institute
CS	Commercial Standard of NBS (U. S. Department of Commerce)
DHI	Door and Hardware Institute
DOC	United States Department of Commerce
DOT	Department of Transportation
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration (U. S. Department of Transportation)
FGMA	Flat Glass Marketing Association
FMRC	Factory Mutual Research Corporation
FS	Federal Specification (General Services Administration)
GA	Gypsum Association
HIS	Hydraulic Institute Standards
IEEE	Institute of Electrical and Electronic Engineers
IES	Illuminating Engineering Society of North America
IRI	Industrial Risk Insurers
ISA	Instrument Society of America
MBMA	Metal Building Manufacturers Association
MCAA	Mechanical Contractors Association of America
MIA	Marble Institute of America

2.0 JOB REQUIREMENTS (continued)

2.21 STANDARDS (continued)

MSS	Manufacturers Standardization Society of the Valve and Fittings Industry
NAAMM	The National Association of Architectural Metal Manufacturers
NCMA	National Concrete Masonry Association
NEC	National Electrical Code (by NFPA)
NECA	National Electrical Contractors Association
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
N.F.P.A.	National Forest Products Association
NRCA	National Roofing Contractors Association
NSF	National Sanitation Foundation
NWMA	National Wood Manufacturers Association
OBC	Ohio Building Code
OSHA	Occupational Safety Health Administration (U. S. Department of Labor)
PCI	Precast/Prestressed Concrete Institute
PDI	Plumbing and Drainage Institute
PS	Product Standard of NBS (U. S. Department of Commerce)
RFCI	Resilient Floor Covering Institute
RMA	Rubber Manufacturers Association
SBCCI	Standard Building Code
SCS	Soil Conservation Service (U. S. Department of Agriculture)
SDI	Steel Deck Institute
S.D.I.	Steel Door Institute
SIGMA	Sealed Insulating Glass Manufacturers Association
SJI	Steel Joist Institute

2.0 JOB REQUIREMENTS (continued)

2.21 STANDARDS (continued)

SMACNA	Sheet Metal and Air Conditioning Contractors' National Association
SPIB	Southern Pine Inspection Bureau (Grading Rules)
SPRI	Single Ply Roofing Institute
SSPC	Steel Structures Painting Council
TCA	Tile Council of America
TIMA	Thermal Insulation Manufacturers Association
TPI	Truss Plate Institute
UBC	Uniform Building Code
UL	Underwriters' Laboratories, Inc.
WWPA	Western Wood Products Association (Grading Rules)

2.22 DEFINITIONS

a. Indicated

The term "indicated" is a cross-reference to details, notes or schedules on the Drawings, to other paragraphs or schedules in the Specifications and to similar means of recording requirements in the Contract Documents. Where terms such as "shown", "noted", "scheduled" and "specified" are used in lieu of "indicated", it is for the purpose of helping the reader locate cross-reference, and no limitation of location is intended except as specifically noted.

b. Directed, Requested, Etc.

Where not otherwise explained, terms such as "directed", "requested", "authorized", "selected", "approved", "required", "accepted" and "permitted" mean "directed by the Contracting Officer of LMHA", "requested by the Contracting Officer of LMHA ", etc. However, no such implied meaning will be interpreted to extend the Contracting Officer of LMHA 's responsibility into the Contractor's area of construction supervision.

c. Approve

Where used in conjunction with the Architect's response to submittals, requests, applications, inquiries, reports and claims by the Contractor, the meaning of the term "approved" will be held to limitations of the Architect's responsibilities and duties as specified in the General Conditions. In no case will "approval" by the Architect be interpreted as a release of the Contractor from responsibilities to fulfill requirements of the Contract Documents.

2.0 JOB REQUIREMENTS (continued)

2.22 DEFINITIONS (continued)

d. Project Site

The space available to the Contractor for performance of the work, either exclusively or in conjunction with others performing other work as part of the project. The extent of the project site is shown on the Drawings, and may or may not be identical with the description of land upon which the project is to be built.

e. Furnish

Except as otherwise defined in greater detail, the term "furnish" is used to mean supply and deliver to the project site, ready for unloading, unpacking, assembly, installation, etc., as applicable in each instance.

f. Install

The term "install" is used to describe operations at the project site including unloading, unpacking, assembly, erection, placing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning and similar operations, as applicable in each instance.

g. Provide

The term "provide" means furnish and install, complete and ready for the intended use, as applicable in each instance.

h. Installer

The entity (person or firm) engaged by the Contractor or his Subcontractor or Sub-Subcontractor for performance of a particular unit of work at the project site, including installation, erection, application and similar required operations. It is a general requirement that such installers be expert in their particular field.

2.23 ENFORCEMENT OF REGULATIONS

It is the responsibility of the Contractor to monitor the enforcement of all local, state and federal regulations, including OSHA. Each Contractor is responsible for the enforcement, etc. Each Contractor must provide proper safety precautions, atmospheres, working conditions, etc., in accordance with all controlling regulations, for all workmen and required inspections by all personnel employed by the Owner, the Architect and inspectors of controlling agencies.

2.24 GUARANTEES AND MANUFACTURER'S WARRANTIES

Guarantee provisions of this Specification do not modify, extend or shorten the guarantee provisions outlined in the Contract between the Contractor and the Owner. All guarantee periods shall start at occupancy or substantial completion. Subcontractors shall note work completed earlier will in effect have longer guarantee periods. It is understood that some manufactured products have more limited guarantees. Work under these Specifications shall carry the longest and least restricted manufacturer's guarantees or warranties available from the accepted manufacturer.

2.0 JOB REQUIREMENTS (continued)

2.24 GUARANTEES AND MANUFACTURER'S WARRANTIES (continued)

Written guarantees shall be delivered by the Contractor to the Architect on or before completion of the work and prior to final payment. Guarantees shall clearly identify the work guaranteed and shall state the work and all of its components will remain, if normally used and maintained by the Owner as recommended by the Contractor, Subcontractor or manufacturer, in normal operating condition and be free of any defects in material and/or workmanship for a period of at least one year, or longer if so specified, from the date of substantial completion of the total project or occupancy whichever comes first. If an element is defective at substantial completion or occupancy as evidenced by the Punch List, the warrantee of that element shall be extended so that the guarantee period will start on final acceptance of that element.

In the event of failure of any guaranteed work, the Owner will give the Contractor timely notice and the Contractor shall promptly affect the necessary repairs, adjustment or replacements as applicable. Should any adjoining work be damaged by the failure or during repair or replacement of faulty work, the Contractor shall cause it to be restored without cost to the Owner.

2.25 EXECUTION, CORRELATION AND INTENT OF DOCUMENTS

The Contract Specification Sections being general may contain items not required on this project or some inconsistencies in its various sections. However, in general, the Contract Documents are complementary, and what is called for by any one shall be as binding as if called for by all. The intention of the Documents is to include all labor and materials, equipment, transportation and services necessary for the proper execution and completion of the work.

The Drawings shall take precedence over the Contract Specifications. However, if the Drawings and Specifications are at variance with each other, the Contractor shall promptly notify the Architect, in writing, and the Architect shall investigate the circumstances and give appropriate instructions to the Contractor. The Contractor shall not take advantage of any manifestly unintentional error or omission, nor shall he proceed with any work where there is uncertainty.

2.26 COMPLIANCE WITH LAWS

Each Contractor shall ascertain that all complete installations comply with state laws and local ordinances and regulations relating to the performance of the work and the protection of adjacent property.

2.27 SUBSTITUTION OF MATERIALS

No substitution requests will be considered by the Architect unless the data, as described below, is received seven days prior to the bid due date. If any substitutions are approved, an Addendum will be issued prior to the bid due date. Base bid costs shall include the specified materials and equipment. Substitutions will not be considered in awarding the Contract. All substitutions shall be equal to the item specified.

2.0 JOB REQUIREMENTS (continued)

2.27 SUBSTITUTION OF MATERIALS (continued)

If substitutions are proposed by any Contractor, Subcontractor or material supplier, the following data must be submitted, three copies, fully identified for product, material or method being replaced by the substitution, including referenced Specification Sections and Drawings. Include product data, Drawings, performance data, description of methods, samples where applicable, comparison between the specified item and the proposed substitution statement of effect on construction, if applicable, coordination with other trades and a statement as to the cost effect on the proposed substitution, if granted, will have with other trades and Contractors.

Approval of any substitution of materials or equipment items by the Architect shall be deemed to be granted for the convenience of the requesting Contractor, and all costs growing out of the substitutions shall be the responsibility of the Contractor. No extra costs resulting from a substitution proposed by the Contractor shall devolve upon the Owner or the Architect.

2.28 SITE USE

All trailers are to be parked in the areas designated by the Owner's representative or the Architect.

Access to the site by all construction vehicles will be as designated on the Drawings. No other site roads or entrances are to be used except as may be authorized for special situations by the Owner.

All Contractors will be responsible for cleaning up all dirt carried onto permanent roads and streets by their trucks and equipment.

End of Section

DIVISION 01 - GENERAL REQUIREMENTS

SECTION 01330 - SUBMITTAL DATA

1.0 GENERAL CONDITIONS

1.01 DESCRIPTION

The following requirements apply to the work specified in all Sections of the Contract Documents. Additional submittal requirements, above what is described herein, may be required by individual Sections in other Divisions of the project Specifications.

1.02 DEFINITION

Submittals include, but are not limited to, such information as letters, selection of samples and colors, Shop Drawings, product data, diagrams, schedules, lists, illustrations, performance charts, brochures, test reports and inspection reports which are prepared by the Contractor or his Subcontractors, illustrating or certifying some part of the work.

2.0 PROCEDURES

2.01 CONTRACTOR'S REVIEW

The Contractor shall review, stamp and submit all submittals at the appropriate times and in proper sequence so as to cause no delay in the performance of the work.

At the time of submittal, the Contractor shall inform the Architect, in writing, of any deviation in the submittals from the Contract Documents.

By sending a submittal, to the Architect, the Contractor certifies that he has reviewed and approved the submittal data for conformance to the Contract Documents.

The Architect's approval of the submittals is not authorization for the Contractor to perform extra work or to change work.

The Contractor shall determine and verify all field measurements, field construction criteria, materials, finishes, fastenings, clearances, sequencing, abutting work, electrical requirements, catalog numbers, availability and the like. He shall check and coordinate each submittal with the requirements of the Contract Documents and the particular needs of the work.

2.02 ARCHITECT'S REVIEW

The submittals listed in each Section of the Contract Documents shall be submitted to the Architect.

The Architect will review submittals only for conformance with the design concept of the project and with the information given in the Contract Documents.

2.0 PROCEDURES (continued)

2.02 ARCHITECT'S REVIEW (continued)

The Architect's review of a separate item shall not indicate approval of an assembly in which the item functions.

The Architect's review of submittals shall not relieve the Contractor of responsibility for any deviation from the requirements of the Contract Documents, unless the Contractor has informed the Architect, in writing, of the deviation.

The Architect's review of submittals shall not relieve the Contractor from responsibility for errors or omissions in the submittals.

The Architect will acknowledge that each submittal has been reviewed and will return the submittal to the Contractor, together with any notes pertaining to the conformance and/or nonconformance of the submittals with the Design Drawings of the project and information given in the Contract Specifications.

2.03 REVIEW, CORRECTIONS AND NOTATIONS

The Contractor shall review the Architect's comments, notations and dimensional changes, make any appropriate corrections and resubmit the corrected and revised submittals until no further submission is requested by the Architect.

Whenever submittals are stamped "Approved as Noted", the Contractor shall resubmit revised submittals with the noted corrections made. In some cases, the resubmittals may be for "Record" purposes only, and in other cases, the resubmittals may be for a second review to confirm that the noted changes have been made.

No portion of the work requiring a submittal shall be commenced until the submittal has been reviewed and approved by the Architect. All such portions of the work shall be constructed in accordance with the approved submittals.

3.0 FORM OF SUBMITTALS

3.01 MATERIAL LIST

A material list shall be submitted within two weeks after award of the Contract, and when accepted by the Architect, shall be considered the list of materials the Contractors will furnish.

Any substitutions for or deviations from the specified products shall have been approved, in writing, by the Architect prior to bidding.

Identify each item on the material list by the manufacturer's trade name and catalog or other identifying number. The term "as specified" will not be accepted.

3.0 FORM OF SUBMITTALS (continued)

3.02 SCHEDULE OF CONTRACTOR FURNISHED MATERIALS

The Contractor shall submit an "Equipment and Material List".

The Contractor shall update the list each month and resubmit same to the Architect. Updates shall include the name of the carrier, purchase order numbers, revised anticipated delivery dates and actual delivery dates.

3.03 COST BREAKDOWN

Within ten days after award of the Contract, the Contractor shall submit, to the Architect, a cost breakdown according to the job order numbers for the total amount of the Contract price in accordance with HUD General Conditions (HUD 5370).

3.04 LETTER SUBMITTALS

Submittals in letter form are specified for certain products and methods for which the name and statements of special qualities is sufficient. Such letters shall originate with, or shall be endorsed by the Contractor.

3.05 SAMPLES

Submit color and finish selection samples in book or kit form for final selection of color, finish, texture and pattern. All products for this project may have approved equal submittals submitted by the Contractor to the Architect for his approval.

Include information with each sample to show generic description, source or product name and manufacturer, limitations and compliance with standards. Samples will be returned by the Architect for comparisons with furnished materials.

Samples shall represent the full range of color and finish, which are or will be available for the specified product at the time the work is to be built.

Samples shall be of a size necessary to adequately represent the product. If there are color or texture ranges in the product, submit extreme samples (not less than three units).

Samples shall have firmly attached labels bearing the following information:

a. Name of product

b. Description of product and finish

c. Name of Contractor

d. Trade name and number of product

e. Quality and standards met by product

3.0 FORM OF SUBMITTALS (continued)

3.06 SHOP DRAWINGS

The Contractor shall submit Shop Drawings in the form of prints and samples. Also refer to DIVISION 01 - GENERAL REQUIREMENTS, SECTION 01780 - CONTRACT CLOSEOUT DATA.

The Architect may make changes or corrections to the Shop Drawings and return marked-up copies to the Contractor for corrections and resubmission.

The Contractor shall identify Shop Drawings with the project name and project number, date and edition of submittal and the Contractor's name and address.

The Contractor shall refer to other Sections of this Specification for additional requirements for submittal of Shop Drawings applicable to the various areas of work.

3.07 PRODUCT DATA

Product data, including but not limited to, such items as catalog cuts, code compliance certificates, brochures, performance charts, illustrations, lists and schedules, shall be submitted for approval with copies of each. The Contractor shall include any additional copies required for the Contractor's use, and as may be required by DIVISION 01 - GENERAL REQUIREMENTS, SECTION 01780 - CONTRACT CLOSEOUT DATA.

The Architect will note corrections, make changes and return copies to the Contractor. If major revisions are required, all copies but one will be returned to the Contractor for correction and resubmission.

The Contractor shall identify product data with the project name and number, date and edition of submittal and the Contractor's name and address.

When the manufacturer's standard catalogs and brochures are submitted, *clearly mark each copy to identify the pertinent data*, which applies to this project on the schedules, diagrams, performance charts, models and illustrations.

3.08 MATERIAL SAFETY DATA SHEETS

The Contractor, Subcontractors and Material Suppliers shall submit Material Safety Data Sheets to the Architect for approval by the Owner's representative for any chemicals that are to be brought onto the property of the Owner for the use of any materials installation, cleaning or any other reason herein specified.

This procedure covers all quantities of chemicals, including "samples". *No chemicals will be introduced to the property of the Owner unless there is a current Material Safety Data Sheet on file or approved by the Owner.*

3.0 FORM OF SUBMITTALS (continued)

3.09 PROGRESS SCHEDULE

Upon the execution of the Contracts, the Roofing Contractor along with the Mechanical Contractor shall submit a combined outline Progress Schedule to the Architect and the Contracting Officer of LMHA. The Schedule shall indicate the various trade divisions of work, organized by the related Specification Section numbers, the proposed starting period and completion and the percent of total Contract. The responsibility of the preparation of the combined schedule shall be the Roofing Contractors for this project.

3.10 CLOSEOUT SUBMITTALS

Refer to individual Sections of the Specifications and to DIVISION 01 - GENERAL REQUIREMENTS, SECTION 01780 - CONTRACT CLOSEOUT DATA for more specific requirements on submittals of closeout information and data.

3.11 MISCELLANEOUS SUBMITTALS

Provide miscellaneous submittals such as field measurements, damage surveys, photographs and similar data as may be required.

End of Section

DIVISION 01 - GENERAL REQUIREMENTS

SECTION 01730 - REMOVALS, CUTTING, PATCHING AND REWORKING

1.0 GENERAL CONDITIONS

1.01 GENERAL

The General Conditions for Construction Contracts - Public Housing Programs, Special Conditions and all portions of DIVISION 01 - GENERAL REQUIREMENTS shall govern this work wherein they apply.

1.02 SCOPE OF WORK

Provide all labor, materials, tools, services, equipment and transportation necessary to perform all required removals, cutting, patching and reworking of existing construction, as shown on the Drawings and herein specified.

All removals, cutting, patching and reworking shall be done under the supervision of the Contractor's project superintendent. Any unforeseen or questionable structural problems arising shall be cleared with the Architect and the Owner's representative prior to removal of the questionable construction.

1.03 REMOVALS

All salvageable equipment and materials removed shall become the property of the Owner, unless otherwise directed by the Architect or herein mentioned. All items shall be cleared with the Architect prior to submitting a bid and prior to removal of same.

All removed materials that are obviously not reusable are to be removed from the site by the Contractors removing same.

All questionable items shall be cleared with the Owner's representative as to whether or not they are to be salvaged or removed from the site.

The Contractors removing the existing materials shall have the responsibility of either removing same from the site, storing the items as directed by the Owner's representative or protecting same until reinstalled if to be reused in this project.

1.04 CUTTING AND PATCHING

This Contractor shall do all cutting of all present work as caused by the alterations and installation of new work.

The size, location, etc., of items requiring an opening, chase or other provisions to receive it for any trade, shall be given by the trade requiring the information in ample time to avoid undue cutting of any new work to be installed. This provision shall not relieve the Contractor from the responsibility of keeping informed as to the required openings, chases, etc., nor from the responsibility for the correctness thereof, or for cutting and repairing after the new work is in place.

1.0 GENERAL CONDITIONS (continued)

1.04 CUTTING AND PATCHING (continued)

For each trade, the Contractor shall include all cutting in connection with existing construction that may be required to make its several parts come together and fit it to receive or be received by the work of other trades, as shown and/or specified or reasonably implied by the Drawings and Specifications. All patching shall be done under the supervision of the Contractor.

All repairing, patching, piecing-out, filling-in, restoring and refinishing shall be neatly done by mechanics skilled in their trade and completed in a proper workmanlike manner to leave the work in a condition satisfactory to the Architect and as described throughout the various Sections of the Specifications.

1.05 PROTECTION AND REPAIRING

Any and all existing work and finish materials of the present construction not directly affected by this work shall be properly protected in a manner as approved to insure against undue damage or injury caused by work performed under this Contract. Any and all such existing work that is in any way cut, damaged, disturbed or otherwise interfered with in such manner, as to cause damage thereto during the progress of the work of the various trades, contrary to intent of the foregoing provisions, shall be fully, properly and carefully repaired and made good in a workmanlike manner as herein before stated or removed, replaced and/or refinished with new materials as may be directed.

Existing materials to be reused shall be carefully dismantled, properly stored and protected and reset as required, furnishing new parts as required.

Work in existing areas shall be carried on only at such times as approved by the Owner's representative. Work shall not interfere with the operation of the Owner and all services are to be maintained.

1.06 TEMPORARY CONSTRUCTION

Provide temporary protection as necessary to partition off working areas required by the Owner's operations. All areas must be protected for the residents in the Glendale Terrace complex. All doorways must be kept in operation for the residents.

1.07 SAFETY

This Contractor shall observe and adhere to state and local building codes governing all construction operations during the erection, alterations, repair or removal of buildings or structures.

2.0 EXTENT OF REMOVALS

2.01 GENERAL

The following is a general list and description of the various items that are to be removed, reworked, replaced and/or reinstalled. It shall be understood that this list may not include all the items that must be removed, relocated, patched and/or reworked. It is the intent that all Bidders visit the site and inspect same and review the Drawings and the Specifications in order to determine all the requirements to furnish a complete project.

2.02 ROOFING

The Roofing Contractor is to remove and replace all existing roof construction, including gravel, roof felts, insulation, metal flashing, counterflashing and metal deck, as required by the new construction work.

All roofing work performed on the existing roofs shall be done by a Roofing Contractor acceptable to the roofing materials manufacturer holding any bonds, warranties or guarantees in force on the roof, if any exists. All work shall be guaranteed for a period of two years.

2.03 UTILITY LINES

All existing piping, ductwork, conduit, equipment, etc., in the area to be reworked shall be removed and/or relocated if not to be used in the layout when completed. Consult the Mechanical Drawings for the extent of these removals covered under their work to avoid duplication.

2.04 MECHANICAL WORK

Existing mechanical installations shall be removed and/or reworked as required by the Mechanical Contractor to allow for the new construction. Refer to the Mechanical Drawings by others.

End of Section

DIVISION 01 - GENERAL REQUIREMENTS

SECTION 01740 - CLEAN UP

1.0 GENERAL CONDITIONS

1.01 GENERAL

The General Conditions for Construction Contracts - Public Housing Programs, Special Conditions and all portions of DIVISION 01 - GENERAL REQUIREMENTS shall govern this work wherein they apply.

1.02 SCOPE OF WORK

a. General

The following requirements shall apply to the work specified in all Sections of the Contract Documents. Additional requirements or more specific information, above what is described herein, may be required by the individual Sections in other Divisions of the project Specifications.

b. Final Clean Up

All work, as specifically mentioned herein and as required to place the facility in a condition for occupancy and ready for its intended use, shall be completed as directed by the Architect.

It is intended that all the work covered in this Section be performed immediately preceding final acceptance of the facility, and is in addition to that specified elsewhere in the Specifications.

c. Construction Clean Up

The Contractor shall provide the following clean-up services during the construction period:

1. The necessary labor to keep the work areas in a broom clean condition on a once-a-week basis. High debris creating areas shall be cleaned daily, if necessary, to keep from tracking dirt into other areas of construction or into existing occupied areas.

2. Provide all required containers or bins for the deposit of small trash and debris in all areas of construction. The containers shall be emptied weekly. Trash and debris shall be picked up daily by the trade creating same.

3. Provide all required on-site, dumpster-type containers for the collection of all trash and debris.

1.0 GENERAL CONDITIONS (continued)

1.03 OPERATION

All mechanical work shall be placed in operation with all components in a good working condition, serviced, lubricated and properly adjusted to fulfill the intended design requirements of the Drawings.

2.0 EXECUTION

2.01 CONSTRUCTION CLEAN UP

All Contractors shall provide all labor and services to perform the required construction clean up. These Contractors shall provide all required containers and dumpsters, in their immediate work areas, to dispose of their own construction debris.

a. Insulation

b. Roofing Materials

All Contractors and their employees shall perform the following clean up services in all work areas:

a. Pick up all trash and debris created by them in excess of 2" in any one dimension, and place in small containers located around the construction work site or in the dumpster boxes on a daily basis.

b. Breakdown all crates, packing cases, boxes, etc. Take out of the building and place in dumpster boxes or otherwise remove from the site.

c. Keep all trash picked up around containers and dumpster boxes.

d. Move material and equipment, as necessary, to permit the broom cleaning of the work areas by others.

e. Keep the change and storage rooms, break areas and yard areas specifically assigned to them picked up and broom clean at all times.

f. Place all food wrappings and containers in the proper containers at the end of each break or lunch period.

2.02 FINAL CLEAN UP

All work shall be cleaned to provide a neat appearing and properly functioning facility acceptable to the Owner and the Architect.

Existing roads and site areas used during the construction period shall be cleaned and repaired as required to restore them to their original condition that existed prior to the start of the construction work.

All staging, storage and parking areas used during the construction period shall be returned to their original condition upon completion of this project.

2.0 EXECUTION (continued)

2.02 FINAL CLEAN UP (continued)

All exterior wall surfaces, aluminum entrances and framing systems, glass, doors, frames and louvers shall be cleaned of all mud, dirt, dust, labels, markings and protective coverings prior to final acceptance if Contractor marred the surfaces.

All operating utilities such as manholes and catch basins shall be cleaned of all construction debris and must be in a proper working order.

All interior surfaces and areas, including walls, floors, ceilings, glass, windows, doors, light fixtures and related trim, shall be cleaned of dust, dirt and debris if Contractor dropped debris in these areas.

Clean dirt and debris from ductwork and any air handling equipment or systems. Clean and replace any dirty or damaged filters.

Once final clean up has been performed in an area, any and all additional clean up required will be performed by the trade that created the condition.

2.03 SITE CLEARANCE

All excess construction materials, trash and other debris resulting from the construction of the facility, shall be removed from the site and disposed of to the satisfaction of the Owner and the Architect.

All construction equipment and other property not a part of the finished facility, nor owned by the Owner shall be removed from the site as directed by the Architect.

Upon completion of this project and before the final acceptance of the project by the Owner, the entire area covered by this project shall be reviewed for any and all construction materials, tools, equipment, debris, etc., which may have been left behind during construction. All items not part of the finished project shall be removed from the areas and disposed of to the satisfaction of the Owner and the Architect.

End of Section

DIVISION 01 - GENERAL REQUIREMENTS

SECTION 01780 - CONTRACT CLOSEOUT DATA

1.0 GENERAL CONDITIONS

1.01 GENERAL

The following requirements shall apply to the work specified in all Sections of the Contract Documents. Additional closeout data requirements, above what is described herein, may be required by the individual Sections in other Divisions of the project Specifications.

1.02 GENERAL DATA REQUIREMENTS

a. Guarantees/Warranties

b. Record Drawings

c. Record Shop Drawings

d. Operational and Maintenance Manuals for HVAC

e. Color Schedule

f. Spare Materials

2.0 DOCUMENTATION PRESENTATION

2.01 GENERAL

The Contractor shall submit two sets of manuals, containing the data on the items herein described, to the Architect for review prior to the project completion.

2.02 GUARANTEES/WARRANTIES

Include all manufacturers' and Contractors' Guarantees/Warranties covering materials, equipment and workmanship for the periods specified. All Guarantees/Warranties shall be dated to correspond with the date of substantial completion of the total project or occupancy, whatever comes first. Refer to DIVISION 01 - GENERAL REQUIREMENTS, SECTION 01011 SPECIAL CONDITIONS, Item 2.24 - GUARANTEES AND MANUFACTURER'S WARRANTIES.

All Guarantees/Warranties shall include the following information:

a. Item of Work

b. Manufacturer's/Contractor's Name

c. Specification Section

d. Time Periods

2.0 DOCUMENTATION PRESENTATION (continued)

2.03 RECORD DRAWINGS

Each Contractor shall keep an accurate record of all deviations from the Contract Drawings and Specifications. He shall neatly and correctly enter in colored pencil any deviations on the Drawings affected and shall keep the Drawings available for inspection. Extra sets of Drawings will be furnished for this purpose.

Record Drawings are to be reviewed monthly by the Architect and the Contractor as a prerequisite for payment to each Contractor.

At the completion of the job and before final acceptance, make any final corrections to the Drawings and certify to the accuracy of each print by the signature thereon and deliver same to the Architect.

Record Drawings shall be legibly marked to record the actual construction data and shall include the following:

a. Field changes of dimensions and details.

b. Changes made by Work Order Changes.

c. Details not shown on the original Contract Drawings.

2.04 RECORD SHOP DRAWINGS

The Contractor and his Subcontractors shall maintain a set of Record Drawings and shall legibly note on the Drawings any record changes that were made after the Architect's review. Submit one set of prints covering the following items of work:

a. Ductwork

b. Roofing System and Components

c. Deck Replacement

2.05 OPERATIONAL AND MAINTENANCE MANUALS

Submit the manufacturer's operating instructions for each item of mechanical equipment and supplement with additional project Specification instructions where necessary. Prepare and submit specific operating instructions for each mechanical, which involves multiple items of equipment, including instructions for charging, start-up, control or sequencing of operation, phase or seasonal variations, shut-down, safety and similar operational instructions. Prepare in a typewritten form and in completely explained and easily understood English language.

Organize each copy of the required system maintenance manuals to include an index followed by thumb-tab marked Sections for the following:

a. System operating instructions.

b. Prepared emergency instructions, including addresses and telephone numbers for service sources.

2.0 DOCUMENTATION PRESENTATION (continued)

2.05 OPERATIONAL AND MAINTENANCE MANUALS (continued)

c. Regular system maintenance procedures, including lubrication.

d. Spare parts listing and stocking recommendations.

e. Inspection, adjusting, rebalancing, cleaning and parts replacement.

f. Similar maintenance instructions and recommendations, including the following:

1. Proper use of tools and accessories.

2. Valve schedule and control diagram for each system.

3. Manufacturer's data for each operational item in each system.

4. Manufacturer's product warranties and guarantee relating to the system and equipment items in the system.

5. Shop Drawings relating to the system.

2.06 INSPECTION/TEST REPORTS

Include copies of all inspection reports and test reports covering the following:

a. Factory Test on Equipment.

b. Plumbing and HVAC Inspections.

c. Air and Water Balancing Reports.

d. Valve Tags and Charts - HVAC.

e. Any other Inspections required and/or performed.

2.07 PARTS LIST MANUAL

Include all parts list manuals for all equipment, properly identified to the equipment.

2.08 COLOR SCHEDULE

Include a neatly typed list of all the colors of the materials used for the project, giving the location, manufacturer, supplier, type and color numbers.

2.09 SPARE MATERIALS

Deliver to the Owner's representative and to the storage areas designated one bundle of shingles.

2.0 DOCUMENTATION PRESENTATION (continued)

2.10 INSTRUCTIONS TO THE OWNER'S PERSONNEL

Provide the services of qualified supervisory personnel to start equipment and instruct the Owner's representatives in the starting, operating, closing down and maintaining all mechanical equipment. Instruct the operating personnel as to the procedures for lubricating, oiling and adjusting systems and equipment.

End of Section

DIVISION 06 - WOOD, PLASTICS AND COMPOSITES

SECTION 06100 - ROUGH CARPENTRY

1.0 GENERAL CONDITIONS

1.01 GENERAL

The General Conditions for Construction Contracts - Public Housing Programs, Special Conditions and all portions of DIVISION 01 - GENERAL REQUIREMENTS shall govern this work wherein they apply.

1.02 SCOPE OF WORK

This Contractor shall furnish all labor, materials and equipment to complete all rough carpentry work shown on the Drawings, herein specified and/or required for a complete installation, including but not limited to, wood blocking, nailers, plywood and screws

This Contractor shall provide all labor and tools required to install the materials furnished by others, where called for in other Sections of the Specifications.

1.03 WORK SPECIFIED ELSEWHERE

a. DIVISION 07 - THERMAL AND MOISTURE PROTECTION, SECTION 07534 - THERMO-PLASTIC SINGLE PLY ROOFING - ADHERED

1.04 PROTECTION

The Carpentry Contractor shall protect all his work in an approved manner and shall make good all damage arising from improper protection.

Provide and maintain suitable temporary railings, barricades and all necessary barricade lights, signs and warnings for the protection of the public and others having access to the site.

1.05 GENERAL REQUIREMENTS

Carefully lay out, cut, fit and erect all blocking and other items of carpentry.

Brace, plumb and level all members and secure with sufficient nails, spikes and bolts to insure rigidity.

Wood blocking and nailers for roofing work.

2.0 MATERIALS

2.01 LUMBER

Lumber shall be sound stock thoroughly seasoned and well manufactured, free from warp or other defects which would impair strength or durability. Moisture content of lumber shall not exceed 19%. Lumber for rough carpentry, blocking, nailers, etc., shall be Construction Grade Douglas Fir, Southern Pine No. 2 or Owner approved equal.

2.0 MATERIALS (continued)

2.01 LUMBER (continued)

Where indicated on the Drawings, all permanent lumber used in conjunction with installation of the roofing, including woodwork at roof openings, roof curbs and plywood, shall be Wolmanized (Koppers Company, Inc., or Architect approved equal) pressure treatment conforming in all respects to the current Specifications of the American Wood Preserver's Association Standard "U1" and Commodity Spec. A. Chemical injection shall be 0.25 pounds per cubic foot of wood. Wood cut on the job shall have cut ends liberally coated with a concentrated solution of the preservative.

Where indicated on the Drawings, all permanent plywood backing, if shown or called for on the Drawings, shall be 3/4" thick, exterior grade, plywood C-C EXT-APA, unsanded pressure treated to meet Federal Specification TT-W-550 and TT-W-535, unless specifically called out differently on the Drawings.

Where indicated on the Drawings, plywood for roof sheathing shall be C-D EXT-APA in the thicknesses noted. Install with face grain across supports. Panel end joints shall occur over framing members. Allow 1/8" spacing at panel ends and 1/8" at panel edges. Nail 6" on center along panel edges and 12" on center at intermediate supports. Use nails sized for plywood thicknesses indicated.

3.0 WORKMANSHIP

3.01 GENERAL

All work shall be well fitted, accurately set and rigidly secured in place.

Cutting and fitting to accommodate other work shall be done as required and in a neat, workmanlike manner; any damaged work shall be patched or replaced.

4.0 INSTALLATION

4.01 WOOD NAILERS AND BLOCKING

Nailers shall be provided where shown on the Drawings and/or required to complete work. Bolts shall be countersunk into nailers. Top members of nailers shall be thoroughly spiked in place. Exterior face of nailers shall be plumb, level and straight in an even plane.

Wood members attached to metal roof deck shall be secured with 3/8" carriage bolts; for continuous nailers, bolts shall be placed not more than 48" on centers and not more than 18" from ends of joints.

Lumber shall be bored for bolts and countersunk for heads. Provide and install washers under all bolt heads and nuts. All nailers and other similar items, unless otherwise indicated, shall be furnished and installed in long lengths to minimize joints. Where joints are required, they shall be made with no projecting edges. Exterior face of nailers shall be plumb, level and straight in even planes.

5.0 GUARANTEE

5.01 GENERAL

The Subcontractor shall guarantee his work against faulty materials and workmanship (and from faulty design or detail if within his control) for a period of one year from date of occupancy or substantial completion of the entire project.

End of Section

DIVISION 07 - THERMAL AND MOISTURE PROTECTION

SECTION 07534 - THERMO-PLASTIC SINGLE PLY ROOFING - ADHERED

1.0 GENERAL CONDITIONS

1.01 GENERAL

The General Conditions for Construction Contracts - Public Housing Programs, Special Conditions and all portions of DIVISION 01 - GENERAL REQUIREMENTS shall govern this work wherein they apply.

1.02 DESCRIPTION

The project consists of installing Carlisle SynTec's Sure-Weld (TPO) Adhered Roofing System as outlined below or approved equal.

Apply the adhered roofing system over 1/2" Dens Deck in conjunction with two layers of 2.2" polyisocyanurate for an R = 25.2 after tear off of the existing roof to expose the wood deck for verification of suitable substrate as specified in this specification.

1.03 EXISTING CONDITIONS

If discrepancies are discovered between the existing conditions and those noted on the drawings, immediately notify the owner's representative by phone and solicit the manufacturer's approval prior to commencing with the work. Necessary steps shall be taken to make the building watertight until the discrepancies are resolved.

1.04 QUALITY ASSURANCE

The membrane must be manufactured by the material supplier. Manufacturer's supplying membrane made by others are not acceptable.

Unless otherwise noted in this specification, the roofing contractor must strictly comply with the manufacturer's current specifications and details.

The roofing system must be installed by an applicator authorized and trained by the manufacturer in compliance with shop drawings as approved by the manufacturer. The roofing applicator shall be thoroughly experienced and upon request be able to provide evidence of having at least five (5) years successful experience installing single-ply TPO roofing systems and having installed at least one (1) roofing application or several similar systems of equal or greater size within one year.

Provide adequate number of experienced workmen regularly engaged in this type of work who are skilled in the application techniques of the materials specified. Provide at least one thoroughly trained and experienced superintendent on the job at all times roofing work is in progress.

There shall be no deviations made from this specification or the approved shop drawings without the prior written approval of the specifier. Any deviation from the manufacturer's installation procedures must be supported by a written certification on the manufacturer's letterhead and presented for the specifier's consideration.

1.0 GENERAL CONDITIONS (continued)

1.04 QUALITY ASSURANCE (continued)

The Sure-Weld TPO White membrane meets CRRC (Cool Roof Rating Council) for reflectance and emittance. When tested in accordance with ASTM C1549, the Sure-Weld White material has an initial solar reflectance of 0.79 and a 3-year aged reflectance of 0.70. The material has also been tested for emittance in accordance with ASTM C1371; an initial emittance of 0.90 and a 3-year aged emittance of 0.86 were achieved.

The Sure-Weld White TPO membrane meets the emittance requirements set forth by the USGBC (U. S. Green Building Council) for their LEED (Leadership in Energy and Environmental Design) Program. The Sure-Weld White TPO material has an emittance of 0.90 (when tested in accordance with ASTM E408) and an SRI (solar reflectance index) of 99 (calculated using ASTM E 1980).

The Sure-Weld TPO Tan membrane meets CRRC (Cool Roof Rating Council) for reflectance and emittance. When tested in accordance with ASTM C1549, the Sure-Weld Tan material has an initial solar reflectance of 0.71. The material has also been tested for emittance in accordance with ASTM C1371; an initial emittance of 0.87 was achieved.

The Sure-Weld Tan TPO membrane meets the emittance requirements set forth by the USGBC (U. S. Green Building Council) for their LEED (Leadership in Energy and Environmental Design) Program. The Sure-Weld Tan TPO material has an emittance of 0.86 (when tested in accordance with ASTM E408) and an SRI (solar reflectance index) of 86 (calculated using ASTM E 1980).

Upon completion of the installation, the applicator shall arrange for an inspection to be made by a non-sales technical representative of the membrane manufacturer in order to determine whether or not corrective work will be required before the warranty will be issued. Notify the building owner seventy-two (72) hours prior to the manufacturer's final inspection.

1.05 JOB CONDITIONS, CAUTIONS AND WARNINGS

Refer to Carlisle's Sure-Weld Roofing System specification for general job site considerations.

Safety Data Sheets (SDS) must be on location at all times during the transportation, storage and application of materials.

When positioning membrane sheets, exercise care to locate all field splices away from low spots and out of drain sumps. All field splices should be shingled to prevent bucking of water.

When loading materials onto the roof, the Carlisle authorized roofing applicator must comply with the requirements of Lucas Metropolitan Housing Authority to prevent overloading and possible disturbance to the building structure.

Proceed with roofing work only when weather conditions are in compliance with the manufacturer's recommended limitations, and when conditions will permit the work to proceed in accordance with the manufacturer's requirements and recommendations.

1.0 GENERAL CONDITIONS (continued)

1.05 JOB CONDITIONS, CAUTIONS AND WARNINGS (continued)

Proceed with work so new roofing materials are not subject to construction traffic. When necessary, new roof sections shall be protected and inspected upon completion for possible damage.

Provide protection, such as 3/4" thick plywood, for all roof areas exposed to traffic during construction. Plywood must be smooth and free of fasteners and splinters.

The surface on which the insulation or roofing membrane is to be applied shall be clean, smooth, dry, and free of projections or contaminants that would prevent proper application of or be incompatible with the new installation, such as fins, sharp edges, foreign materials, oil and grease.

New roofing shall be complete and weather tight at the end of the work day.

Contaminants such as grease, fats and oils shall not be allowed to come in direct contact with the roofing membrane.

1.06 WARRANTY

Provide manufacturer's 30 year Total System Warranty covering both labor and material with no dollar limitation. The maximum wind speed coverage shall be peak gusts of 90 mph measured at 10 meters above ground level. Certification is required with bid submittal indicating the manufacturer has reviewed and agreed to such wind coverage.

Note:

Warranty Length	Minimum Membrane Thickness
30 year	80-mil Sure-Weld

Warranty shall also cover leaks caused by accidental punctures: 16 man-hours per year for 80-mil Sure-Weld.

Warranty shall also cover leaks caused by hail:

a. Hail up to 2" diameter hail when 80-mil Sure-Weld is adhered over SecurShield HD, SecurShield HD Plus, SecurShield HD or Stormbase Composite, Dens Deck Prime, or Securock.

When white Sure-Weld membrane is specified, a Reflectivity Warranty Amendment is available indicating the membrane will meet the Energy Star program reflectivity guidelines for both new and aged membrane for a period of 10 years.

Pro-rated System Warranties shall not be accepted.

Evidence of the manufacturer's warranty reserve shall be included as part of the project submittals for the specifier's approval.

2.0 MATERIALS

2.01 GENERAL

All components of the specified roofing system shall be products of Carlisle SynTec or approved equal.

All products (including insulation, fasteners, fastening plates, prefabricated accessories and edgings) must be manufactured and/or supplied by the roofing system manufacturer and covered by the warranty.

2.02 MEMBRANE

Furnish Sure-Weld SAT 80-mil thick white reinforced TPO (Thermoplastic Polyolefin) membrane as needed to complete the roofing system. Membrane thickness over the reinforcing scrim (top-ply thickness) shall be nominal 15 mil thick or greater. Membrane sheets in rolls 10' wide by 100' long.

2.03 INSULATION/UNDERLAYMENT

When applicable, insulation shall be installed in multiple layers. The first and second layers of insulation shall be mechanically fastened to the substrate in accordance with the manufacturer's published specifications.

Insulation shall be two layers of 2.2" polyisocyaurate insulation with a minimum R-value of (R=25.2). Include insulation "crickets" between the drains to help improve the drainage

A foam core insulation board covered on both sides with a medium weight fiber-reinforced felt facer meeting ASTM C 1289-06, Type II, Class 1, Grade 2 (20 psi) or Grade 3 (25 psi) will be used. The product is available in 4' x 8' standard size with a thickness from 1 to 4 inches. 4' x 4' tapered panels are also available through Carlisle - Insulbase Polyisocyanurate.

a. Dens Deck Prime

Gypsum core that incorporates glass-mat facings on the top and bottom side. The top surface is pre-primed and provides excellent bond strength for adhered membrane for use as a cover board. Available in 1/4" to 5/8" and 4'-0" x 4'-0" or 4'-0" x 8'-0" size boards.

2.04 FASTENING COMPONENTS

To be used for mechanical attachment of insulation and to provide additional membrane securement:

a. Fasteners, Plates and Bars

1. HP- Fasteners

A threaded, #14 fastener with a #3 phillips drive used with steel and wood roof decks.

2.0 MATERIALS (continued)

2.04 FASTENING COMPONENTS (continued)

a. Fasteners, Plates and Bars (continued)

2. HP-X Fasteners

A heavy duty #15 threaded fastener with a #3 phillips drive used for membrane or insulation securement into steel, wood plank or minimum 15/32" thick plywood when increased pullout resistance is desired.

3. Pre-Assembled ASAP Fasteners

A pre-assembled 3" diameter Plastic Plate and # 12 threaded fastener with a #3 drive used for insulation attachment into steel or wood decks. Installed using OMG Fastening Tools.

4. InsulFast Fasteners

A threaded #12 fastener with #3 phillips drive used for insulation attachment into steel or wood decks.

5. CD-10 Fasteners

A non-threaded, hammer driven fastener used with structural concrete roof decks rated 3,000 psi or greater.

6. Piranha Plates

A 2-3/8" diameter metal barbed fastening plate used with Carlisle HP-X or HP-14-10 Fasteners for membrane securement. This plate can be used for insulation securement.

7. Piranha Xtra Plates

A 2-3/8" diameter metal barbed fastening plate with an oversized hole for use with Carlisle HP-Xtra Fasteners for membrane securement.

8. Insulation Fastening Plates

A nominal 3" diameter plastic or metal plate used for insulation attachment.

9. Sure-Weld Pressure-Sensitive RUSS™ (Reinforced Universal Securement Strip)

A 6" wide, nominal 45-mil thick reinforced TPO membrane with 3" wide Pressure Sensitive Tape laminated along one edge. The 6" wide Pressure-Sensitive RUSS is used horizontally at the base of walls, curbs, etc., in conjunction with 2" diameter Seam Fastening Plates below the TPO deck membrane for additional membrane securement.

2.0 MATERIALS (continued)

2.04 FASTENING COMPONENTS (continued)

a. Fasteners, Plates and Bars (continued)

9. Sure-Weld Pressure-Sensitive RUSS™ (Reinforced Universal Securement Strip) (continued)

a) 6" wide Pressure-Sensitive RUSS is used horizontally or vertically at the base of walls, curbs, etc., in conjunction with Piranha Fastening Plates below the TPO deck membrane for additional membrane securement.

b) 10" wide Pressure-Sensitive RUSS is for perimeter membrane securement.

b. Insulation Adhesive

1. Carlisle OlyBond 500 BA

A two-component, construction-grade, low-rise, expanding polyurethane adhesive designed for bonding insulation to various substrates.

2.05 ADHESIVES, CLEANERS AND SEALANTS

All products shall be furnished by Carlisle and specifically formulated for the intended purpose.

a. Sure-Weld Bonding Adhesive

A high-strength, synthetic rubber adhesive used for bonding Sure-Weld membrane to various surfaces. The adhesive is applied to both the membrane and the substrate at a coverage rate of approximately 60 square feet per gallon per finished surface (includes coverage on both surfaces).

b. Low VOC Bonding Adhesive for TPO

This product meets the <250 gpl VOC (volatile organic compound) content requirements of the OTC Model Rule for Single-Ply Roofing Adhesives. A high strength, solvent-based contact adhesive that allows bonding of TPO membrane to various porous and non-porous substrates. Apply at a rate of 60 ft2 per gallon finished surface. Available in 5 gallon pails.

c. Low VOC Bonding Adhesive 1168

This product meets the <250 gpl VOC (volatile organic compound) content requirements of the OTC Model Rule for Single Ply Roofing Adhesives. A high strength, solvent-based contact adhesive the allows bonding of TPO membrane to various porous and non-porous substrates. Apply at a rate of 60 ft2 per gallon finished surface. Available in 5-gallon cans. This product complies with southern California counties with additional restrictions on solvents. See Carlisle's Product Data Sheet for a listing of the counties involved.

2.0 MATERIALS (continued)

2.05 ADHESIVES, CLEANERS AND SEALANTS (continued)

d. Aqua Base 120 Bonding Adhesive

A semi pressure-sensitive, water based adhesive used as a two-sided contact adhesive. Coverage rate is 120 square feet per gallon finished surface (applied to membrane and substrate). Refer to Spec Supplement G-10-17 "Aqua Base 120 Bonding Adhesive" for Warranty limitations and other considerations.

e. Cut-Edge Sealant

A white or clear colored sealant used to seal cut edges of reinforced Sure-Weld membrane. A coverage rate of approximately 225 - 275 linear feet per squeeze bottle can be achieved when a 1/8" diameter bead is applied.

f. Water Cut-Off Mastic

Used as a mastic to prevent moisture migration at drains, compression terminations and beneath conventional metal edging (at a coverage rate of approximately 10' per tube or 100' per gallon).

g. Universal Single-Ply Sealant

A 100% solids, solvent free, voc free, one part polyether sealant that provides a weather tight seal to a variety of building materials. It is white in color and is used for general caulking such as above termination bars and metal counter flashings and at scuppers.

h. Thermoplastic One-Part Pourable Sealer

A one-part, moisture curing, elastomeric polyether sealant used to fill TPO Molded Pourable Sealant Pockets. Packaged in 4, 2-liter foil pouches inside a reusable plastic bucket. 1 pouch will fill 2 TPO Molded Pourable Sealant Pockets.

i. Weathered Membrane Cleaner

Used to prepare membrane for heat welding that has been exposed to the elements or to remove general construction dirt at an approximate coverage rate of 400 square feet per gallon (one surface).

j. TPO Primer

A solvent-based primer used to prepare the surface of Sure-Weld Membrane prior to application of Pressure-Sensitive Coverstrip and TPO Pressure-Sensitive RUSS.

2.0 MATERIALS (continued)

2.05 ADHESIVES, CLEANERS AND SEALANTS (continued)

k. Carlisle CAV-GRIP III Low-VOC Aerosol Contact Adhesive/Primer

A low-VOC, methylene chloride-free adhesive that can be used for a variety of applications including: bonding Sure-Weld membrane to various surfaces, enhancing the bond between Carlisle's VapAir Seal 725TR and various substrates, priming unexposed asphalt prior to applying Flexible FAST Adhesive and for adhering Sure-Seal/Sure-Weld/Sure-Flex FleeceBACK and Sure-Seal EPDM or Sure-Weld TPO membrane to vertical walls. Coverage rate is approximately 2,000-2,500 sq. ft. per 40 lb. cylinder and 4,000-5,000 sq. ft. per 85 lb. cylinder as a primer, in a single-sided application and 750 sq. ft. per 40 lb. cylinder and 1,500 sq. ft. per 85 lb. cylinder as an adhesive for vertical walls, in a double-sided application.

2.06 METAL EDGING AND MEMBRANE TERMINATIONS

All metal edging s shall be tested and meet ANSI/SPRI ES-1 standards and comply with International Building Code.

a. SecurEdge 400

A coping or fascia, snap-on edge system consisting of a 22 gauge galvanized metal water dam and .040" thick aluminum, Kynar 500 finish or 24 gauge steel, Kynar 500 finish. Metal fascia color shall be as designated by the Owner's Representative. ANSI/SPRI ES-1 Certified.

b. SecurEdge 4000

A metal fascia system with a 20 gauge steel retainer bar and .040" thick aluminum, Kynar 500 or 24 gauge steel, Kynar 500 finish fascia. Metal fascia color shall be as designated by the Owner's Representative. ANSI/SPRI ES-1 Certified.

c. SecurEdge 300

A coping or fascia, snap-on edge system consisting of a 24 gauge galvanized metal water dam and .050" or .063" thick Kynar 500, clear and colored anodized finish or 24 gauge steel, Kynar 500 finish. Metal fascia color shall be as designated by the Owner's Representative. ANSI/SPRI ES-1 Certified. Coping FM Approved 1-90 with 20 ga. Cleat, 1-180 with 16 ga. Cleat. Fascia FM Approved 1-225.

d. SecurEdge 3000

A metal fascia system with a 20 gauge steel retainer bar and .032", .040" or .050" thick aluminum or 24 gauge galvanized steel fascia. Metal fascia color shall be as designated by the Owner's Representative. ANSI/SPRI ES-1 Certified. 3000 Coping FM Approved 1-465 with .050 aluminum retainer, 1-180 with 20 ga. Steel retainer. 3000 XT Coping FM Approved 1-315.

2.0 MATERIALS (continued)

2.06 METAL EDGING AND MEMBRANE TERMINATIONS (continued)

e. SecurEdge 200

A coping or fascia, snap-on edge system consisting of a 24 gauge galvanized metal water dam and .040", .050" or .063" thick Kynar 500, clear and colored anodized finish or 24 gauge steel, Kynar 500 finish. Metal fascia color shall be as designated by the Owner's Representative. ANSI/SPRI ES-1 Certified. Coping FM Approved 1-90. Fascia FM Approved 1-195.

f. SecurEdge 2000

A metal fascia system with an extruded aluminum anchor bar and .040" thick aluminum or 24 gauge galvanized steel fascia. Metal fascia color shall be as designated by the Owner's Representative. ANSI/SPRI ES-1 Certified. 2000 Fascia FM Approved 1-645. 2000 Extended Fascia FM Approved 1-270. 2000 Canted Fascia FM Approved 1-270.

g. Drip Edge

A metal fascia/edge system with a 22 or 24 gauge continuous anchor cleat and .032" thick aluminum or 24 gauge steel fascia. Metal fascia color shall be as designated by the Owner's Representative.

h. SecurEdge Coping

Incorporates a 20 gauge anchor cleat with 4 pre-slotted holes, a concealed joint cover and 10 foot continuous sections of coping cap; can accommodate minimum 5" wide parapet walls. Metal coping cap color shall be as designated by the Owner's Representative.

i. Termination Bar

A 1" wide and .098" thick extruded aluminum bar pre-punched 6" on center; incorporates a sealant ledge to support lap sealant and provide increased stability for membrane terminations.

j. SecurEdge Term Bar Fascia

A 1.75" wide formed aluminum termination bar with pre-slotted fastening holes for ease of locating and installing. The decorative cover is available in 0.040" aluminum or 24-gauge galvanized steel. SecurEdge Term Bar Fascia is manufactured in 12' lengths for fewer joints/seams, fewer sections to handle and faster installation.

2.07 WALKWAYS

Protective surfacing for roof traffic shall be TPO Walkway Rolls installed per manufacturer's requirements and as per the Drawings.

3.0 EXECUTION

3.01 GENERAL

Comply with the manufacturer's published instructions for the installation of the membrane roofing system including proper substrate preparation, job site considerations and weather restrictions.

Position sheets to accommodate contours of the roof deck and shingle splices to avoid bucking water.

3.02 INSULATION PLACEMENT AND ATTACHMENT

Install insulation or membrane underlayment over the substrate with boards butted tightly together with no joints or gaps greater than 1/4". Stagger joints horizontally and vertically if multiple layers are provided.

Secure insulation to the substrate with the required mechanical fasteners in accordance with the manufacturer's specifications.

3.03 MEMBRANE PLACEMENT AND ATTACHMENT

Position Sure-Weld membrane over the acceptable substrate. Fold membrane sheet back onto itself so half the underside of the membrane is exposed.

Apply Bonding Adhesive in accordance with the manufacturer's published instructions, to the exposed underside of the membrane and the corresponding substrate area. Do not apply Bonding Adhesive along the splice edge of the membrane to be hot air welded over the adjoining sheet. Allow the adhesive to dry until it is tacky but will not string or stick to a dry finger touch.

1. Remove the release liner on one half of the sheet starting from the split in the liner at the middle of the sheet. The liner should be removed at an angle to reduce risk of splitting or tearing.

2. Roll the membrane onto the substrate while avoiding wrinkles. To achieve the best adhesion, the membrane should be rolled onto the substrate at an angle with 150 lb. weighted roller. When applying the TPO membrane it is recommended to maintain a large curve on the leading edge of the membrane. This will help eliminate creases and bubbles that cannot be removed after the sheet is in place.

3. Fold back the remaining half of the sheet and repeat the above process

Position adjoining sheets to allow a minimum overlap of 2" to provide a minimum 1-1/2" hot air weld.

Continue to install adjoining membrane sheets in the same manner, overlapping edges a minimum of 2" and complete the bonding procedures as stated previously.

3.0 EXECUTION (continued)

3.05 MEMBRANE HOT AIR WELDING PROCEDURES

Hot air weld the membrane using an automatic hot air welding machine or hot air hand welder in accordance with the manufacturer's specifications. At all splice intersections, roll the seam with a silicone roller immediately after welder crossed the membrane step-off to ensure a continuous hot air welded seam.

Probe all seams once the hot air welds have thoroughly cooled (approximately 30 minutes).

Repair all seam deficiencies the same day they are discovered.

Apply cut edge sealant on all cut edges of reinforced membrane (where the scrim reinforcement is exposed) after seam probing is complete. Cut edge sealant is not required on vertical splices.

3.06 FLASHING

Flashing of parapets, curbs, expansion joints and other parts of the roof must be performed using reinforced membrane. Non-reinforced membrane can be used for flashing pipe penetrations, Sealant pockets and scuppers, as well as inside and outside corners, when the use of prefabricated accessories is not feasible.

Follow manufacturer's typical flashing procedures for all wall, curb, and penetration flashing including metal edging/coping and roof drain applications.

3.07 WALKWAYS

Install walkways at all traffic concentration points (such as roof hatches, access doors, rooftop ladders, etc.) and all locations as identified on the specifier's drawing.

Hot air weld walkway material to the membrane in accordance with the manufacturer's specifications.

3.08 DAILY SEAL

On phased roofing, when the completion of flashings and terminations is not achieved by the end of the work day, a daily seal must be performed to temporarily close the membrane to prevent water infiltration.

Complete an acceptable membrane seal in accordance with the manufacturer's requirements.

3.09 CLEAN UP

Perform daily clean up to collect all wrappings, empty containers, paper, and other debris from the project site. Upon completion, all debris must be disposed of in a legally acceptable manner.

3.0 EXECUTION (continued)

3.09 CLEAN UP (continued)

Prior to the manufacturer's inspection for warranty, the applicator must perform a pre-inspection to review all work and to verify all flashing has been completed as well as the application of all caulking.

End of Section

DIVISION 07 - THERMAL AND MOISTURE PROTECTION

SECTION 07550 - REROOFING

1.0 GENERAL CONDITIONS

1.01 GENERAL

The General Conditions for Construction Contracts - Public Housing Programs, Special Conditions and all portions of DIVISION 01 - GENERAL REQUIREMENTS shall govern this work wherein they apply.

1.02 SCOPE OF WORK

Provide all labor, transportation, materials and equipment necessary to perform all removals and new work required to reroof the sectors shown on Drawing Nos. A-1.1 and A-1.2.

1.03 WORK INCLUDED

This Contractor shall furnish all labor, materials and equipment to perform all operations in connection with the removal of existing roofing system and the furnishing and installation of the new roofing system, which consists of, but is not limited to, the following:

a. Roof Membrane.

b. Asphalt Shingles

c. Roof Insulation.

d. Tapered Roof Insulation and Crickets.

e. Flashing and Counterflashing.

f. Flashing of Roof Penetration, Roof Drains and Curbs.

g. Lead Pans at Roof Drains.

h. Plywood and Wood Blocking.

i. Mechanical Insulation Fasteners.

j. Roofing Cement and Adhesives.

k. Installation of Curbs, Fascias, Gutters, Scuppers and Equipment Curbs.

l. Caulking and Sealants.

m. Cutting, Patching, Removals and Reworking.

n. Painting

o. Tools and Equipment.

1.0 GENERAL CONDITIONS (continued)

1.03 WORK INCLUDED (continued)

p. Guarantees/Warranties

The existing installation at all of the vertical surfaces, flashings and fascias are to be retained, except where shown new, they are to be reworked and/or replaced as required to put them in a first class acceptable, weathertight condition, as required to qualify for a Twenty Year Bond with the Flashing Endorsement.

This Contractor shall furnish all labor, materials and equipment and shall perform all operations in connection with removals, furnishing and installing roofing, sheet metal work, composition and metal flashing, metal counterflashing, including the reworking of existing materials as required, complete as herein specified and shown on the Drawings and/or as required to meet the manufacturer's requirements.

The complete roofing and flashing installation covered by these Specifications must be approved by the Owner's Insurance Companies.

This Contractor shall examine the existing roof surfaces to make himself aware of the existing conditions and shall accept same as they are.

All cutting, patching, removals and reworking of existing roofing and deck in place shall be performed by this Contractor.

1.04 EXISTING ROOF CONSTRUCTION

The following is a description of the existing roof construction.

Glendale Terrace - Single Ply Membrane Roof over existing built up roofing.

1.05 REMOVALS

The removals shall consist of, but not be limited to, all existing roofing and materials, including flashings, gravel stops, insulation, fascias and vertical surface coverings as required to allow for the replacement or repair of same as specified and to allow for the new roofing system installation.

All removed materials shall be removed from the property of the Owner by this Contractor.

1.06 WOOD DECKING REPAIR - UNIT PRICE

In the space allotted for same, in the Proposal Form, quote the *Unit Price* for repairing any rotted or damaged wood deck. The exact type and thickness of the wood deck is unknown and must be field verified. The *Unit Price* shall be quoted in square feet and include any additional framing that is required. All repair materials and methods must be approved by the Architect.

1.0 GENERAL CONDITIONS (continued)

1.07 WOOD DECK FASTENING - UNIT PRICE

In the space allotted for same, in the Proposal Form, quote the *Unit Price*, *per fastener*, for refastening the plywood roof deck where the deck is found to be deteriorated from the supporting members. Plywood deck shall be fastened with galvanized steel or aluminum nails - ASTM F1667, minimum 12 gauge with 0.0808" shank and 3/8" diameter head complying with the Building Code. The unit price shall be for units of 100 square feet.

1.08 SOFFIT REPLACEMENT - UNIT PRICE

In the space allotted for same, in the Proposal Form, quote the *Unit Price* to replace deteriorated or damaged soffit material. Material will match what is currently in place and must be field verified. The unit price shall be for 100 square feet.

1.09 WOOD BLOCKING REPLACEMENT - UNIT PRICE

In the space allotted for same, in the Proposal Form, quote the *Unit Price* for furnishing the labor and materials to replace any wood blocking at the roof's edge that has rotted, to the extent that it must be replaced. The wood blocking used to replace any rotted blocking is to be the same size and shape as that being removed and shall be pressure treated lumber conforming to the current American Wood Preservers Association Standard "U1" Commodity Spec A.

The *Unit Price* quoted shall be based on a lineal foot.

1.10 SET-UP AREAS

Areas shall be agreed upon with the Roofing Contractor and the Owner in respect to locations for the Contractor to set up his operations for the purpose of raising the new materials to the roof level. Refer to Drawing No. C-1.

1.11 PREJOB MEETING

The Roofing Contractor shall meet with the Architect and the Owner to review the Specifications for the installation of the insulation, roofing and flashing work and to agree upon a complete understanding of the requirements and responsibilities relative to deck acceptability, scope of work, storage and type of materials, flashing details, guarantee, etc., necessary to accomplish a first-class acceptable project in compliance with the intent of the Drawings and Specifications.

1.12 PROJECT INSPECTION

A field inspector representing the Owner and the Architect will be furnished weekly for this project. Weekly reports will be written and photographs will be taken.

2.0 NEW ROOFING

2.01 GENERAL

Furnish all labor, materials and equipment required to install a completely new roofing system.

Materials shall be Underwriters' Laboratories', Inc., listed for Class A roof coverings.

2.02 QUALIFICATIONS OF ROOFER

The applicator of roofing work shall be approved by and shall operate under a franchise from the manufacturer of the roofing materials used. He shall have a minimum of ten years' experience and shall have completely operational equipment of sufficient quantity to perform this work efficiently.

2.03 MANUFACTURER'S LITERATURE

Submit two copies of the roofing materials manufacturer's written Specifications for the materials and methods proposed for use, for review and approval by the Architect. This literature shall identify each component and shall certify compliance of each component with the applicable ASTM Standard.

2.04 ROOFING MATERIAL MANUFACTURER'S CERTIFICATION

Submit a written certification from the manufacturer of the roofing material that the materials and methods proposed for use have been reviewed and conform with his written Specifications for a bondable roof with flashing endorsement.

Submit two copies of a letter, from the manufacturer of the roofing materials, signed by an authorized official setting forth the procedures for application of the roofing system. The letter shall refer to the number by which the manufacturer identifies the specific bonded type roof to be installed, together with printed instructions pertaining to the proper application of such roofing system.

Upon completion of the roofing work, submit a written certificate to the Owner, signed by the Contractor, stating that all roofing and base flashing were furnished and installed in strict accordance with the roofing material manufacturer's procedures as set forth in the above letter.

2.05 MATERIAL DELIVERY, STORAGE AND HANDLING

Deliver only acceptable materials to the site. Deliver materials in original containers with all seals and labels intact. If bitumen materials are delivered to the site in bulk, each shipment shall be accompanied by a written certificate from the materials manufacturer clearly stating the type, quality, softening point and other pertinent data.

Store materials at the site in properly protected and dry storage facilities, until ready for use. *Wet, damp or damaged materials shall not be used.*

2.0 NEW ROOFING (continued)

2.05 MATERIAL DELIVERY, STORAGE AND HANDLING (continued)

Do not store more than one day's supply of materials on the roof at any time. While on the roof, stack materials on pallets, and completely cover with plastic sheet or waterproof tarpaulin whenever work is interrupted or when there is precipitation of any kind, secured to the pallets in such a way as to be completely weathertight. *Material not so protected shall be permanently removed from the site*.

Locate flame-heated equipment so as not to endanger the structure, or other materials on the site or adjacent property. No heating kettles may be located on the roof or inside the structure. Provide and maintain fire extinguishers of appropriate, approved type throughout the construction area. Clean off all surfaces that may become soiled from roofing materials.

2.06 WEATHER CONDITIONS

Do not install materials when rain, cold, moisture, frost, snow or other climatic conditions prevent adhesion of bitumen or the formation of a homogeneous membrane. When ambient air temperature is less than 45°F, roofing work will be permitted only upon written approval and then only after receipt of written assurance that all materials will be installed properly and in full compliance with the Specifications under such conditions.

2.07 MATERIALS

The following materials shall be used on Glendale Terrace:

a. Insulation

Mechanically fasten two layers of 2.2" polyisocyaurate insulation in accordance with the manufacturer's recommendations (R=25.2). Include insulation "crickets" between the drains to help improve the drainage

b. Fasteners

See Drawings for type of fasteners and methods of fastening.

2.08 VENTS, STACKS AND SUPPORTS

All vent pipes, stacks, equipment supports and all other projections penetrating the roofing, whether indicated on the Drawings or not, must have a proper metal sleeve flashing with flange, furnished by this Contractor. Refer to Drawings for details.

All flashings at existing penetrations must be removed and replaced and/or reworked as required to provide a first class acceptable installation.

3.0 INSTALLATION PROCEDURES

3.01 GENERAL

Apply materials over smooth, dry surfaces that are free from dirt, debris and other coating that prevent adhesion of materials to be applied. Have all temporary structures, tools, equipment, loose rubbish and debris removed from areas to be covered. Do not apply materials over wet, damp, frosty or frozen surfaces. Do not apply materials when effects of low temperature or excessive moisture would prevent bonding of materials to substrates.

3.02 INSULATION

This Contractor shall apply no more insulation in one day *than can be completely roofed over the same day*.

Temporary water cut-offs must be installed at the end of each day's work to protect the roof insulation. Upon resumption of the work, they must be completely removed.

Do not use damaged or wet insulation, and do not install more insulation than can be completely covered with the complete roofing membrane and gravel on the same day. At the end of each day's work, seal exposed edges of insulation with 14" wide cut-off strips, extend half over the insulation and half over the roof deck. Remove such strips prior to restarting roofing operations. Fill flutes of deck to prevent water from running in flutes under areas that have been roofed.

Taper insulation around roof drains to provide for positive drainage to the drains.

Roof insulation *shall not* be installed when either or both of the following conditions exist:

a. Unstable weather conditions that do not assure a completely dry roof deck and insulation.

b. Traffic by crews and equipment of other trades that may permanently injure roof insulation or roof deck.

All insulation shall be completely dry before, during and after installation. *Any insulation which becomes damaged and/or wet after installation shall be completely removed to the satisfaction of the Architect and replaced with dry undamaged material*.

All insulation stored on the job shall be raised above the deck or ground level on platforms and covered with waterproof tarpaulins.

Lay each layer of roof insulation in parallel courses to the layer above or below. Stagger end joints in adjacent courses. Stagger joints in each layer with the joints in the layer below. Butt each panel tightly to adjacent panels. *Discard damaged panels, and do not use any insulation that is less than 6" in any direction*.

3.03 ROOF DRAINS

All roof drains are to be reworked as required by the installation of the new roofing. Avoid building up the plies around the roof drains, so that a dam *is not built* around each drain. Unless damaged, all existing roof drains are to be reused. *Install a 3'-0" square, 4 pound lead pan at all roof drains*.

3.0 INSTALLATION PROCEDURES (continued)

3.04 WOOD BLOCKING

This Contractor shall furnish and install all new wood blocking, including fasteners as required to build up the existing roof edge to the height shown on the Drawings.

All wood used in conjunction with the roof construction shall be pressure treated lumber which conforms in all respects to the current American Wood Preservers Association Standard "U1" Commodity Spec A.

3.05 DISSIMILAR METAL

At any place where dissimilar metals adjoin, they shall be permanently and completely together by a nonconductor, or shall permanently and positively be separated with a sufficient gap so there will be no possibility of any galvanic or electrolytic action between them.

3.06 ROOF DRAIN LEAD PANS

Extend roofing felts to the outside edge on the roof drain bowl. Furnish and install a 3'-0" square, 4 pound sheet lead flashing *embedded in the roofing cement* in the sump at all existing roofing drains. Apply a flashing of two plies of roofing felt with one ply of glass fabric over 4 pound lead flashing edges to the roofing felts. Embed flashing in the roofing cement. Apply a final roof surfacing over stripping on flanges and roofing.

Taper insulation at roof drains to allow for proper drainage and to compensate for the added thickness of insulation.

3.07 EXISTING ROOF AREAS

All existing roof areas at the low elevation of the main roof must be covered with sheets of plywood wherever any traffic is to take place. The existing roof surface must be protected from damage, and if damage should occur, it shall be repaired at no expense to the Owner.

3.08 NEW ROOF SURFACES

The removal of the existing roof and the placement of the new roof must be coordinated to prevent traffic over newly completed roof areas.

3.09 PROTECTION

The Contractor shall provide adequate protection on the side of the building where roofing materials are raised to the roof level.

When the existing roofing materials are removed in an area, provide protection in the floor area below to prevent seeping rain water through the roof deck from damaging existing in place facilities.

3.10 SET UP AREAS

Areas have been selected for the Contractor to set up his operations for the purpose of removing the existing roofing materials from the roof and to raise the new materials to the roof level. These areas will be coordinated with the Owner.

3.0 INSTALLATION PROCEDURES (continued)

3.11 PREJOB MEETING

A prejob meeting will be held at the project site with the Contractor, the Owner and the Architect. At that time, it is required that all material submittals be furnished and that all items pertaining to this project will be discussed and documented.

A date for this meeting will be given to the successful Bidder at a later date.

3.12 PROJECT INSPECTION

An inspector may be furnished for this project. It is the intent that this inspector shall be on the roof, following this project, at all times when roofing is being installed.

Weekly reports will be written and photographs will be taken.

4.0 GUARANTEES

4.01 ROOF GUARANTEE

The Contractor, for the work contemplated by these Drawings and Specifications, guarantees to the Owner the complete and proper installation of all work furnished by him, for one year from the date of substantial completion, which shall be in strict accordance with the true intent of the Drawings and Specifications. If the Contractor is not satisfied that the requirements set forth will make such guarantee possible, he shall submit with his Bid a brief statement of such changes as he desires to have made therein which will enable him to give such guarantee.

The Contractor shall also guarantee to protect the Owner from any loss from any alleged patent infringement in any of the materials furnished by him.

Any defects in workmanship or materials that may develop within a period of two years from date of final completion and all direct and indirect damage caused by defective work of any kind, shall be made good by this Contractor without expense to the Owner.

4.02 ROOF INSPECTION AND SERVICE GUARANTEE

The *manufacturer roofing guarantee* shall provide for the repair of all roof leaks, including the cost of materials and labor, without expense to the Owner, for a period listed in the Specification Sections.

If the Roofing Contractor is not satisfied that the requirements here set forth will make the guarantee possible, he shall submit with his Bid a brief statement of such changes as he desires to have made therein which will enable him to give such guarantee.

4.03 CLEAN UP

This Contractor shall remove all rubbish and debris from the job site, which is caused by this work. He must sweep the area broom clean.

End of Section

SECTION 23 0513 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on ac power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.2 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:

1. Motor controllers.
2. Torque, speed, and horsepower requirements of the load.
3. Ratings and characteristics of supply circuit and required control sequence.
4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

A. Comply with NEMA MG 1 unless otherwise indicated.

2.2 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet (1000 m) above sea level.

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

2.3 POLYPHASE MOTORS

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

B. Efficiency: Energy efficient, as defined in NEMA MG 1.

C. Service Factor: 1.15.

D. Multispeed Motors: Variable torque.

1. For motors with 2:1 speed ratio, consequent pole, single winding.
2. For motors with other than 2:1 speed ratio, separate winding for each speed.

E. Rotor: Random-wound, squirrel cage.

F. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

G. Temperature Rise: Match insulation rating.

H. Insulation: Class F.

I. Code Letter Designation:

1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.

J. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

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

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

1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
2. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

2.5 SINGLE-PHASE MOTORS

A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:

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

B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.

C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

D. Motors 1/20 HP and Smaller: Shaded-pole type.

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

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 230513

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SECTION 23 0517 - SLEEVES AND SLEEVE SEALS FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Sleeves.
2. Sleeve-seal systems.
3. Grout.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.

C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.

D. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.

E. Galvanized-Steel-Sheet Sleeves: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.

2.2 SLEEVE-SEAL SYSTEMS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Advance Products & Systems, Inc.
2. CALPICO, Inc.
3. Metraflex Company (The).
4. Pipeline Seal and Insulator, Inc.
5. Proco Products, Inc.

B. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.

1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: Stainless Steel.
3. Connecting Bolts and Nuts: Stainless Steel of length required to secure pressure plates to sealing elements.

2.3 GROUT

A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Nonshrink; recommended for interior and exterior applications.

C. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch (25-mm) annular clear space between piping and concrete slabs and walls.

1. Sleeves are not required for core-drilled holes.

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.

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 (50 mm) above finished floor level.

2. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.

1. Cut sleeves to length for mounting flush with both surfaces.
2. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation.

3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Section 079200 "Joint Sealants."

E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.3 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:

1. Exterior Concrete Walls above Grade:

   a. Piping Smaller Than NPS 6 (DN 150) Galvanized-steel-pipe sleeves.
   b. Piping NPS 6 (DN 150) Galvanized-steel-pipe sleeves.

2. Exterior Concrete Walls below Grade:

   a. Piping Smaller Than NPS 6 (DN 150) Galvanized-steel-pipe sleeves with sleeve-seal system.

      1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.

   b. Piping NPS 6 (DN 150) and Larger: Galvanized-steel-pipe sleeves with sleeve-seal system.

      1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.

3. Concrete Slabs-on-Grade:

   a. Piping Smaller Than NPS 6 (DN 150) : Galvanized-steel-pipe sleeves with sleeve-seal system.

      1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.

b. Piping NPS 6 (DN 150) and Larger: Galvanized-steel-pipe sleeves with sleeve-seal system.

1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.

4. Concrete Slabs above Grade:

a. Piping Smaller Than NPS 6 (DN 150): [Galvanized-steel-pipe sleeves.
b. Piping NPS 6 (DN 150) and Larger: Galvanized-steel-pipe sleeves.

5. Interior Partitions:

a. Piping Smaller Than NPS 6 (DN 150): Galvanized-steel-pipe sleeves.
b. Piping NPS 6 (DN 150) and Larger: Galvanized-steel-sheet sleeves.

END OF SECTION 230517

SECTION 23 0519 - METERS AND GAGES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Bimetallic-actuated thermometers.
2. Liquid-in-glass thermometers.
3. Thermowells.
4. Dial-type pressure gages.
5. Gage attachments.
6. Pitot-tube flowmeters.
7. Turbine flowmeters.
8. Venturi flowmeters.
9. Impeller-turbine, thermal-energy meters.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Wiring Diagrams: For power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Product certificates.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 BIMETALLIC-ACTUATED THERMOMETERS

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

1. Ashcroft Inc.
2. Ernst Flow Industries.
3. Marsh Bellofram.
4. Miljoco Corporation.
5. Nanmac Corporation.

6. Noshok.
7. Palmer Wahl Instrumentation Group.
8. REOTEMP Instrument Corporation.
9. Tel-Tru Manufacturing Company.
10. Trerice, H. O. Co.
11. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
12. Weiss Instruments, Inc.
13. WIKA Instrument Corporation - USA.
14. Winters Instruments - U.S.

B. Standard: ASME B40.200.

C. Case: sealed type(s); stainless steel with 6-inch nominal diameter.

D. Dial: Nonreflective aluminum with permanently etched scale markings and scales in deg F (deg C).

E. Connector Type(s): Union joint, adjustable angle, with unified-inch screw threads.

F. Connector Size: 1/2 inch (13 mm), with ASME B1.1 screw threads.

G. Stem: 0.25 or 0.375 inch (6.4 or 9.4 mm) in diameter; stainless steel.

H. Window: Plain glass.

I. Ring: Stainless steel.

J. Element: Bimetal coil.

K. Pointer: Dark-colored metal.

L. Accuracy: Plus or minus 1 percent of scale range.

2.2 LIQUID-IN-GLASS THERMOMETERS

A. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:

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

   a. Flo Fab Inc.
   b. Miljoco Corporation.
   c. Palmer Wahl Instrumentation Group.
   d. Tel-Tru Manufacturing Company.
   e. Trerice, H. O. Co.
   f. Weiss Instruments, Inc.
   g. Winters Instruments - U.S.

2. Standard: ASME B40.200.
3. Case: Cast aluminum 9-inch (229-mm) nominal size unless otherwise indicated.

4. Case Form: Adjustable angle unless otherwise indicated.
5. Tube: Glass with magnifying lens and blue or red organic liquid.
6. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F (deg C).
7. Window: Glass.
8. Stem: Aluminum and of length to suit installation.

    a. Design for Air-Duct Installation: With ventilated shroud.
    b. Design for Thermowell Installation: Bare stem.

9. Connector: 1-1/4 inches (32 mm), with ASME B1.1 screw threads.
10. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

B. Plastic-Case, Industrial-Style, Liquid-in-Glass Thermometers:

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

    a. Ernst Flow Industries.
    b. Marsh Bellofram.
    c. Miljoco Corporation.
    d. Palmer Wahl Instrumentation Group.
    e. REOTEMP Instrument Corporation.
    f. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
    g. Weiss Instruments, Inc.
    h. WIKA Instrument Corporation - USA.

2. Standard: ASME B40.200.
3. Case: Plastic 9-inch (229-mm) nominal size unless otherwise indicated.
4. Case Form: Adjustable angle unless otherwise indicated.
5. Tube: Glass with magnifying lens and blue or red organic liquid.
6. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F (deg C).
7. Window: Glass.
8. Stem: Aluminum and of length to suit installation.

    a. Design for Air-Duct Installation: With ventilated shroud.
    b. Design for Thermowell Installation: Bare stem.

9. Connector: 1-1/4 inches (32 mm), with ASME B1.1 screw threads.
10. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

2.3 DUCT-THERMOMETER MOUNTING BRACKETS

A. Description: Flanged bracket with screw holes, for attachment to air duct and made to hold thermometer stem.

2.4 THERMOWELLS

A. Thermowells:

1. Standard: ASME B40.200.
2. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.
3. Material for Use with Copper Tubing: CNR or CUNI.
4. Material for Use with Steel Piping: CRES CSA .
5. Type: Stepped shank unless straight or tapered shank is indicated.
6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, (DN 15, DN 20, or NPS 25,) ASME B1.20.1 pipe threads.
7. Internal Threads: 1/2, 3/4, and 1 inch (13, 19, and 25 mm), with ASME B1.1 screw threads.
8. Bore: Diameter required to match thermometer bulb or stem.
9. Insertion Length: Length required to match thermometer bulb or stem.
10. Lagging Extension: Include on thermowells for insulated piping and tubing.
11. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

B. Heat-Transfer Medium: Mixture of graphite and glycerin.

2.5 PRESSURE GAGES

A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:

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

    a. AMETEK, Inc.; U.S. Gauge.
    b. Ashcroft Inc.
    c. Ernst Flow Industries.
    d. Flo Fab Inc.
    e. Marsh Bellofram.
    f. Miljoco Corporation.
    g. Noshok.
    h. Palmer Wahl Instrumentation Group.
    i. REOTEMP Instrument Corporation.
    j. Tel-Tru Manufacturing Company.
    k. Trerice, H. O. Co.
    l. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
    m. Weiss Instruments, Inc.
    n. WIKA Instrument Corporation - USA.
    o. Winters Instruments - U.S.

2. Standard: ASME B40.100.
3. Case: Sealed type(s); cast aluminum or drawn steel ; 6-inch (152-mm) nominal diameter.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2 (DN 8 or DN 15) , ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
6. Movement: Mechanical, with link to pressure element and connection to pointer.

7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi (kPa).
8. Pointer: Dark-colored metal.
9. Window: Glass.
10. Ring: Brass.
11. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

2.6 GAGE ATTACHMENTS

A. Snubbers: ASME B40.100, brass; with NPS 1/4 or NPS 1/2 (DN 8 or DN 15), ASME B1.20.1 pipe threads and piston porous-metal-type surge-dampening device. Include extension for use on insulated piping.

B. Siphons: Loop-shaped section of brass pipe with NPS 1/4 or NPS 1/2 (DN 8 or DN 15) pipe threads.

C. Valves: Brass or stainless-steel needle, with NPS 1/4 or NPS 1/2 (DN 8 or DN 15), ASME B1.20.1 pipe threads.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install thermowells with socket extending a minimum of 2 inches (51 mm) into fluid and in vertical position in piping tees.

B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.

C. Install thermowells with extension on insulated piping.

D. Fill thermowells with heat-transfer medium.

E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.

F. Install remote-mounted thermometer bulbs in thermowells and install cases on panels; connect cases with tubing and support tubing to prevent kinks. Use minimum tubing length.

G. Install duct-thermometer mounting brackets in walls of ducts. Attach to duct with screws.

H. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.

I. Install remote-mounted pressure gages on panel.

J. Install valve and snubber in piping for each pressure gage for fluids (except steam).

K. Install valve and syphon fitting in piping for each pressure gage for steam.

L. Install flow indicators in piping systems in accessible positions for easy viewing.

M. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters according to manufacturer's written instructions.

N. Install flowmeter elements in accessible positions in piping systems.

O. Install differential-pressure-type flowmeter elements, with at least minimum straight lengths of pipe, upstream and downstream from element according to manufacturer's written instructions.

P. Install permanent indicators on walls or brackets in accessible and readable positions.

Q. Install connection fittings in accessible locations for attachment to portable indicators.

R. Mount thermal-energy meters on wall if accessible; if not, provide brackets to support meters.

S. Install thermometers in the following locations:

1. Inlet and outlet of each hydronic zone.
2. Inlet and outlet of each hydronic boiler.
3. Two inlets and two outlets of each chiller.
4. Inlet and outlet of each hydronic coil in air-handling units.
5. Two inlets and two outlets of each hydronic heat exchanger.
6. Inlet and outlet of each thermal-storage tank.
7. Outside-, return-, supply-, and mixed-air ducts.

T. Install pressure gages in the following locations:

1. Discharge of each pressure-reducing valve.
2. Inlet and outlet of each chiller chilled-water and condenser-water connection.
3. Suction and discharge of each pump.

3.2 CONNECTIONS

A. Install meters and gages adjacent to machines and equipment to allow service and maintenance of meters, gages, machines, and equipment.

B. Connect flowmeter-system elements to meters.

C. Connect flowmeter transmitters to meters.

D. Connect thermal-energy meter transmitters to meters.

3.3 ADJUSTING

A. After installation, calibrate meters according to manufacturer's written instructions.

B. Adjust faces of meters and gages to proper angle for best visibility.

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SECTION 23 0529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Thermal-hanger shield inserts.
4. Fastener systems.
5. Equipment supports.

1.2 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design trapeze pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

1. Design supports for multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.
2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
3. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following; include Product Data for components:

1. Trapeze pipe hangers.
2. Equipment supports.

C. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.5 QUALITY ASSURANCE

A. Structural Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.

B. Stainless-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
3. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.

C. Copper Pipe Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.

2.2 TRAPEZE PIPE HANGERS

A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.3 THERMAL-HANGER SHIELD INSERTS

A. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psig (688-kPa) minimum compressive strength and vapor barrier.

B. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate with 100-psig (688-kPa) minimum compressive strength.

C. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

D. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

E. Insert Length: Extend 2 inches (50 mm) beyond sheet metal shield for piping operating below ambient air temperature.

2.4 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

B. Mechanical-Expansion Anchors: Insert-wedge-type, stainless steel anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

2.5 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

2.6 MISCELLANEOUS MATERIALS

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

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

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

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

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

C. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

D. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches (100 mm) thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

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

F. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

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

H. Install lateral bracing with pipe hangers and supports to prevent swaying.

I. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 (DN 65) and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

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

K. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

L. Insulated Piping:

1. Attach clamps and spacers to piping.

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

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

   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.

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

   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.

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

   a. NPS 1/4 to NPS 3-1/2 (DN 8 to DN 90): 12 inches (305 mm) long and 0.048 inch (1.22 mm) thick.
   b. NPS 4 (DN 100): 12 inches (305 mm) long and 0.06 inch (1.52 mm) thick.
   c. NPS 5 and NPS 6 (DN 125 and DN 150): 18 inches (457 mm) long and 0.06 inch (1.52 mm) thick.
   d. NPS 8 to NPS 14 (DN 200 to DN 350): 24 inches (610 mm) long and 0.075 inch (1.91 mm) thick.
   e. NPS 16 to NPS 24 (DN 400 to DN 600): 24 inches (610 mm) long and 0.105 inch (2.67 mm) thick.

5. Pipes NPS 8 (DN 200) and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.2 EQUIPMENT SUPPORTS

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

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

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.3 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers.

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/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:

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

3.4 ADJUSTING

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

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches (40 mm).

3.5 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils (0.05 mm).

B. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 09.

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

3.6 HANGER AND SUPPORT SCHEDULE

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

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

C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use carbon-steel pipe hangers and supports and metal trapeze pipe hangers and attachments for general service applications.

F. Use stainless-steel pipe hangers and stainless-steel attachments for hostile environment applications.

G. Use copper-plated pipe hangers and stainless-steel attachments for copper piping and tubing.

H. Use padded hangers for piping that is subject to scratching.

I. Use thermal-hanger shield inserts for insulated piping and tubing.

J. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F (566 deg C), pipes NPS 4 to NPS 24 (DN 100 to DN 600), requiring up to 4 inches (100 mm) of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36 (DN 20 to DN 900), requiring clamp flexibility and up to 4 inches (100 mm) of insulation.
4. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
5. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).
6. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36 (DN 100 to DN 900), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
7. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36 (DN 100 to DN 900), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
8. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30 (DN 25 to DN 750), from two rods if longitudinal movement caused by expansion and contraction might occur.
9. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 (DN 50 to DN 1050) if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.

K. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24 (DN 24 to DN 600).

2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 (DN 20 to DN 600) if longer ends are required for riser clamps.

L. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches (150 mm) for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F (49 to 232 deg C) piping installations.

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

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads:

    a. Light (MSS Type 31): 750 lb (340 kg).
    b. Medium (MSS Type 32): 1500 lb (680 kg).
    c. Heavy (MSS Type 33): 3000 lb (1360 kg).

8. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
9. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.

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

1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

O. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches (32 mm).
2. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.

3. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.

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

Q. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION 230529

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SECTION 23 0548 - VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Isolation pads.
2. Isolation mounts.
3. Restrained elastomeric isolation mounts.
4. Freestanding spring isolators.
5. Housed spring mounts.
6. Elastomeric hangers.
7. Spring hangers.
8. Spring hangers with vertical-limit stops.
9. Pipe riser resilient supports.
10. Resilient pipe guides.
11. Restraining braces and cables.

1.2 ACTION SUBMITTALS

A. Product Data: For each product indicated.

B. Delegated-Design Submittal: For vibration isolation and seismic-restraint calculations and details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For professional engineer.

B. Welding certificates.

C. Field quality-control test reports.

1.4 QUALITY ASSURANCE

A. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

B. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

C. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

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

B. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

1. Ace Mountings Co., Inc.
2. Amber/Booth Company, Inc.
3. California Dynamics Corporation.
4. Isolation Technology, Inc.
5. Kinetics Noise Control.
6. Mason Industries.
7. Vibration Eliminator Co., Inc.
8. Vibration Isolation.
9. Vibration Mountings & Controls, Inc.

C. Pads : Arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.

1. Resilient Material: Oil- and water-resistant neoprene.

D. Mounts : Double-deflection type, with molded, oil-resistant rubber, hermetically sealed compressed fiberglass, or neoprene isolator elements with factory-drilled, encapsulated top plate for bolting to equipment and with baseplate for bolting to structure. Color-code or otherwise identify to indicate capacity range.

1. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
2. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.

E. Restrained Mounts: All-directional mountings with seismic restraint.

1. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
2. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.

F. Spring Isolators : Freestanding, laterally stable, open-spring isolators.

1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
5. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch- (6-mm-) thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig (3447 kPa).
6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

G. Restrained Spring Isolators : Freestanding, steel, open-spring isolators with seismic or limit-stop restraint.

1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to 1/4-inch- (6-mm-) thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
2. Restraint: Seismic or limit stop as required for equipment and authorities having jurisdiction.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

H. Housed Spring Mounts : Housed spring isolator with integral seismic snubbers.

1. Housing: Ductile-iron or steel housing to provide all-directional seismic restraint.
2. Base: Factory drilled for bolting to structure.
3. Snubbers: Vertically adjustable to allow a maximum of 1/4-inch (6-mm) travel up or down before contacting a resilient collar.

I. Elastomeric Hangers : Single or double-deflection type, fitted with molded, oil-resistant elastomeric isolator elements bonded to steel housings with threaded connections for hanger rods. Color-code or otherwise identify to indicate capacity range.

J. Spring Hangers : Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
7. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

K. Spring Hangers with Vertical-Limit Stop : Combination coil-spring and elastomeric-insert hanger with spring and insert in compression and with a vertical-limit stop.

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
7. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
8. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

L. Pipe Riser Resilient Support : All-directional, acoustical pipe anchor consisting of 2 steel tubes separated by a minimum of 1/2-inch- (13-mm-) thick neoprene. Include steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions. Design support for a maximum load on the isolation material of 500 psig (3.45 MPa) and for equal resistance in all directions.

M. Resilient Pipe Guides: Telescopic arrangement of 2 steel tubes or post and sleeve arrangement separated by a minimum of 1/2-inch- (13-mm-) thick neoprene. Where clearances are not readily visible, a factory-set guide height with a shear pin to allow vertical motion due to pipe expansion and contraction shall be fitted. Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

B. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

3.2 VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Comply with requirements in Division 07 "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.

B. Equipment Restraints:

1. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch (3.2 mm).

C. Piping Restraints:

1. Comply with requirements in MSS SP-127.
2. Space lateral supports a maximum of 40 feet (12 m) o.c., and longitudinal supports a maximum of 80 feet (24 m) o.c.
3. Brace a change of direction longer than 12 feet (3.7 m).

D. Install cables so they do not bend across edges of adjacent equipment or building structure.

E. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

F. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

G. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Set anchors to manufacturer's recommended torque, using a torque wrench.

5. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
5. Test to 90 percent of rated proof load of device.
6. Measure isolator restraint clearance.
7. Measure isolator deflection.
8. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.

C. Remove and replace malfunctioning units and retest as specified above.

D. Prepare test and inspection reports.

3.4 ADJUSTING

A. Adjust isolators after piping system is at operating weight.

B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

C. Adjust active height of spring isolators.

D. Adjust restraints to permit free movement of equipment within normal mode of operation.

END OF SECTION 230548

SECTION 23 0553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following mechanical identification materials and their installation:

1. Equipment markers.
2. Access panel and door markers.
3. Pipe markers.
4. Duct markers.
5. Stencils.
6. Valve tags.
7. Valve schedules.
8. Warning tags.

2.2 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Valve numbering scheme.

D. Valve Schedules: For each piping system. Furnish extra copies (in addition to mounted copies) to include in maintenance manuals.

2.3 QUALITY ASSURANCE

A. ASME Compliance: Comply with ASME A13.1, "Scheme for the Identification of Piping Systems," for letter size, length of color field, colors, and viewing angles of identification devices for piping.

2.4 COORDINATION

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with location of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

PRODUCTS

2.5 EQUIPMENT IDENTIFICATION DEVICES

A. Equipment Markers: Engraved, color-coded laminated plastic. Include contact-type, permanent adhesive.

1. Terminology: Match schedules as closely as possible.
2. Data:

    a. Name and plan number.
    b. Equipment service.
    c. Design capacity.
    d. Other design parameters such as pressure drop, entering and leaving conditions, and speed.

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

B. Access Panel and Door Markers: 1/16-inch- thick, engraved laminated plastic, with abbreviated terms and numbers corresponding to identification. Provide 1/8-inch center hole for attachment.

1. Fasteners: Self-tapping, stainless-steel screws or contact-type, permanent adhesive.

2.6 PIPING IDENTIFICATION DEVICES

A. Manufactured Pipe Markers, General: Preprinted, color-coded, with lettering indicating service, and showing direction of flow.

1. Colors: Comply with ASME A13.1, unless otherwise indicated.
2. Lettering: Use piping system terms indicated and abbreviate only as necessary for each application length.
3. Pipes with OD, Including Insulation, Less Than 6 Inches: Full-band pipe markers extending 360 degrees around pipe at each location.
4. Pipes with OD, Including Insulation, 6 Inches and Larger: Either full-band or strip-type pipe markers at least three times letter height and of length required for label.
5. Arrows: Integral with piping system service lettering to accommodate both directions; or as separate unit on each pipe marker to indicate direction of flow.

B. Pretensioned Pipe Markers: Precoiled semirigid plastic formed to cover full circumference of pipe and to attach to pipe without adhesive.

C. Self-Adhesive Pipe Markers: Plastic with pressure-sensitive, permanent-type, self-adhesive back.

D. Plastic Tape: Continuously printed, vinyl tape at least 3 mils thick with pressure-sensitive, permanent-type, self-adhesive back.

1. Width for Markers on Pipes with OD, Including Insulation, Less Than 6 Inches: 3/4 inch minimum.
2. Width for Markers on Pipes with OD, Including Insulation, 6 Inches or Larger: 1-1/2 inches minimum.

3.2 DUCT IDENTIFICATION DEVICES

A. Duct Markers: Engraved, color-coded laminated plastic. Include direction and quantity of airflow and duct service (such as supply, return, and exhaust). Include contact-type, permanent adhesive.

3.3 STENCILS

A. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; minimum letter height of 1-1/4 inches for ducts; and minimum letter height of 3/4 inch for access panel and door markers, equipment markers, equipment signs, and similar operational instructions.

1. Stencil Material: Metal or fiberboard.
2. Stencil Paint: Exterior, gloss, acrylic enamel black, unless otherwise indicated. Paint may be in pressurized spray-can form.
3. Identification Paint: Exterior, acrylic enamel in colors according to ASME A13.1, unless otherwise indicated.

3.4 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers, with numbering scheme approved by Engineer. Provide 5/32-inch hole for fastener.

1. Material: 0.032-inch- thick brass.
2. Valve-Tag Fasteners: Brass wire-link or beaded chain; or S-hook.

4.2 VALVE SCHEDULES

A. Valve Schedules: For each piping system, on standard-size bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Valve-Schedule Frames: Glazed display frame for removable mounting on masonry walls for each page of valve schedule. Include mounting screws.
2. Frame: Extruded aluminum.
3. Glazing: ASTM C 1036, Type I, Class 1, Glazing Quality B, 2.5-mm, single-thickness glass.

4.3 WARNING TAGS

A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags; of plasticized card stock with matte finish suitable for writing.

1. Size: Approximately 4 by 7 inches.
2. Fasteners: Brass grommet and wire.
3. Nomenclature: Large-size primary caption such as DANGER, CAUTION, or DO NOT OPERATE.
4. Color: Yellow background with black lettering.

EXECUTION

4.4 APPLICATIONS, GENERAL

A. Products specified are for applications referenced in other Division 23 Sections. If more than single-type material, device, or label is specified for listed applications, selection is Installer's option.

4.5 EQUIPMENT IDENTIFICATION

A. Install equipment markers with permanent adhesive on or near each major item of mechanical equipment. Data required for markers may be included on signs, and markers may be omitted if both are indicated.

1. Letter Size: Minimum 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
2. Data: Distinguish among multiple units, indicate operational requirements, indicate safety and emergency precautions, warn of hazards and improper operations, and identify units.
3. Locate markers where accessible and visible. Include markers for the following general categories of equipment:

a. Main control and operating valves, including safety devices and hazardous units such as gas outlets.
b. Fire department hose valves and hose stations.
c. Meters, gages, thermometers, and similar units.
d. Fuel-burning units, including boilers.
e. Pumps, chillers, and similar motor-driven units.
f. Heat exchangers, coils, evaporators, heat recovery units, and similar equipment.
g. Fans, blowers.
h. Packaged HVAC central-station units.
i. Tanks and pressure vessels.
j. Strainers, filters, water-treatment systems, and similar equipment.

A. Install access panel markers with screws on equipment access panels.

7.2 PIPING IDENTIFICATION

A. Install manufactured pipe markers indicating service on each piping system. Install with flow indication arrows showing direction of flow.

1. Pipes with OD, Including Insulation, Less Than 6 Inches: Pretensioned pipe markers. Use size to ensure a tight fit.
1. Pipes with OD, Including Insulation, Less Than 6 Inches: Self-adhesive pipe markers. Use color-coded, self-adhesive plastic tape, 1-1/2 inches wide, lapped at least 1-1/2 inches at both ends of pipe marker, and covering full circumference of pipe.
1. Pipes with OD, Including Insulation, 6 Inches and Larger: Self-adhesive pipe markers. Use color-coded, self-adhesive plastic tape, at least 1-1/2 inches wide, lapped at least 3 inches at both ends of pipe marker, and covering full circumference of pipe.

A. Stenciled Pipe Marker Option: Stenciled markers may be provided instead of manufactured pipe markers, at Installer's option. Install stenciled pipe markers with painted, color-coded bands or rectangles complying with ASME A13.1 on each piping system.

1. Identification Paint: Use for contrasting background.
2. Stencil Paint: Use for pipe marking.

A. Locate pipe markers and color bands where piping is exposed in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior nonconcealed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and nonaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced markers.

12.2 DUCT IDENTIFICATION

A. Install duct markers with permanent adhesive on air ducts in the following color codes:

1. Green: For cold-air supply ducts.
2. Yellow: For hot-air supply ducts.
3. Blue: For exhaust-, outside-, relief-, return-, and mixed-air ducts.
4. ASME A13.1 Colors and Designs: For hazardous material exhaust.
5. Letter Size: Minimum 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

A. Stenciled Duct Marker Option: Stenciled markers, showing service and direction of flow, may be provided instead of laminated-plastic duct markers, at Installer's option, if lettering larger than 1 inch high is needed for proper identification because of distance from normal location of required identification.

B. Locate markers near points where ducts enter into concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.

13.2 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; plumbing fixture supply stops; shutoff valves; faucets; convenience and lawn-watering hose connections; and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following:

1. Valve-Tag Size and Shape:

a. Cold Water: 1-1/2 inches, round.
b. Hot Water: 1-1/2 inches, round.
c. Fire Protection: 1-1/2 inches, round.
d. Gas: 1-1/2 inches, round.

1. Valve-Tag Color:

a. Cold Water: Natural.
b. Hot Water: Natural.
c. Fire Protection: Natural.
d. Gas: Natural.

2. Letter Color:

a. Cold Water: Black.
b. Hot Water: Black.
c. Fire Protection: Black.
d. Gas: Black.

16.2 VALVE-SCHEDULE INSTALLATION

A. Mount valve schedule on wall in accessible location in each major equipment room.

16.3 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.

16.4 ADJUSTING

A. Relocate mechanical identification materials and devices that have become visually blocked by other work.

16.5 CLEANING

A. Clean faces of mechanical identification devices and glass frames of valve schedules.

END OF SECTION 230553

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SECTION 23 0593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Balancing Air Systems:

a. Constant-volume air systems.
b. Variable-air-volume systems.

2. Balancing Hydronic Piping Systems:

a. Constant-flow hydronic systems.
b. Variable-flow hydronic systems.

1.2 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. NEBB: National Environmental Balancing Bureau.

C. TAB: Testing, adjusting, and balancing.

D. TABB: Testing, Adjusting, and Balancing Bureau.

E. TAB Specialist: An entity engaged to perform TAB Work.

1.3 ACTION SUBMITTALS

A. LEED Submittals:

1. Air-Balance Report for Prerequisite IEQ 1: Documentation of work performed for ASHRAE 62.1, Section 7.2.2 - "Air Balancing."
2. TAB Report for Prerequisite EA 2: Documentation of work performed for ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."

1.4 INFORMATIONAL SUBMITTALS

A. Strategies and Procedures Plan: Within 30 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.

B. Certified TAB reports.

1.5 QUALITY ASSURANCE

A. TAB Contractor Qualifications: Engage a TAB entity certified by AABC NEBB or TABB.

1. TAB Field Supervisor: Employee of the TAB contractor and certified by AABC NEBB or TABB.
2. TAB Technician: Employee of the TAB contractor and who is certified by AABC NEBB or TABB as a TAB technician.

B. Certify TAB field data reports and perform the following:

1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
2. Certify that the TAB team complied with the approved TAB plan and the procedures specified and referenced in this Specification.

C. TAB Report Forms: Use standard TAB contractor's forms approved by Architect, Owner, Construction Manager and Commissioning Authority.

D. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in ASHRAE 111, Section 5, "Instrumentation."

E. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."

F. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.

B. Examine systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they meet the leakage class of connected ducts as specified in Section 233113 "Metal

Ducts" Section 233116 "Nonmetal Ducts" and are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.

F. Examine equipment performance data including fan and pump curves.

1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

H. Examine test reports specified in individual system and equipment Sections.

I. Examine HVAC equipment and filters and verify that bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

J. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.

K. Examine strainers. Verify that startup screens are replaced by permanent screens with indicated perforations.

L. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.

M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

N. Examine system pumps to ensure absence of entrained air in the suction piping.

O. Examine operating safety interlocks and controls on HVAC equipment.

P. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

A. Prepare a TAB plan that includes strategies and step-by-step procedures.

B. Complete system-readiness checks and prepare reports. Verify the following:

1. Permanent electrical-power wiring is complete.
2. Hydronic systems are filled, clean, and free of air.
3. Automatic temperature-control systems are operational.

4. Equipment and duct access doors are securely closed.
5. Balance, smoke, and fire dampers are open.
6. Isolating and balancing valves are open and control valves are operational.
7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
8. Windows and doors can be closed so indicated conditions for system operations can be met.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance", ASHRAE 111, NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems", SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing" and in this Section.

1. Comply with requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.

1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
2. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 230713 "Duct Insulation," Section 230716 "HVAC Equipment Insulation," Section 230719 "HVAC Piping Insulation."

C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) and metric (SI) units.

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' "as-built" duct layouts.

C. For variable-air-volume systems, develop a plan to simulate diversity.

D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

G. Verify that motor starters are equipped with properly sized thermal protection.

H. Check dampers for proper position to achieve desired airflow path.

I. Check for airflow blockages.

J. Check condensate drains for proper connections and functioning.

K. Check for proper sealing of air-handling-unit components.

L. Verify that air duct system is sealed as specified in Section 233113 "Metal Ducts."

3.5 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure total airflow.

    a. Where sufficient space in ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow.

2. Measure fan static pressures as follows to determine actual static pressure:

    a. Measure outlet static pressure as far downstream from the fan as practical and upstream from restrictions in ducts such as elbows and transitions.
    b. Measure static pressure directly at the fan outlet or through the flexible connection.
    c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from the flexible connection, and downstream from duct restrictions.
    d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.

3. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.

    a. Report the cleanliness status of filters and the time static pressures are measured.

4. Measure static pressures entering and leaving other devices, such as sound traps, heat-recovery equipment, and air washers, under final balanced conditions.
5. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
6. Obtain approval from Architect, Owner, Construction Manager and Commissioning Authority for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
7. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor

amperage to ensure that no overload will occur. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.

1. Measure airflow of submain and branch ducts.

a. Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.

2. Measure static pressure at a point downstream from the balancing damper, and adjust volume dampers until the proper static pressure is achieved.
3. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.

C. Measure air outlets and inlets without making adjustments.

1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.

D. Adjust air outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using branch volume dampers rather than extractors and the dampers at air terminals.

1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
2. Adjust patterns of adjustable outlets for proper distribution without drafts.

3.6 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Compensating for Diversity: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a minimum set-point airflow with the remainder at maximum airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan. Select the reduced-airflow terminal units so they are distributed evenly among the branch ducts.

B. Pressure-Independent, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Set outdoor-air dampers at minimum, and set return- and exhaust-air dampers at a position that simulates full-cooling load.
2. Select the terminal unit that is most critical to the supply-fan airflow and static pressure. Measure static pressure. Adjust system static pressure so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.

3. Measure total system airflow. Adjust to within indicated airflow.
4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal-unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
5. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow the same as described for constant-volume air systems.

    a. If air outlets are out of balance at minimum airflow, report the condition but leave outlets balanced for maximum airflow.

6. Remeasure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.

    a. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.

7. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure that adequate static pressure is maintained at the most critical unit.
8. Record final fan-performance data.

C. Pressure-Dependent, Variable-Air-Volume Systems without Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Balance variable-air-volume systems the same as described for constant-volume air systems.
2. Set terminal units and supply fan at full-airflow condition.
3. Adjust inlet dampers of each terminal unit to indicated airflow and verify operation of the static-pressure controller. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
4. Readjust fan airflow for final maximum readings.
5. Measure operating static pressure at the sensor that controls the supply fan if one is installed, and verify operation of the static-pressure controller.
6. Set supply fan at minimum airflow if minimum airflow is indicated. Measure static pressure to verify that it is being maintained by the controller.
7. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow the same as described for constant-volume air systems.

    a. If air outlets are out of balance at minimum airflow, report the condition but leave the outlets balanced for maximum airflow.

8. Measure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.

    a. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.

D. Pressure-Dependent, Variable-Air-Volume Systems with Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Set system at maximum indicated airflow by setting the required number of terminal units at minimum airflow. Select the reduced-airflow terminal units so they are distributed evenly among the branch ducts.
2. Adjust supply fan to maximum indicated airflow with the variable-airflow controller set at maximum airflow.
3. Set terminal units at full-airflow condition.
4. Adjust terminal units starting at the supply-fan end of the system and continuing progressively to the end of the system. Adjust inlet dampers of each terminal unit to indicated airflow. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
5. Adjust terminal units for minimum airflow.
6. Measure static pressure at the sensor.
7. Measure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.

3.7 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports with pertinent design data, and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against the approved pump flow rate. Correct variations that exceed plus or minus 5 percent.

B. Prepare schematic diagrams of systems' "as-built" piping layouts.

C. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:

1. Open all manual valves for maximum flow.
2. Check liquid level in expansion tank.
3. Check makeup water-station pressure gage for adequate pressure for highest vent.
4. Check flow-control valves for specified sequence of operation, and set at indicated flow.
5. Set differential-pressure control valves at the specified differential pressure. Do not set at fully closed position when pump is positive-displacement type unless several terminal valves are kept open.
6. Set system controls so automatic valves are wide open to heat exchangers.
7. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.
8. Check air vents for a forceful liquid flow exiting from vents when manually operated.

3.8 PROCEDURES FOR CONSTANT-FLOW HYDRONIC SYSTEMS

A. Measure water flow at pumps. Use the following procedures except for positive-displacement pumps:

1. Verify impeller size by operating the pump with the discharge valve closed. Read pressure differential across the pump. Convert pressure to head and correct for

differences in gage heights. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.

a. If impeller sizes must be adjusted to achieve pump performance, obtain approval from Architect, Owner, Construction Manager, and Commissioning Authority and comply with requirements in Section 232123 "Hydronic Pumps."

2. Check system resistance. With all valves open, read pressure differential across the pump and mark pump manufacturer's head-capacity curve. Adjust pump discharge valve until indicated water flow is achieved.

a. Monitor motor performance during procedures and do not operate motors in overload conditions.

3. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.
4. Report flow rates that are not within plus or minus 10 percent of design.

B. Measure flow at all automatic flow control valves to verify that valves are functioning as designed.

C. Measure flow at all pressure-independent characterized control valves, with valves in fully open position, to verify that valves are functioning as designed.

D. Set calibrated balancing valves, if installed, at calculated presettings.

E. Measure flow at all stations and adjust, where necessary, to obtain first balance.

1. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.

F. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than indicated flow.

G. Adjust balancing stations to within specified tolerances of indicated flow rate as follows:

1. Determine the balancing station with the highest percentage over indicated flow.
2. Adjust each station in turn, beginning with the station with the highest percentage over indicated flow and proceeding to the station with the lowest percentage over indicated flow.
3. Record settings and mark balancing devices.

H. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures including outdoor-air temperature.

I. Measure the differential-pressure-control-valve settings existing at the conclusion of balancing.

J. Check settings and operation of each safety valve. Record settings.

3.9 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals and proceed as specified above for hydronic systems.

3.10 PROCEDURES FOR MOTORS

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer's name, model number, and serial number.
2. Motor horsepower rating.
3. Motor rpm.
4. Efficiency rating.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter thermal-protection-element rating.

B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass of the controller to prove proper operation. Record observations including name of controller manufacturer, model number, serial number, and nameplate data.

3.11 PROCEDURES FOR CHILLERS

A. Balance water flow through each evaporator and condenser to within specified tolerances of indicated flow with all pumps operating. With only one chiller operating in a multiple chiller installation, do not exceed the flow for the maximum tube velocity recommended by the chiller manufacturer. Measure and record the following data with each chiller operating at design conditions:

1. Evaporator-water entering and leaving temperatures, pressure drop, and water flow.
2. For water-cooled chillers, condenser-water entering and leaving temperatures, pressure drop, and water flow.
3. Evaporator and condenser refrigerant temperatures and pressures, using instruments furnished by chiller manufacturer.
4. Power factor if factory-installed instrumentation is furnished for measuring kilowatts.
5. Kilowatt input if factory-installed instrumentation is furnished for measuring kilowatts.
6. Capacity: Calculate in tons of cooling.
7. For air-cooled chillers, verify condenser-fan rotation and record fan and motor data including number of fans and entering- and leaving-air temperatures.

3.12 PROCEDURES FOR COOLING TOWERS

A. Shut off makeup water for the duration of the test, and verify that makeup and blowdown systems are fully operational after tests and before leaving the equipment. Perform the following tests and record the results:

1. Measure condenser-water flow to each cell of the cooling tower.
2. Measure entering- and leaving-water temperatures.
3. Measure wet- and dry-bulb temperatures of entering air.
4. Measure wet- and dry-bulb temperatures of leaving air.
5. Measure condenser-water flow rate recirculating through the cooling tower.
6. Measure cooling-tower spray pump discharge pressure.
7. Adjust water level and feed rate of makeup water system.
8. Measure flow through bypass.

3.13 PROCEDURES FOR CONDENSING UNITS

A. Verify proper rotation of fans.

B. Measure entering- and leaving-air temperatures.

C. Record compressor data.

3.14 PROCEDURES FOR BOILERS

A. Hydronic Boilers: Measure and record entering- and leaving-water temperatures and water flow.

B. Steam Boilers: Measure and record entering-water temperature and flow and leaving-steam pressure, temperature, and flow.

3.15 PROCEDURES FOR HEAT-TRANSFER COILS

A. Measure, adjust, and record the following data for each water coil:

1. Entering- and leaving-water temperature.
2. Water flow rate.
3. Water pressure drop.
4. Dry-bulb temperature of entering and leaving air.
5. Wet-bulb temperature of entering and leaving air for cooling coils.
6. Airflow.
7. Air pressure drop.

B. Measure, adjust, and record the following data for each electric heating coil:

1. Nameplate data.
2. Airflow.
3. Entering- and leaving-air temperature at full load.
4. Voltage and amperage input of each phase at full load and at each incremental stage.
5. Calculated kilowatt at full load.
6. Fuse or circuit-breaker rating for overload protection.

C. Measure, adjust, and record the following data for each steam coil:

1. Dry-bulb temperature of entering and leaving air.
2. Airflow.
3. Air pressure drop.
4. Inlet steam pressure.

D. Measure, adjust, and record the following data for each refrigerant coil:

1. Dry-bulb temperature of entering and leaving air.
2. Wet-bulb temperature of entering and leaving air.
3. Airflow.
4. Air pressure drop.
5. Refrigerant suction pressure and temperature.

3.16 PROCEDURES FOR TESTING, ADJUSTING, AND BALANCING EXISTING SYSTEMS

A. Perform a preconstruction inspection of existing equipment that is to remain and be reused.

1. Measure and record the operating speed, airflow, and static pressure of each fan.
2. Measure motor voltage and amperage. Compare the values to motor nameplate information.
3. Check the refrigerant charge.
4. Check the condition of filters.
5. Check the condition of coils.
6. Check the operation of the drain pan and condensate-drain trap.
7. Check bearings and other lubricated parts for proper lubrication.
8. Report on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.

B. Before performing testing and balancing of existing systems, inspect existing equipment that is to remain and be reused to verify that existing equipment has been cleaned and refurbished. Verify the following:

1. New filters are installed.
2. Coils are clean and fins combed.
3. Drain pans are clean.
4. Fans are clean.
5. Bearings and other parts are properly lubricated.
6. Deficiencies noted in the preconstruction report are corrected.

C. Perform testing and balancing of existing systems to the extent that existing systems are affected by the renovation work.

1. Compare the indicated airflow of the renovated work to the measured fan airflows, and determine the new fan speed and the face velocity of filters and coils.
2. Verify that the indicated airflows of the renovated work result in filter and coil face velocities and fan speeds that are within the acceptable limits defined by equipment manufacturer.
3. If calculations increase or decrease the air flow rates and water flow rates by more than 5 percent, make equipment adjustments to achieve the calculated rates. If increase or decrease is 5 percent or less, equipment adjustments are not required.

4. Balance each air outlet.

3.17 TOLERANCES

A. Set HVAC system's air flow rates and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.
2. Air Outlets and Inlets: Plus or minus 10 percent.
3. Heating-Water Flow Rate: Plus or minus 10 percent.
4. Cooling-Water Flow Rate: Plus or minus 10 percent.

3.18 REPORTING

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

B. Status Reports: Prepare weekly progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.19 FINAL REPORT

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.

1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
2. Include a list of instruments used for procedures, along with proof of calibration.

B. Final Report Contents: In addition to certified field-report data, include the following:

1. Pump curves.
2. Fan curves.
3. Manufacturers' test data.
4. Field test reports prepared by system and equipment installers.
5. Other information relative to equipment performance; do not include Shop Drawings and product data.

C. General Report Data: In addition to form titles and entries, include the following data:

1. Title page.
2. Name and address of the TAB contractor.
3. Project name.

4. Project location.
5. Architect's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
8. Report date.
9. Signature of TAB supervisor who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents including the following:

    a. Indicated versus final performance.
    b. Notable characteristics of systems.
    c. Description of system operation sequence if it varies from the Contract Documents.

12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer's name, type, size, and fittings.
14. Notes to explain why certain final data in the body of reports vary from indicated values.
15. Test conditions for fans and pump performance forms including the following:

    a. Settings for outdoor-, return-, and exhaust-air dampers.
    b. Conditions of filters.
    c. Cooling coil, wet- and dry-bulb conditions.
    d. Face and bypass damper settings at coils.
    e. Fan drive settings including settings and percentage of maximum pitch diameter.
    f. Inlet vane settings for variable-air-volume systems.
    g. Settings for supply-air, static-pressure controller.
    h. Other system operating conditions that affect performance.

D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outdoor, supply, return, and exhaust airflows.
2. Water and steam flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Terminal units.
6. Balancing stations.
7. Position of balancing devices.

3.20 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION 230593

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SECTION 23 0713 - DUCT INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulating the following duct services:

1. Indoor, concealed supply and outdoor air.
2. Indoor, exposed supply and outdoor air.
3. Indoor, concealed return located in unconditioned space.
4. Indoor, exposed return located in unconditioned space.
5. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
6. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
7. Outdoor, concealed supply and return.
8. Outdoor, exposed supply and return.

B. Related Sections:

1. Section 230716 "HVAC Equipment Insulation."
2. Section 230719 "HVAC Piping Insulation."
3. Section 233113 "Metal Ducts" for duct liners.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. LEED Submittals:

1. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.
2. Laboratory Test Reports for Credit IEQ 4: For adhesives and sealants, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail insulation application at elbows, fittings, dampers, specialties and flanges for each type of insulation.
3. Detail application of field-applied jackets.
4. Detail application at linkages of control devices.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Duct Insulation Schedule, General," "Indoor Duct and Plenum Insulation Schedule," and "Aboveground, Outdoor Duct and Plenum Insulation Schedule" articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type I. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, provide one of the following:

a. CertainTeed Corp.; SoftTouch Duct Wrap.
b. Johns Manville; Microlite.
c. Knauf Insulation; Friendly Feel Duct Wrap.
d. Manson Insulation Inc.; Alley Wrap.
e. Owens Corning; SOFTR All-Service Duct Wrap.

G. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. P P Products: Subject to compliance with requirements provide one of the following :

a. CertainTeed Corp.; Commercial Board.
b. Fibrex Insulations Inc.; FBX.
c. Johns Manville; 800 Series Spin-Glas.
d. Knauf Insulation; Insulation Board.
e. Manson Insulation Inc.; AK Board.
f. Owens Corning; Fiberglas 700 Series.

2.2 FIRE-RATED INSULATION SYSTEMS

A. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is tested and certified to provide a 2-hour fire rating by an NRTL acceptable to authorities having jurisdiction.

1. Products: Subject to compliance with requirements, provide one of the following:

a. CertainTeed Corp.; FlameChek.
b. Johns Manville; Firetemp Wrap.
c. Nelson Fire Stop Products; Nelson FSB Flameshield Blanket.
d. Thermal Ceramics; FireMaster Duct Wrap.
e. 3M; Fire Barrier Wrap Products.
f. Unifrax Corporation; FyreWrap.

2.3 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.
b. Eagle Bridges - Marathon Industries; 225.
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60/85-70.
d. Mon-Eco Industries, Inc.; 22-25.

2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

1. Products: Subject to compliance with requirements, provide one of the following:

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82.
   b. Eagle Bridges - Marathon Industries; 225.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-50.
   d. Mon-Eco Industries, Inc.; 22-25.

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

D. PVC Jacket Adhesive: Compatible with PVC jacket.

1. Products: Subject to compliance with requirements, provide one of the following:

   a. Dow Corning Corporation; 739, Dow Silicone.
   b. Johns Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
   c. P.I.C. Plastics, Inc.; Welding Adhesive.
   d. Speedline Corporation; Polyco VP Adhesive.

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.4 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below ambient services.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-80/30-90.
b. Vimasco Corporation; 749.

2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm (0.009 metric perm) at 43-mil (1.09-mm) dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
5. Color: White.

C. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-10.
b. Eagle Bridges - Marathon Industries; 550.
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 46-50.
d. Mon-Eco Industries, Inc.; 55-50.
e. Vimasco Corporation; WC-1/WC-5.

2. Water-Vapor Permeance: ASTM F 1249, 1.8 perms (1.2 metric perms) at 0.0625-inch (1.6-mm) dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
4. Solids Content: 60 percent by volume and 66 percent by weight.
5. Color: White.

2.5 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, provide one of the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
b. Eagle Bridges - Marathon Industries; 405.
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 95-44.
d. Mon-Eco Industries, Inc.; 44-05.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
5. Color: Aluminum.
6. For indoor applications, use sealants that have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. ASJ Flashing Sealants, and Vinyl and PVC Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, provide one of the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
5. Color: White.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.6 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
5. Vinyl Jacket: White vinyl with a permeance of 1.3 perms (0.86 metric perm) when tested according to ASTM E 96/E 96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.7 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Johns Manville; Zeston.
b. P.I.C. Plastics, Inc.; FG Series.
c. Proto Corporation; LoSmoke.

d. Speedline Corporation; SmokeSafe.

2. Adhesive: As recommended by jacket material manufacturer.
3. Color: Color as selected by Architect.

D. Aluminum Jacket: Comply with ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005, Temper H-14.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Metal Jacketing Systems.
b. ITW Insulation Systems; Aluminum and Stainless Steel Jacketing.
c. RPR Products, Inc.; Insul-Mate.

2. Sheet and roll stock ready for shop or field sizing.
3. Finish and thickness are indicated in field-applied jacket schedules.
4. Moisture Barrier for Indoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper.
5. Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper.

E. Self-Adhesive Outdoor Jacket: 60-mil- (1.5-mm-) thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a crosslaminated polyethylene film covered with white aluminum-foil facing.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Polyguard Products, Inc.; Alumaguard 60.

2.8 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

1. Products: Subject to compliance with requirements, provide one of the following:

a. ABI, Ideal Tape Division; 428 AWF ASJ.
b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
c. Compac Corporation; 104 and 105.
d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.

2. Width: 3 inches (75 mm).
3. Thickness: 11.5 mils (0.29 mm).
4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.

7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

1. Products: Subject to compliance with requirements, provide one of the following:

   a. ABI, Ideal Tape Division; 491 AWF FSK.
   b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
   c. Compac Corporation; 110 and 111.
   d. Venture Tape; 1525 CW NT, 1528 CW, and 1528 CW/SQ.

2. Width: 3 inches (75 mm).
3. Thickness: 6.5 mils (0.16 mm).
4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.

1. Products: Subject to compliance with requirements, provide one of the following:

   a. ABI, Ideal Tape Division; 370 White PVC tape.
   b. Compac Corporation; 130.
   c. Venture Tape; 1506 CW NS.

2. Width: 2 inches (50 mm).
3. Thickness: 6 mils (0.15 mm).
4. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
5. Elongation: 500 percent.
6. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Products: Subject to compliance with requirements, provide one of the following:

   a. ABI, Ideal Tape Division; 488 AWF.
   b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
   c. Compac Corporation; 120.
   d. Venture Tape; 3520 CW.

2. Width: 2 inches (50 mm).
3. Thickness: 3.7 mils (0.093 mm).
4. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.

2.9 SECUREMENTS

A. Aluminum Bands: ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 3/4 inch (19 mm) wide with wing seal or closed seal.

1. Products: Subject to compliance with requirements, provide one of the following:

a. ITW Insulation Systems; Gerrard Strapping and Seals.
b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.
c. Childers Products; Banos

B. Insulation Pins and Hangers:

1. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

a. Products: Subject to compliance with requirements, provide one of the following:

1) AGM Industries, Inc.; Tactoo Perforated Base Insul-Hangers.
2) GEMCO; Perforated Base.
3) Midwest Fasteners, Inc.; Spindle.

b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
c. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.

a. Products: Subject to compliance with requirements, provide one of the following:

1) AGM Industries, Inc.; RC-150.
2) GEMCO; R-150.
3) Midwest Fasteners, Inc.; WA-150.
4) Nelson Stud Welding; Speed Clips.

b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.\

c. Staples: Outward-clinching insulation staples, nominal ¾ inch-wide, stainless stell or Monel.

d. Wire: 0.080- inch nickel copper alloy.

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

   a. C & F Wire.
   b. Childers Products.
   c. PABCO Metals Corporation.
   d. RPR Products Inc.

2.10 CORNER ANGLES

A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch (25 by 25 mm), PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.

B. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch (25 by 25 mm), aluminum according to ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14.

PART 3 - EXECUTION

3.1 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.

B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Keep insulation materials dry during application and finishing.

G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

H. Install insulation with least number of joints practical.

I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

K. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at [2 inches (50 mm)] [4 inches (100 mm)] o.c.

    a. For below ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.

L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.3 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches (50 mm) below top of roof flashing.

4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches (50 mm).
4. Seal jacket to wall flashing with flashing sealant.

C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches (50 mm).

1. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

E. Insulation Installation at Floor Penetrations:

1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches (50 mm).
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.4 INSTALLATION OF MINERAL-FIBER INSULATION

A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

a. On duct sides with dimensions 18 inches (450 mm) and smaller, place pins along longitudinal centerline of duct. Space 3 inches (75 mm) maximum from insulation end joints, and 16 inches (400 mm) o.c.
b. On duct sides with dimensions larger than 18 inches (450 mm), place pins 16 inches (400 mm) o.c. each way, and 3 inches (75 mm) maximum from insulation

joints. Install additional pins to hold insulation tightly against surface at cross bracing.

c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
d. Do not overcompress insulation during installation.
e. Impale insulation over pins and attach speed washers.
f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches (50 mm) from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch (13-mm) outward-clinching staples, 1 inch (25 mm) o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

   a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
   b. Install vapor stops for ductwork and plenums operating below 50 deg F (10 deg C) at 18-foot (5.5-m) intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches (75 mm).

5. Overlap unfaced blankets a minimum of 2 inches (50 mm) on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches (450 mm) o.c.
6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- (150-mm-) wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches (150 mm) o.c.

B. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

   a. On duct sides with dimensions 18 inches (450 mm) and smaller, place pins along longitudinal centerline of duct. Space 3 inches (75 mm) maximum from insulation end joints, and 16 inches (400 mm) o.c.
   b. On duct sides with dimensions larger than 18 inches (450 mm), space pins 16 inches (400 mm) o.c. each way, and 3 inches (75 mm) maximum from insulation

joints. Install additional pins to hold insulation tightly against surface at cross bracing.

c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
d. Do not overcompress insulation during installation.
e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches (50 mm) from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch (13-mm) outward-clinching staples, 1 inch (25 mm) o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

   a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
   b. Install vapor stops for ductwork and plenums operating below 50 deg F (10 deg C) at 18-foot (5.5-m) intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches (75 mm).

5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- (150-mm-) wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches (150 mm) o.c.

3.5 FIELD-APPLIED JACKET INSTALLATION

A. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch (38-mm) laps at longitudinal seams and 3-inch- (75-mm-) wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

B. Where PVC jackets are indicated, install with 1-inch (25-mm) overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

C. Where metal jackets are indicated, install with 2-inch (50-mm) overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches (300 mm) o.c. and at end joints.

3.6 FIRE-RATED INSULATION SYSTEM INSTALLATION

A. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.

B. Insulate duct access panels and doors to achieve same fire rating as duct.

C. Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are specified in Section 078413 "Penetration Firestopping."

3.7 FINISHES

A. Insulation with ASJ or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

1. Flat Acrylic Finish: two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

C. Do not field paint aluminum or stainless-steel jackets.

3.8 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Inspect ductwork, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.

C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.9 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation:

1. Indoor, concealed supply and outdoor air.
2. Indoor, exposed supply and outdoor air.
3. Indoor, concealed return located in unconditioned space.
4. Indoor, exposed return located in unconditioned space.
5. Indoor, concealed, Type I, commercial, kitchen hood exhaust.
6. Indoor, exposed, Type I, commercial, kitchen hood exhaust.
7. Indoor, concealed oven and warewash exhaust.
8. Indoor, exposed oven and warewash exhaust.
9. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
10. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
11. Outdoor, concealed supply and return.
12. Outdoor, exposed supply and return.

B. Items Not Insulated:

1. Fibrous-glass ducts.
2. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
3. Factory-insulated flexible ducts.
4. Factory-insulated plenums and casings.
5. Flexible connectors.
6. Vibration-control devices.
7. Factory-insulated access panels and doors.

3.10 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Concealed, Supply-Air Duct and Plenum Insulation: Mineral-fiber blanket or boards, 1-1/2 inches thick and 0.75-lb/cu.ft. in nominal density.

B. Concealed, Return-Air Duct and Plenum Insulation: Mineral-fiber blanket or board 1-1/2 inches thick and 0.75-lb/cu.ft. nominal density.

C. Concealed, Outdoor-Air Duct and Plenum Insulation: Mineral-fiber blanket or board 1-1/2 inches thick and 0.75-lb/cu.ft. nominal density.

D. Concealed, Exhaust-Air Duct and Plenum Insulation: Mineral-fiber Mineral fiber blanket or board 1-1/2 inches thick and 0.75-lb/cu.ft. nominal density.

E. Exposed, Supply-Air Duct and Plenum Insulation: Mineral-fiber Mineral-fiber blanket or board 2 inches thick and 0.75-lb/cu.ft. nominal density.

F. Exposed, Return-Air Duct and Plenum Insulation: Mineral-fiber Mineral-fiber blanket or board 2 inches thick and 0.75-lb/cu.ft. nominal density.

G. Exposed, Outdoor-Air Duct and Plenum Insulation: Mineral-fiber Mineral-fiber blanket or board 2 inches thick and 0.75-lb/cu.ft. nominal density.

H. Exposed, Exhaust-Air Duct and Plenum Insulation: Mineral-fiber Mineral-fiber blanket or board 2 inches thick and 0.75-lb/cu.ft. nominal density.

END OF SECTION 230713

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SECTION 23 0719 - HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulating the following HVAC piping systems:
   1. Heating hot-water piping, indoors and outdoors.
   2. Refrigerant suction and hot-gas piping, indoors and outdoors.

B. Related Sections:

   1. Section 230713 "Duct Insulation."
   2. Section 230716 "HVAC Equipment Insulation."
   3. Section 232113.13 "Underground Hydronic Piping" for loose-fill pipe insulation in underground piping outside the building.
   4. Section 336313 "Underground Steam and Condensate Distribution Piping" for loose-fill pipe insulation in underground piping outside the building.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. LEED Submittals:

   1. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.
   2. Laboratory Test Reports for Credit IEQ 4: For adhesives and sealants, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

   1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
   2. Detail attachment and covering of heat tracing inside insulation.
   3. Detail insulation application at pipe expansion joints for each type of insulation.
   4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
   5. Detail removable insulation at piping specialties.
   6. Detail application of field-applied jackets.
   7. Detail application at linkages of control devices.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Mineral-Fiber Insulation:

a. CertainTeed Manson.
b. Knauf FiberGlass GmbH.
c. Owens-Corning Fiberglas Corp.
d. Schuller International, Inc.

2. Flexible Elastomeric Thermal Insulation:

a. Armstrong World Industries, Inc.
b. Rubatex Corp.

2.2 INSULATION MATERIALS

A. Mineral-Fiber Insulation: Glass fibers bonded with a thermosetting resin complying with the following:

1. Preformed Pipe Insulation: Comply with ASTM C 547, Type 1, with factory-applied, all-purpose, vapor-retarder jacket.
2. Blanket Insulation: Comply with ASTM C 553, Type II, without facing.
3. Fire-Resistant Adhesive: Comply with MIL-A-3316C in the following classes and grades:

a. Class 1, Grade A for bonding glass cloth and tape to unfaced glass-fiber insulation, for sealing edges of glass-fiber insulation, and for bonding lagging cloth to unfaced glass-fiber insulation.
b. Class 2, Grade A for bonding glass-fiber insulation to metal surfaces.

4. Vapor-Retarder Mastics: Fire- and water-resistant, vapor-retarder mastic for indoor applications. Comply with MIL-C-19565C, Type II.

B. Flexible Elastomeric Thermal Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.

1. Adhesive: As recommended by insulation material manufacturer.
2. Ultraviolet-Protective Coating: As recommended by insulation manufacturer.

C. Prefabricated Thermal Insulating Fitting Covers: Comply with ASTM C 450 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.

2.3 FIELD-APPLIED JACKETS

A. General: ASTM C 921, Type 1, unless otherwise indicated.

B. Foil and Paper Jacket: Laminated, glass-fiber-reinforced, flame-retardant kraft paper and aluminum foil.

C. PVC Jacket: High-impact, ultraviolet-resistant PVC; 20 mils thick; roll stock ready for shop or field cutting and forming.

1. Adhesive: As recommended by insulation material manufacturer.
2. PVC Jacket Color: White.

D. Aluminum Jacket: Factory cut and rolled to indicated sizes. Comply with ASTM B 209, 3003 alloy, H-14 temper.

2.4 ACCESSORIES AND ATTACHMENTS

A. Glass Cloth and Tape: Comply with MIL-C-20079H, Type I for cloth and Type II for tape. Woven glass-fiber fabrics, plain weave, presized a minimum of 8 oz./sq. yd.

1. Tape Width: 4 inches.

B. Bands: 3/4 inch wide, in one of the following materials compatible with jacket:

1. Stainless Steel: ASTM A 666, Type 304; 0.020 inch thick.

C. Wire: 0.080-inch, nickel-copper alloy; 0.062-inch, soft-annealed, stainless steel; or 0.062-inch, soft-annealed, galvanized steel.

2.5 VAPOR RETARDERS

A. Mastics: Materials recommended by insulation material manufacturer that are compatible with insulation materials, jackets, and substrates.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.

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

3.2 PREPARATION

A. Surface Preparation: Clean and dry pipe and fitting surfaces. Remove materials that will adversely affect insulation application.

3.3 GENERAL APPLICATION REQUIREMENTS

A. Apply insulation materials, accessories, and finishes according to the manufacturer's written instructions; with smooth, straight, and even surfaces; free of voids throughout the length of piping, including fittings, valves, and specialties.

B. Refer to schedules at the end of this Section for materials, forms, jackets, and thicknesses required for each piping system.

C. Use accessories compatible with insulation materials and suitable for the service. Use accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Apply insulation with longitudinal seams at top and bottom of horizontal pipe runs.

E. Apply multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Seal joints and seams with vapor-retarder mastic on insulation indicated to receive a vapor retarder.

H. Keep insulation materials dry during application and finishing.

I. Apply insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by the insulation material manufacturer.

J. Apply insulation with the least number of joints practical.

K. Apply insulation over fittings, valves, and specialties, with continuous thermal and vapor-retarder integrity, unless otherwise indicated. Refer to special instructions for applying insulation over fittings, valves, and specialties.

L. Hangers and Anchors: Where vapor retarder is indicated, seal penetrations in insulation at hangers, supports, anchors, and other projections with vapor-retarder mastic.

1. Apply insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor retarders are indicated, extend insulation on anchor legs at least 12 inches from point of attachment to pipe and taper insulation ends. Seal tapered ends with a compound recommended by the insulation material manufacturer to maintain vapor retarder.
3. Install insert materials and apply insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by the insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect the jacket from tear or puncture by the hanger, support, and shield.

M. Insulation Terminations: For insulation application where vapor retarders are indicated, taper insulation ends. Seal tapered ends with a compound recommended by the insulation material manufacturer to maintain vapor retarder.

N. Apply adhesives and mastics at the manufacturer's recommended coverage rate.

O. Apply insulation with integral jackets as follows:

1. Pull jacket tight and smooth.
2. Circumferential Joints: Cover with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip and spaced 4 inches o.c.
3. Longitudinal Seams: Overlap jacket seams at least 1-1/2 inches. Apply insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4 inches o.c.

    a. Exception: Do not staple longitudinal laps on insulation having a vapor retarder.

4. Vapor-Retarder Mastics: Where vapor retarders are indicated, apply mastic on seams and joints and at ends adjacent to flanges, unions, valves, and fittings.
5. At penetrations in jackets for thermometers and pressure gages, fill and seal voids with vapor-retarder mastic.

P. Exterior Wall Penetrations: For penetrations of below-grade exterior walls, terminate insulation flush with mechanical sleeve seal. Seal terminations with vapor-retarder mastic.

Q. Interior Wall and Partition Penetrations: Apply insulation continuously through walls and floors.

R. Fire-Rated Wall and Partition Penetrations: Apply insulation continuously through penetrations of fire-rated walls and partitions.

1. Firestopping and fire-resistive joint sealers are specified in Division 7 Section "Firestopping."

S. Floor Penetrations: Apply insulation continuously through floor assembly.

1. For insulation with vapor retarders, seal insulation with vapor-retarder mastic where floor supports penetrate vapor retarder.

3.4 MINERAL-FIBER INSULATION APPLICATION

A. Apply insulation to straight pipes and tubes as follows:

1. Secure each layer of preformed pipe insulation to pipe with wire, tape, or bands without deforming insulation materials.
2. Where vapor retarders are indicated, seal longitudinal seams and end joints with vapor-retarder mastic. Apply vapor retarder to ends of insulation at intervals of 15 to 20 feet to form a vapor retarder between pipe insulation segments.
3. For insulation with factory-applied jackets, secure laps with outward clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets with vapor retarders, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by the insulation material manufacturer and seal with vapor-retarder mastic.

B. Apply insulation to flanges as follows:

1. Apply preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation segment the same as overall width of the flange and bolts, plus twice the thickness of the pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.

C. Apply insulation to fittings and elbows as follows:

1. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When premolded insulation elbows and fittings are not available, apply mitered sections of pipe insulation, or glass-fiber blanket insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire, tape, or bands.
3. Cover fittings with standard PVC fitting covers (not allowed in return air plenum).

D. Apply insulation to valves and specialties as follows:

1. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When premolded insulation sections are not available, apply glass-fiber blanket insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation. For check valves, arrange insulation for access to strainer basket without disturbing insulation.
3. Apply insulation to flanges as specified for flange insulation application.

4. Use preformed standard PVC fitting covers for valve sizes where available. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic (not allowed in return air plenums).

3.5 FLEXIBLE ELASTOMERIC THERMAL INSULATION APPLICATION

A. Apply insulation to straight pipes and tubes as follows:

1. Follow manufacturer's written instructions for applying insulation.
2. Seal longitudinal seams and end joints with manufacturer's recommended adhesive. Cement to avoid openings in insulation that will allow passage of air to the pipe surface.

B. Apply insulation to flanges as follows:

1. Apply pipe insulation to outer diameter of pipe flange.
2. Make width of insulation segment the same as overall width of the flange and bolts, plus twice the thickness of the pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of the same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive. Cement to avoid openings in insulation that will allow passage of air to the pipe surface.

C. Apply insulation to fittings and elbows as follows:

1. Apply mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive. Cement to avoid openings in insulation that will allow passage of air to the pipe surface.

D. Apply insulation to valves and specialties as follows:

1. Apply preformed valve covers manufactured of the same material as pipe insulation and attached according to the manufacturer's written instructions.
2. Apply cut segments of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation. For check valves, fabricate removable sections of insulation arranged to allow access to stainer basket.
3. Apply insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive. Cement to avoid openings in insulation that will allow passage of air to the pipe surface.

3.6 FIELD-APPLIED JACKET APPLICATION

A. Foil and Paper Jackets: Apply foil and paper jackets where indicated.

1. Draw jacket material smooth and tight.
2. Apply lap or joint strips with the same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.

4. Apply jackets with 1-1/2-inch laps at longitudinal seams and 3-inch- wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-retarder mastic.

B. Apply PVC jacket where indicated, with 1-inch overlap at longitudinal seams and end joints. Seal with manufacturer's recommended adhesive.

C. Apply metal jacket where indicated, with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.7 FINISHES

A. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of the insulation manufacturer's recommended protective coating.

3.8 PIPING SYSTEM APPLICATIONS

A. Insulation materials and thicknesses are specified in schedules at the end of this Section.

B. Items Not Insulated: Unless otherwise indicated, do not apply insulation to the following systems, materials, and equipment:

1. Flexible connectors.
2. Vibration-control devices.
3. Fire-suppression piping.
4. Drainage piping located in crawl spaces, unless otherwise indicated.
5. Below-grade piping, unless otherwise indicated.
6. Chrome-plated pipes and fittings, unless potential for personnel injury.
7. Air chambers, unions, strainers, check valves, plug valves, and flow regulators.

3.9 FIELD QUALITY CONTROL

A. Insulation applications will be considered defective if sample inspection reveals noncompliance with requirements. Remove defective Work and replace with new materials according to these Specifications.

B. Reinstall insulation and covers on fittings and valves uncovered for inspection according to these Specifications.

3.10 INSULATION APPLICATION SCHEDULE, GENERAL

A. Refer to insulation application schedules for required insulation materials, vapor retarders, and field-applied jackets.

B. Application schedules identify piping system and indicate pipe size ranges and material, thickness, and jacket requirements.

3.11 INTERIOR INSULATION APPLICATION SCHEDULE

A. Service: Condensate drain piping.

1. Operating Temperature: 35 to 75 deg F .
2. Insulation Material: Flexible elastomeric.
3. Insulation Thickness: 1 inch.
4. Field-Applied Jacket: None.
5. Vapor Retarder Required: Yes.

B. Service: Refrigerant suction and hot-gas piping.

1. Operating Temperature: 35 to 50 deg F.
2. Insulation Material: Flexible elastomeric.
3. Insulation Thickness: 3/4 inch.

4. Jacket: Jacket is not required for interior applications.
5. Vapor Retarder Required: No.

C. Service: Heating hot-water supply and return.

1. Operating Temperature: 100 to 200 deg F .
2. Insulation Material: Mineral fiber.
3. Insulation Thickness: Apply the following insulation thicknesses:

    a. Pipe, 2" and smaller: 1" thick.
    b. Pipe, 2 1/2" and larger: 1 1/2" thick.

4. Jacket: Field applied PVC jacket for exposed, interior installations. Manufacturer applied jacket for concealed, interior installations.
5. Vapor Retarder Required: Yes.

3.12 EXTERIOR INSULATION APPLICATION SCHEDULE

A. This application schedule is for aboveground insulation outside the building. Loose-fill insulation, for belowground piping, is specified in Division 2 piping distribution Sections.

B. Service: Refrigerant suction.

1. Operating Temperature: 35 to 50 deg F .
2. Insulation Material: Flexible elastomeric.
    a. Insulation Thickness: 3/4 inch.

3. Field-Applied Jacket: Aluminum for exterior applications.
4. Vapor Retarder Required: Yes.

END OF SECTION 230719

SECTION 23 0900 - TEMPERATURE CONTROL SYSTEM (TCS)

PART 1 - General

1.1 Related Documents

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

1.2 Related Sections

A. This Section includes the Building Management System (BMS) control equipment for HVAC systems and components.

1.3 Standard Terms

A. Standard

1. ASHRAE: American Society Heating, Refrigeration, Air Conditioning Engineers
2. AHU: Air Handling Unit
3. BACnet: Building Automation Controls Network
4. BMS: Building Management System
5. DDC: Direct Digital Control
6. EIA: Electronic Industries Alliance
7. GUI: Graphical User Interface
8. HVAC: Heating, Ventilation, and Air Conditioning
9. IEEE: Institute Electrical Electronic Engineers
10. MER: Mechanical Equipment Room
11. PID: Proportional, Integral, Derivative
12. VAV: Variable Air Volume Box

B. Communications and protocols

1. ARP: Address Resolution Protocol
2. CORBA: Common Object Request Broker Architecture
3. CSMA/CD: Carrier Sense Multiple Access/Collision Detect
4. DDE: Dynamic Data Exchange
5. FTT: Free Topology Transceivers
6. HTTP: Hyper Text Transfer Protocol
7. IIOP: Internet Inter-ORB Protocol
8. LAN: Local Area Network
9. LON: Echelon Communication – Local Operating Network
10. MS/TP: Master Slave Token Passing
11. ODBC: Open Database Connectivity
12. ORB: Object Request Broker
13. SNVT: Standard Network Variables Types
14. SQL: Structured Query Language
15. UDP: User Datagram Protocol
16. XML: eXtensible Markup Language

C. Controllers
   1. ASD: Application Specific Device
   2. AAC: Advanced Application Controller
   3. ASC: Application Specific Controller.
   4. CAC: Custom Application Controller.
   5. DCU: Distributed Control Unit
   6. LCM: Local Control Module
   7. MC: MicroControllers
   8. MCI: MicroInterface
   9. MN-II: Microzone II direct digital controller
   10. MN-FLO: Micronet 2000 Pressure Independent VAV Controller
   11. NSC: Network Server Controller
   12. PEM: Package Equipment Module
   13. PPC: Programmable Process Controller
   14. SDCU: Standalone Digital Control Units
   15. SLC: Supervisory Logic Controller
   16. UEC: Unitary Equipment Controller
   17. VAVDDC: Variable Air Volume Direct Digital Controller

D. Tools and Software
   1. CCDT: Configuration, Commissioning and Diagnostic Tool
   2. BPES: BACnet Portable Engineering Station
   3. LPES: LON Portable Engineering Station
   4. POT: Portable Operator's Terminal

1.4 Qualifications of Bidder

A. All bidders must be a certified installer and a certified manufacturer's representative, distributor or branch office of the DDC automation control system being installed with a minimum of 3 years' experience and have installed similar systems to that being proposed in the design documents.
B. The Building Management System contractor shall have a full service facility within 200 miles of the project that is staffed with engineers trained and certified by the manufacturer in the configuration, programming and service of the automation system. The contractor's technicians shall be fully capable of providing instructions and routine emergency maintenance service on all system components.

1.5 Scope of Work

A. The Contractor shall furnish and install a complete building automation system including all necessary hardware and all operating and applications software necessary to perform the control sequences of operation as called for in this specification and on the contract drawings. All components of the system – workstations, servers, application controllers, unitary controllers, etc. shall communicate using the BACnet protocol, as defined by ASHRAE Standard 135-2007, or EIA standard 709.1, the LonTalk™ protocol, or Modbus protocol. No gateways shall be used for communication to controllers furnished under this section. At a minimum, provide controls for the following:
   1. Air handling units
   2. Exhaust and supply fans **(NOT IN SCOPE)**
   3. Boilers including hot water pumps

4. Smoke evacuation sequence of AHUs and return fans including smoke control dampers and fire command override panel. **(NOT IN SCOPE)**
5. Finned tube radiation control **(NOT IN SCOPE)**
6. Power wiring to DDC devices, smoke control dampers and BAS panels except as otherwise specified.

B. Except as otherwise noted, the control system shall consist of all necessary Ethernet Network Controllers, Standalone Digital Control Units, workstations, software, sensors, transducers, relays, valves, dampers, damper operators, control panels, and other accessory equipment, along with a complete system of electrical interlocking wiring to fill the intent of the specification and provide for a complete and operable system. Except as otherwise specified, provide operators for equipment such as dampers if the equipment manufacturer does not provide these. Coordinate requirements with the various Contractors.
C. The BAS contractor shall review and study all HVAC drawings and the entire specification to familiarize themselves with the equipment and system operation and to verify the quantities and types of dampers, operators, alarms, etc. to be provided.
D. All interlocking wiring, wiring and installation of control devices associated with the equipment listed below shall be provided under this Contract. When the BAS system is fully installed and operational, the BAS Contractor and representatives of the Owner will review and check out the system – see System Acceptance and Testing section of this document. At that time, the BAS contractor shall demonstrate the operation of the system and prove that it complies with the intent of the drawings and specifications.
E. Provide services and manpower necessary for commissioning of the system in coordination with the HVAC Contractor, Balancing Contractor and Owner's representative.
F. All work performed under this section of the specifications will comply with all governing codes, laws and governing bodies. If the drawings and/or specifications are in conflict with governing codes, the Contractor, with guidance from the engineer, shall submit a proposal with appropriate modifications to the project to meet code restrictions. If this specification and associated drawings exceed governing code requirements, the specification will govern. The Contractor shall obtain and pay for all necessary construction permits and licenses.

1.6 System Description

A. In accordance to the scope of work, the system shall also provide a graphical, web-based, operator interface that allows for instant access to any system through a standard browser. The contractor must provide PC-based programming workstations, operator workstations and microcomputer controllers of modular design providing distributed processing capability, and allowing future expansion of both input/output points and processing/control functions.

For this project, the system shall consist of the following components:

a. Administration and Programming Workstation(s): The BAS Contractor shall furnish (1) Administration and Programming Workstation Computers as described in Part 2 of the specification. These workstations must be running the standard workstation software developed and tested by the manufacturer of the network server controllers and the standalone controllers. No third party front-end workstation software will be acceptable. Workstations must conform to the B-OWS BACnet device profile. A minimum of 6 concurrent operators shall be provided.
2. Web-Based Operator Workstations: The BAS Contractor shall furnish licenses for web connection to the BAS system. Web-based users shall have access to all system points and graphics, shall be able to receive and acknowledge alarms, and

shall be able to control setpoints and other parameters. All engineering work, such as trends, reports, graphics, etc. that are accomplished from the WorkStation shall be available for viewing through the web browser interface without additional changes. The web-based interface must conform to the B-OWS BACnet device profile. There will be no need for any additional computer based hardware to support the web-based user interface.

3. Ethernet-based Network Router and/or Network Server Controller(s): The BAS Contractor shall furnish the needed Ethernet-based Network Server Controllers as described in Part 2 of the specification. These controllers will connect directly to the Operator Workstation over Ethernet at a minimum of 100mbps, and provide communication to the Standalone Digital Control Units and/or other Input/Output Modules. Network Server Controllers shall conform to BACnet device profile B-BC. Network controllers that utilize RS232 serial communications or ARCNET to communicate with the workstations will not be accepted.
   Network Controllers shall be tested and certified by the BACnet Testing Laboratory (BTL) as Network Server Controllers (B-BC).
4. Standalone Digital Control Units (SDCUs): Provide the necessary quantity and types of SDCUs to meet the requirements of the project for mechanical equipment control including air handlers, central plant control, and terminal unit control. Each SDCU will operate completely standalone, containing all of the I/O and programs to control its associated equipment. Each BACnet protocol SDCU shall conform to the BACnet device profile B-AAC.
   BACnet SDCUs shall be tested and certified by the BACnet Testing Laboratory (BTL) as Advanced Application Controllers (B-AAC).

B. The Local Area Network (LAN) shall be either a 10 or 100 Mpbs Ethernet network supporting BACnet, Modbus, Java, XML, HTTP, and CORBA IIOP for maximum flexibility for integration of building data with enterprise information systems and providing support for multiple Network Server Controllers (NSCs), user workstations and a local host computer system.
C. The Enterprise Ethernet (IEEE 802.3) LAN shall utilize Carrier Sense Multiple/Access/Collision Detect (CSMA/CD), Address Resolution Protocol (ARP) and User Datagram Protocol (UDP) operating at 10 or 100 Mbps.
D. The system shall enable an open architecture that utilizes EIA standard 709.1, the LonTalk™ protocol and/or ANSI / ASHRAE™ Standard 135-2007, BACnet functionality to assure interoperability between all system components. Native support for the LonTalk™ protocol and the ANSI / ASHRAE™ Standard 135-2007, BACnet protocol are required to assure that the project is fully supported by the HVAC open protocols to reduce future building maintenance, upgrade, and expansion costs.
E. The system shall enable an architecture that utilizes a MS/TP selectable 9.6-76.8 KBaud protocol, as the common communication protocol between all controllers and integral ANSI / ASHRAE™ Standard 135-2008, BACnet functionality to assure interoperability between all system components. The AAC shall be capable of communicating as a MS/TP device or as a BACnet IP device communicating at 10/100 Mbps on a TCP/IP trunk. The ANSI / ASHRAE™ Standard 135-2008, BACnet protocol is required to assure that the project is fully supported by the leading HVAC open protocol to reduce future building maintenance, upgrade, and expansion costs.
F. LonTalk™ packets may be encapsulated into TCP/IP messages to take advantage of existing infrastructure or to increase network bandwidth where necessary or desired.

1. Any such encapsulation of the LonTalk™ protocol into IP datagrams shall conform to existing LonMark™ guide functionality lines for such encapsulation and shall be based on industry standard protocols.
2. The products used in constructing the BMS shall be LonMark™ compliant.
3. In those instances in which Lon-Mark™ devices are not available, the BMS contractor shall provide device resource files and external interface definitions for LonMark devices.

G. The software tools required for network management of the LonTalk™ protocol and the ANSI / ASHRAE™ Standard 135-2008, BACnet protocol must be provided with the system. Drawings are diagrammatic only. Equipment and labor not specifically referred to herein or on the plans and are required to meet the functional intent, shall be provided without additional cost to the Owner. Minimum BACnet compliance is Level 4; with the ability to support data read and write functionality. Physical connection of BACnet devices shall be via Ethernet IP or MS/TP. Physical connection of LonWorks devices shall be via Ethernet IP or FTT-10A.

H. The system shall support Modbus TCP and RTU protocols natively, and not require the use of gateways.

I. Complete temperature control system to be DDC with electronic sensors and electronic/electric actuation of Mechanical Equipment Room (MER) valves and dampers and electronic actuation of terminal equipment valves and actuators as specified herein. The BMS is intended to seamlessly connect devices throughout the building regardless of subsystem type, i.e. variable frequency drives, low voltage lighting systems, electrical circuit breakers, power metering and card access should easily coexist on the same network channel.
    1. The supplied system must incorporate the ability to access all data using Java enabled browsers without requiring proprietary operator interface and configuration programs.
    2. Data shall reside on a supplier-installed server for all database access.
    3. A hierarchical topology is required to assure reasonable system response times and to manage the flow and sharing of data without unduly burdening the customer’s internal Intranet network.

J. All work described in this section shall be installed, wired, circuit tested and calibrated by factory certified technicians qualified for this work and in the regular employment of the approved manufacturer's local field office. The approved manufacturer's local field office shall have a minimum of 3 years of installation experience with the manufacturer. Supervision, hardware and software engineering, calibration and checkout of the system shall be by the employees of the approved manufacturer's local field office. The control contractor shall have an in place support facility within 200 miles of the site with factory certified technicians and engineers, spare parts inventory and all necessary test and diagnostic equipment for the installed system, and the control contractor shall have 24 hours/day, 7 days/week emergency service available.

K. Provide the Commissioning, configuration and diagnostic tool (CCDT), color display personnel computer, software, and interfaces to provide uploading/downloading of High Point Count Controllers (AAC), Unitary Equipment Controllers (UEC) and VAV controllers (VAVDDC) monitoring all BACnet objects, monitoring overrides of all controller physical input/output points, and editing of controller resident time schedules.

L. Provide a Portable Operator’s Terminal (POT) color display personnel computer, software, and interfaces to provide uploading/downloading of Custom Application Controller and Application Specific Controllers databases, monitoring of all LonMark™ Standard Network Variables Types (SNVTs) including display of all bound SNVTs, monitoring and overrides of all

controller physical input/output points, and editing of controller resident time schedules. POT connectivity shall be via digital wall sensor connected to controller.

1.7 Work by Others

A. The BAS Contractor shall cooperate with other contractors performing work on this project necessary to achieve a complete and neat installation. To that end, each contractor shall consult the drawings and specifications for all trades to determine the nature and extent of others' work.
B. The BAS Contractor shall furnish all control valves, sensor wells, flow meters and other similar equipment for installation by the Mechanical Contractor.
C. The BAS Contractor shall provide field supervision to the designated contractor for the installation of the following:
    1. Automatic control dampers
    2. Blank-off plates for dampers that are smaller than duct size.
    3. Sheet metal baffles plates to eliminate stratification.
    4. The Electrical Contractor shall provide:
        a. All power wiring to motors, heat trace, junction boxes for power to BAS panels.
        b. Furnish smoke detectors and wire to the building fire alarm system. HVAC Contractor to mount devices. BAS Contractor to hardwire to fan shut down.

1.8 Code Compliance

A. Provide BAS components and ancillary equipment, which are UL-916 listed and labeled.
B. All equipment or piping used in conditioned air streams, spaces or return air plenums shall comply with NFPA 90A Flame/Smoke/Fuel contribution rating of 25/50/0 and all applicable building codes or requirements.
C. All wiring shall conform to the National Electrical Code.
D. All smoke dampers shall be rated in accordance with UL 555S.
E. Comply with FCC rules, Part 15 regarding Class A radiation for computing devices and low power communication equipment operating in commercial environments.
F. Comply with FCC, Part 68 rules for telephone modems and data sets.

1.9 Submittals

A. All shop drawings shall be prepared in Visio Professional or AutoCAD software. In addition to the drawings, the Contractor shall furnish a CD containing the identical information. Drawings shall be B size or larger.
B. Shop drawings shall include a riser diagram depicting locations of all controllers and workstations, with associated network wiring. Also included shall be individual schematics of each mechanical system showing all connected points with reference to their associated controller. Typicals will be allowed where appropriate.
C. Submittal data shall contain manufacturer's data on all hardware and software products required by the specification. Valve, damper and air flow station schedules shall indicate size, configuration, capacity and location of all equipment.
D. Software submittals shall contain narrative descriptions of sequences of operation, program listings, point lists, and a complete description of the graphics, reports, alarms and

configuration to be furnished with the workstation software. Information shall be bound or in a three ring binder with an index and tabs. Diagrams shall be on 11" by 17" foldouts. If color has been used to differentiate information, the printed copies shall be in color.

E. Submit five (5) copies of submittal data and shop drawings to the Engineer for review prior to ordering or fabrication of the equipment. The Contractor, prior to submitting, shall check all documents for accuracy.

F. The Engineer will make corrections, if required, and return to the Contractor. The Contractor will then resubmit with the corrected or additional data. This procedure shall be repeated until all corrections are made to the satisfaction of the Engineer and the submittals are fully approved.

G. The following is a list of post construction submittals that shall be updated to reflect any changes during construction and re-submitted as "As-Built".
    1. System architecture drawing.
    2. Layout drawing for each control panel
    3. Wiring diagram for individual components
    4. System flow diagram for each controlled system
    5. Instrumentation list for each controlled system
    6. Sequence of control
    7. Binding map
    8. Operation and Maintenance Manuals

H. Information common to the entire system shall be provided. This shall include but not be limited to the following.
    1. Product manuals for the key software tasks.
    2. Operating the system.
    3. Administrating the system.
    4. Engineering the operator workstation.
    5. Application programming.
    6. Engineering the network.
    7. Setting up the web server.
    8. Report creation.
    9. Graphics creation.
    10. All other engineering tasks.
    11. System Architecture Diagram.
    12. List of recommended maintenance tasks associated with the system servers, operator workstations, data servers, web servers and web clients.
    13. Define the task.
    14. Recommend a frequency for the task.
    15. Reference the product manual that includes instructions on executing the task.
    16. Names, addresses, and telephone numbers of installing contractors and service representatives for equipment and control systems.
    17. Licenses, guarantees, and warranty documents for equipment and systems.
    18. Submit one copy for each building, plus two extra copies.

I. Information common to the systems in a single building shall be provided.
    1. System architecture diagram for components within the building annotated with specific location information.
    2. As-built drawing for each control panel.
    3. As-built wiring design diagram for all components.
    4. Installation design details for each I/O device.
    5. As-built system flow diagram for each system.

6. Sequence of control for each system.
7. Binding map for the building.
8. Product data sheet for each component.
9. Installation data sheet for each component.
10. Submit two copies for each building and two extra copies.

J. Software shall be provided:
1. Submit a copy of all software installed on the servers and workstations.
2. Submit all licensing information for all software installed on the servers and workstations.
3. Submit a copy of all software used to execute the project even if the software was not installed on the servers and workstations.
4. Submit all licensing information for all of the software used to execute the project.
5. All software revisions shall be as installed at the time of the system acceptance.
6. Firmware Files
7. Submit a copy of all firmware files that were downloaded to or pre-installed on any devices installed as part of this project.
8. This does not apply to firmware that is permanently burned on a chip at the factory and can only be replaced by replacing the chip.
9. Submit a copy of all application files that were created during the execution of the project.
10. Submit a copy of all graphic page files created during the execution of the project.

1.10 Coordination

A. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation.
B. Coordinate equipment from other divisions including "Intrusion Detection," "Lighting Controls," "Motor Control Centers," "Panel boards," and "Fire Alarm" to achieve compatibility with equipment that interfaces with those systems.
C. Coordinate supply of conditioned electrical circuits for control units and operator workstation.
D. Coordinate location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3 Section "Cast-in-Place Concrete".
E. Coordinate with the Owner's IT department on locations for network controllers, Ethernet communication cabling and TCP/IP addresses.

1.11 Ownership

A. The Owner shall retain licenses to software for this project.
B. The Owner shall sign a copy of the manufacturer’s standard software and firmware licensing agreement as a condition off this contractor. Such license shall grant use of all programs and application software to the Owner as defined by the manufacturer’s license agreement, but shall protect the manufacturer’s rights to disclosure of Trade Secrets contained within such software.
C. The licensing agreement shall not preclude the use of the software by individuals under contract to the owner for commissioning, servicing or altering the system in the future. Use of the software by individuals under contract to the owner shall be restricted to use on the owner’s computers and only for the purpose of commissioning, servicing, or altering the installed system.

D. All project developed software, files and documentation shall become the property of the Owner. These include but are not limited to:
    1. Server and workstation software
    2. Application programming tools
    3. Configuration tools
    4. Network diagnostic tools
    5. Addressing tools
    6. Application files
    7. Configuration files
    8. Graphic files
    9. Report files
    10. Graphic symbol libraries
    11. All documentation

1.12 Quality Assurance - System Startup and Commissioning

A. Each point in the system shall be tested for both hardware and software functionality. In addition, each mechanical and electrical system under control of the BAS will be tested against the appropriate sequence of operation specified herein. Successful completion of the system test shall constitute the beginning of the warranty period. A written report will be submitted to the owner indicating that the installed system functions in accordance with the plans and specifications.
B. The BAS contractor shall commission and set in operating condition all major equipment and systems, such as the chilled water, hot water and all air handling systems, in the presence of the equipment manufacturer's representatives, as applicable, and the Owner and Architect's representatives.
C. The BAS Contractor shall provide a technician for as required for manpower and engineering services required to assist the HVAC Contractor and Balancing Contractor in testing, adjusting, and balancing all systems in the building. The BAS Contractor shall coordinate all requirements to provide a complete air balance with the Balancing Contractor and shall include all labor and materials in his contract.
D. Startup Testing shall be performed for each task on the startup test checklist, which shall be initialed by the technician and dated upon test was completion along with any recorded data such as voltages, offsets or tuning parameters. Any deviations from the submitted installation plan shall also be recorded.
E. Required elements of the startup testing include:
    1. Measurement of voltage sources, primary and secondary
    2. Verification of proper controller power wiring.
    3. Verification of component inventory when compared to the submittals.
    4. Verification of labeling on components and wiring.
    5. Verification of connection integrity and quality (loose strands and tight connections).
    6. Verification of bus topology, grounding of shields and installation of termination devices.
    7. Verification of point checkout.
    8. Each I/O device is landed per the submittals and functions per the sequence of control.
    9. Analog sensors are properly scaled and a value is reported
    10. Binary sensors have the correct normal position and the state is correctly reported.

11. Analog outputs have the correct normal position and move full stroke when so commanded.
12. Binary outputs have the correct normal state and respond appropriately to energize/de-energize commands.
13. Documentation of analog sensor calibration (measured value, reported value and calculated offset).
14. Documentation of Loop tuning (sample rate, gain and integral time constant).

F. A performance verification test shall also be completed for the operator interaction with the system. Test elements shall be written to require the verification of all operator interaction tasks including, but not limited to the following.
1. Graphics navigation.
2. Trend data collection and presentation.
3. Alarm handling, acknowledgement and routing.
4. Time schedule editing.
5. Application parameter adjustment.
6. Manual control.
7. Report execution.
8. Automatic backups.
9. Web Client access.

G. A Startup Testing Report and a Performance Verification Testing Report shall be provided upon test completion.

1.13 Warranty and Maintenance

A. All components, system software, and parts furnished and installed by the BMS contractor shall be guaranteed against defects in materials and workmanship for 1 year of substantial completion. Labor to repair, reprogram, or replace these components shall be furnished by the BMS contractor at no charge during normal working hours during the warranty period. Materials furnished but not installed by the BMS contractor shall be covered to the extent of the product only. Installation labor shall be the responsibility of the trade contractor performing the installation. All corrective software modifications made during warranty periods shall be updated on all user documentation and on user and manufacturer archived software disks. The Contractor shall respond to the owner's request for warranty service within 24 standard working hours.

1.14 Training

A. The BAS Contractor shall provide both on-site and classroom training to the Owner’s representative and maintenance personnel per the following description:
B. On-site training shall consist of a minimum of (40) hours of hands-on instruction geared at the operation and maintenance of the systems. The curriculum shall include
1. System Overview
2. System Software and Operation
3. System access
4. Software features overview
5. Changing setpoints and other attributes
6. Scheduling
7. Editing programmed variables

8. Displaying color graphics
9. Running reports
10. Workstation maintenance
11. Viewing application programming
12. Operational sequences including start-up, shutdown, adjusting and balancing.
13. Equipment maintenance.
14. Factory, classroom training will include a minimum of (2) training reservation for a 3 day course with material covering workstation operation tuition free with travel expense responsibility of the owner. The option for 2-3 weeks of system engineering and controller programming shall be possible if necessary and desired.

PART 2 - Products

2.1 Approved Manufacturers

A. Subject to compliance with requirements, provide products by one of the following manufacturers:
   1. Schneider Electric
   2. Novar
   3. Honeywell
   4. Johnson Controls
   5. Tridium Vykon
   6. Or as approved by Owners

2.2 System Architecture

A. General
   1. The Building Automation System (BAS) shall consist of Network Server/Controllers (NSCs), a family of Standalone Digital Control Units (SDCUs), Administration and Programming Workstations (APWs), and Web-based Operator Workstations (WOWs). The BAS shall provide control, alarm detection, scheduling, reporting and information management for the entire facility, and Wide Area Network (WAN) if applicable.
   2. An Enterprise Level BAS shall consist of an Enterprise Server, which enables multiple NSCs (including all graphics, alarms, schedules, trends, programming, and configuration) to be accessible from a single Workstation simultaneously for operations and engineering tasks.
   3. For Enterprise reporting capability and robust reporting capability outside of the trend chart and listing ability of the Workstation, a Reports Server shall be installed on a Microsoft Windows based computer. The Reports Server can be installed on the same computer as the Enterprise Server.
   4. The system shall be designed with a top-level 10/100bT Ethernet network, using the BACnet/IP, LonWorks IP, and/or Modbus TCP protocol. All protocols shall be native to the NSCs. There shall not be a need to provide multiple NSCs to support all the network protocols, nor should there be a need to supply additional software to allow all three protocols to be natively supported. A sub-network of SDCUs using the BACnet MS/TP, LonTalk FTT-10A, and/or Modbus RTU protocol shall

connect the local, stand-alone controllers with Ethernet-level Network Server Controllers/IP Routers.

B. TCP/IP Level
   1. The TCP/IP layer connects all of the buildings on a single Wide Area Network (WAN) isolated behind the campus firewall. Fixed IP addresses for connections to the campus WAN shall be used for each device that connects to the WAN.

C. Fieldbus Level with Standalone Digital Control Units (SDCUs)
   1. The fieldbus layer shall be support all of the following types of SDCUs:
      a. BACnet SDCU requirements: The system shall consist of one or more BACnet MS/TP field buses managed by the Network Server Controller. Minimum speed shall be 76.8kbps. The field bus layer consists of an RS485, token passing bus that supports up to 50 Standalone Digital Control Units (SDCUs) for operation of HVAC and lighting equipment. These devices shall conform to BACnet standard 135-2007
      b. LonWorks SDCU requirements: The system shall consist of one or more LonWorks FTT-10A field buses managed by the Network Server Controller. Minimum speed shall be 76.8kbps. The field bus layer shall consist of up to 64 Lonworks SDCUs using peer-to-peer, event-driven communication for operation of HVAC and lighting equipment. An addition of up to 30 TAC Xenta controllers is acceptable.
      c. Modbus SDCU requirements: The system shall consist of one or more Modbus RTU (RS-485 or RS-232) field buses managed by the Network Server Controller. The field bus layer shall consist of up to 62 SDCUs for operation of HVAC, power metering, and lighting equipment. If utilizing Modbus TCP, the field bus layer shall consist of up to 100 SDCUs for operation of HVAC, power metering, and lighting equipment.
      d. NETWORK 8000 SDCU requirements: The system shall consist of one or more ASD or LCM field buses managed by the Network Server Controller. The field bus layer shall consist of up to 128 ASD SDCUs or 31 LCM SDCUs for operation of HVAC, power metering, and lighting equipment.
      e. I/NET SDCU requirements: The system shall consist of one or more controller LANs and subLANs managed by the Network Server Controller. The network shall consist of up to 100,000 I/NET points capable through numerous links and devices for operation of HVAC, power metering, and lighting equipment.

D. BAS LAN Segmentation
   1. The BAS shall be capable of being segmented, through software, into multiple local area networks (LANs) distributed over a wide area network (WAN). Workstations can manage a single LAN (or building), and/or the entire system with all portions of that LAN maintaining its own, current database.

E. Standard Network Support
   1. All NSCs, Workstation(s) and Servers shall be capable of residing directly on the owner's Ethernet TCP/IP LAN/WAN with no required gateways. Furthermore, the NSC's, Workstation(s), and Server(s) shall be capable of using standard, commercially available, off-the-shelf Ethernet infrastructure components such as routers, switches and hubs. With this design the owner may utilize the investment of an existing or new enterprise network or structured cabling system. This also allows the option of the maintenance of the LAN/WAN to be performed by the owner's Information Systems Department as all devices utilize standard TCP/IP components.

F. System Expansion
1. The BAS system shall be scalable and expandable at all levels of the system using the same software interface, and the same TCP/IP level and fieldbus level controllers. Systems that require replacement of either the workstation software or field controllers in order to expand the system shall not be acceptable.
2. Web-based operation shall be supported directly by the NSCs and require no additional software, other than a Java supported network browser.
3. The system shall be capable of using graphical and/or line application programming language for the Network Server Controllers.

G. Support For Open Systems Protocols
1. All Network Server Controllers must natively support the BACnet IP, BACnet MS/TP, LonWorks IP, LonWorks FTT-10, Modbus TCP, Modbus RTU (RS-485 and RS-232), and Modbus ASCII protocols.

2.3 Operator Workstation Requirements

A. General
1. The operator workstation portion of the BAS shall consist of one or more full-powered configuration and programming workstations, and one or more web-based operator workstations. For this project provide a minimum of 1 operator user and 1 engineering user.
2. The programming and configuration workstation software shall allow any user with adequate permission to create and/or modify any or all parts of the NSC and/or Enterprise Server database.
3. All configuration workstations shall be personal computers operating under the Microsoft Windows operating system. The application software shall be capable of communication to all Network Server Controllers and shall feature high-resolution color graphics, alarming, trend charting. It shall be user configurable for all data collection and data presentation functions.
4. A minimum of 1 Workstation shall be allowed on the Ethernet network. In this client/server configuration, any changes or additions made from one workstation will automatically appear on all other workstations since the changes are accomplished to the databases within the NSC. Systems with a central database will not be acceptable.

B. Administration/Programming Workstation & Enterprise Server Requirements
1. The Enterprise Server shall consist of the following:
   a. Processor
      a) Minimum: 2.0 GHz
      b) Recommended: 2.6 GHz or higher
   b. Memory
      a) Minimum: 8GB
      b) Recommended: 8GB or higher
   c. Operating systems:
      a) Microsoft Windows 10 Pro
      b) Microsoft Server 2019
   d. 10/100MBPS Ethernet NIC

e. 250 GB hard disk
f. License agreement for all applicable software

2. The workstation shall consist of the following:
   a. Processor
      a) Minimum: 2.0 GHz
      b) Recommended: 2.6 GHz or higher
   b. Memory
      a) Minimum: 8GB
      b) Recommended: 8GB or higher
   c. Operating systems:
      a) Microsoft Windows 10 Pro
   d. Serial port, parallel port, USB port
   e. 10/100MBPS Ethernet NIC
   f. 250 GB hard disk
   g. DVD drive
   h. High resolution (minimum 1280 x 1024), 17" flat panel display
   i. Optical mouse and full function keyboard
   j. Audio sound card and speakers
   k. License agreement for all applicable software.

C. Web-Based Operator PC Requirements
   1. Any user on the network can access the system, using the following software:
      a. Windows 8 and above
      b. Microsoft Edge (32-bit) and above
      c. Firefox 78 (32-bit) and above
      d. Java-enabled

D. General Administration and Programming Workstation Software
   1. System architecture shall be truly client server in that the Workstation shall operate as the client while the NSCs shall operate as the servers. The client is responsible for the data presentation and validation of inputs while the server is responsible for data gathering and delivery.
   2. The workstation functions shall include monitoring and programming of all DDC controllers. Monitoring consists of alarming, reporting, graphic displays, long term data storage, automatic data collection, and operator-initiated control actions such as schedule and setpoint adjustments.
   3. Programming of SDCUs shall be capable of being done either off-line or on-line from any operator workstation. All information will be available in graphic or text displays stored at the NSC. Graphic displays will feature animation effects to enhance the presentation of the data, to alert operators of problems, and to facilitate location of information throughout the DDC system. All operator functions shall be selectable through a mouse.

E. User Interface:
   1. The BAS workstation software shall allow the creation of a custom, browser-style interface linked to the user when logging into any workstation. Additionally, it shall be possible to create customized workspaces that can be assigned to user groups. This interface shall support the creation of "hot-spots" that the user may link to view/edit any object in the system or run any object editor or configuration tool contained in the software. Furthermore, this interface must be able to be configured to become a user's "PC Desktop" – with all the links that a user needs to run other applications. This, along with the Windows user security capabilities,

will enable a system administrator to setup workstation accounts that not only limit the capabilities of the user within the BAS software, but may also limit what a user can do on the PC and/or LAN/WAN. This might be used to ensure, for example, that the user of an alarm monitoring workstation is unable to shutdown the active alarm viewer and/or unable to load software onto the PC.

2. System shall be able to automatically switch between displayed metric vs. imperial units based on the workstation/webstations localization.

F. User Security

1. The software shall be designed so that each user of the software can have a unique username and password. This username/password combination shall be linked to a set of capabilities within the software, set by and editable only by, a system administrator. The sets of capabilities shall range from View only, Acknowledge alarms, Enable/disable and change values, Program, and Administer. The system shall allow the above capabilities to be applied independently to each and every class of object in the system. The system must allow a minimum of 256 users to be configured per workstation. Additionally, the software shall enable the ability to add/remove users based upon Microsoft Windows Security Domains that enable the customer IT department to assist in user access.

G. Configuration Interface

1. The workstation software shall use a familiar Windows Explorer□-style interface for an operator or programmer to view and/or edit any object (controller, point, alarm, report, schedule, etc.) in the entire system. In addition, this interface shall present a “network map” of all controllers and their associated points, programs, graphics, alarms, and reports in an easy to understand structure. All object names shall be alphanumeric and use Windows long filename conventions.
2. The configuration interface shall also include support for user defined object types. These object types shall be used as building blocks for the creation of the BAS database. They shall be created form the base object types within the system input, output, string variables, setpoints, etc., alarm algorithms, alarm notification objects, reports, graphics displays, schedules, and programs. Groups of user defined object types shall be able to be set up as a predefined aggregate of subsystems and systems. The configuration interface shall support copying/pasting and exporting/importing portions of the database for additional efficiency. The system shall also maintain a link to all “child” objects created. If a user wishes to make a change to a parent object, the software shall ask the user if he/she wants to update all of the child objects with the change.

H. Color Graphic Displays

1. The system shall allow for the creation of user defined, color graphic displays for the viewing of mechanical and electrical systems, or building schematics. These graphics shall contain point information from the database including any attributes associated with the point (engineering units, etc.). In addition operators shall be able to command equipment or change setpoints from a graphic through the use of the mouse.
2. Requirements of the color graphic subsystem include:
   a. At a minimum, the user shall have the ability to import .gif, .png, .bmp, .jpeg, .tif, and CAD generated picture files as background displays, and layering shall be possible.

b. It shall be possible for the user to use JavaScript to customize the behavior of each graphic.
c. The editor shall use Scalable Vector Graphics (SVG) technology.
d. A built-in library of animated objects such as dampers, fans, pumps, buttons, knobs, gauges, ad graphs which can be “dropped” on a graphic through the use of a software configuration “wizard”. These objects shall enable operators to interact with the graphic displays in a manner that mimics their mechanical equivalents found on field installed control panels.
e. Using the mouse, operators shall be able to adjust setpoints, start or stop equipment, modify PID loop parameters, or change schedules.
f. Status changes or alarm conditions must be able to be highlighted by objects changing screen location, size, color, text, blinking or changing from one display to another.
g. Ability to link graphic displays through user defined objects, alarm testing, or the result of a mathematical expression. Operators must be able to change from one graphic to another by selecting an object with a mouse - no menus will be required.
h. It shall be possible to create and save graphical components and JavaScript code in reusable and transferrable, customized libraries.

3. Additionally, the Graphics Editor portion of the Engineering Software shall provide the following capabilities:
   a. Create and save pages.
   b. Group and ungroup symbols.
   c. Modify an existing symbol.
   d. Modify an existing graphic page.
   e. Rotate and mirror a symbol.
   f. Place a symbol on a page.
   g. Place analog dynamic data in decimal format on a page.
   h. Place binary dynamic data using state descriptors on a page.
   i. Create motion through the use of animated .gif files or JavaScript.
   j. Place test mode indication on a page.
   k. Place manual mode indication on a page.
   l. Place links using a fixed symbol or flyover on a page.
   m. Links to other graphics.
   n. Links to web sites.
   o. Links to notes.
   p. Links to time schedules.
   q. Links to any .exe file on the operator work station.
   r. Links to .doc files.
   s. Assign a background color.
   t. Assign a foreground color.
   u. Place alarm indicators on a page.
   v. Change symbol/text/value color as a function of an analog variable.
   w. Change a symbol/text/value color as a function of a binary state.
   x. Change symbol/text/value as a function of a binary state.
   y. All symbols used in the creation of graphic pages shall be saved to a library file for use by the owner.

I. Automatic monitoring

1. The software shall allow for the automatic collection of data and reporting from any controller or NSC. The frequency of data collection shall be user-configurable.

J. Alarm Management

1. The software shall be capable of accepting alarms directly from NSCs or controllers, or generating alarms based on evaluation of data in controllers and comparing to limits or conditional equations configured through the software. Any alarm (regardless of its origination) will be integrated into the overall alarm management system and will appear in all standard alarm reports, be available for operator acknowledgment, and have the option for displaying graphics, or reports.
2. Alarm management features shall include:
   a. A minimum of 1000 alarm notification levels. Each notification level will establish a unique set of parameters for controlling alarm display, distribution, acknowledgment, keyboard annunciation, and record keeping.
   b. Automatic logging in the database of the alarm message, point name, point value, source device, timestamp of alarm, username and time of acknowledgement, username and time of alarm silence (soft acknowledgement)
   c. Playing an audible sound on alarm initiation or return to normal.
   d. Sending an email or alphanumeric pager to anyone listed in a workstation's email account address list on either the initial occurrence of an alarm and/or if the alarm is repeated because an operator has not acknowledged the alarm within a user-configurable timeframe. The ability to utilize email and alphanumeric paging of alarms shall be a standard feature of the software integrated with the operating system's mail application interface (MAPI). No special software interfaces shall be required and no email client software must be running in order for email to be distributed.
   e. Individual alarms shall be able to be re-routed to a user at user-specified times and dates. For example, a critical high temp alarm can be configured to be routed to a Facilities Dept. workstation during normal working hours (7am-6pm, Mon-Fri) and to a Central Alarming workstation at all other times.
   f. It shall be possible to re-route an alarm if a user-defined response time has been exceeded. For example, if a critical alarm has an acknowledgment time of 5 minutes and that acknowledgement does not occur, the alarm can be re-routed to a secondary receiver.
   g. An active alarm viewer shall be included which can be customized for each user or user type to hide or display any alarm attributes.
   h. The font type and color, and background color for each alarm notification level as seen in the active alarm viewer shall be customizable to allow easy identification of certain alarm types or alarm states.
   i. The active alarm viewer can be configured such that an operator must type in text in an alarm entry and/or pick from a drop-down list of user actions for certain alarms. This ensures accountability (audit trail) for the response to critical alarms.
   j. The active alarm viewer can be configured such that an operator must type in text in an alarm entry and/or pick from a drop-down list of causes for certain alarms. This ensures accountability (audit trail) for the response to critical alarms.

k. The active alarm viewer can be configured such that an operator must confirm that all of the steps in a check list have been accomplished prior to acknowledging the alarm.
l. An operator shall have the capability to assign an alarm to another user of the system. Such assignments shall be tracked to insure alarm response.

K. Report Generation

1. The Reports Server shall be able to process large amounts of data and produce meaningful reports to facilitate analysis and optimization of each installation.
2. Reports shall be possible to generate and view from the operator Workstation, and/or Webstation, and/or directly from a reports-only web interface.
3. A library of predefined automatically generated reports that prompt users for input prior to generation shall be available. The properties and configurations made to these reports shall be possible to save as Dashboard reports, so that the configurations are saved for future used.
4. It shall be possible to create reports standard tools, such as Microsoft Report Builder 2.0 or Visual Studio, shall be used for customized reports.
5. Additional reports or sets of reports shall be downloadable, transferrable, and importable
6. All reports shall be able to be set up to automatically run or be generated on demand.
7. Each report shall be capable of being automatically emailed to a recipient in Microsoft Word, Excel, and/or Adobe .pdf format.
8. Reports can be of any length and contain any point attributes from any controller on the network.
9. Image management functionality shall be possible to enable the system administrators to easily upload new logos or images to the system.
10. It shall be possible to run other executable programs whenever a report is initiated.
11. Report Generator activity can be tied to the alarm management system, so that any of the configured reports can be displayed in response to an alarm condition.
12. Minimum supplied reports shall include:
    a. Activities Per Server Report
    b. Activities Per User Report
    c. Alarm Amount by Category Report
    d. Alarm Amount by Type Report
    e. Alarms Per Sever Report
    f. Current Alarm Report
    g. Most Active Alarm Report
    h. System Errors Per Server Report
    i. Top Activities Report
    j. Top Alarms Report
    k. Top System Errors Report
    l. Trend Log Comparison Report
    m. User Logins Report
    n. Users and Groups Reports
13. Minimum Energy Reports shall include:
    a. Energy Monitoring Calendar Consumption Report: Shall provide an interactive report that shows the energy usage on one or multiple selected days.

b. Energy Monitoring Consumption Breakdown Report: Shall provide a report on energy consumption broken down using sub-metering.
c. Energy Monitoring Consumption Report: Shall show the energy consumption against a specified target value.

14. Reports Server Hardware Requirements
    a. Processor
        a) Minimum: 2.0 GHz
        b) Recommended: 2.6 GHz or higher
    b. Memory
        a) Minimum: 8 GB
        b) Recommended: 8GB or higher
    c. Hard Disk: 500 GB
15. Reports Server Software Requirements
    a. Operating System: Microsoft Windows Server 2008 R2 (64-bit)
    b. SQL Versions:
        a) Microsoft SQL Server 2008 R2 Express with Advanced Services (64-bit)
        b) Microsoft SQL Server 2008 R2 Standard (64-bit)

L. Scheduling
1. From the workstation or webstation, it shall be possible to configure and download schedules for any of the controllers on the network.
2. Time of day schedules shall be in a calendar style and viewable in both a graphical and tabular view.
3. Schedules shall be programmable for a minimum of one year in advance.
4. To change the schedule for a particular day, a user shall simply select the day and make the desired modifications.
5. Additionally, from the operator webstations, each schedule will appear on the screen viewable as the entire year, monthly, week and day. A simple mouse click shall allow switching between views. It shall also be possible to scroll from one month to the next and view or alter any of the schedule times.
6. Schedules will be assigned to specific controllers and stored in their local RAM memory. Any changes made at the workstation will be automatically updated to the corresponding schedule in the controller.
7. It shall be possible to assign a lead schedule such that shadow/local schedules are updated based upon changes in the Lead.
8. It shall be possible to assign a list(s) of exception event days, dates, date ranges to a schedule.

M. Programmer's Environment
1. Programming in the NSC shall be either in graphical block format or line-programming format or both.
2. The programmer's environment will include access to a superset of the same programming language supported in the SDCUs.
3. NSC devices will support both script programming language as well as the graphical function block programming language. For both languages, the programmer will be able to configure application software off-line (if desired) for custom program development, and write global control programs.

4. It shall be possible to save custom programs as libraries for reuse throughout the system. A wizard tool shall be available for loading programs from a library file in the program editor.
5. It shall be possible to view graphical programming live and real-time from the Workstation.

N. Saving/Reloading
1. The workstation software shall have an application to save and restore NSC and field controller memory files.
2. For the NSC, this application shall not be limited to saving and reloading an entire controller – it must also be able to save/reload individual objects in the controller. This allows off-line debugging of control programs, for example, and then reloading of just the modified information.

O. Audit Trail
1. The workstation software shall automatically log and timestamp every operation that a user performs at a workstation, from logging on and off a workstation to changing a point value, modifying a program, enabling/disabling an object, viewing a graphic display, running a report, modifying a schedule, etc.
2. It shall be possible to view a history of alarms, user actions, and commands for any system object individually or at least the last 5000 records of all events for the entire system from Workstation.
3. It shall be possible to save custom filtered views of event information that are viewable and configurable in Workstation.

P. Fault Tolerant Enterprise Server Operation (Top level NSC)
1. A single component failure in the system shall not cause the entire system to fail. All system users shall be informed of any detectable component failure via an alarm event. System users shall not be logged off as a result of a system failure or switchover.

Q. Web-based Operator Software
1. General:
   a. Day-to-day operation of the system shall be accessible through a standard web browser interface, allowing technicians and operators to view any part of the system from anywhere on the network.
2. Graphic Displays
   a. The browser-based interface must share the same graphical displays as the Administration and Programming Workstations, presenting dynamic data on site layouts, floor plans, and equipment graphics. The browser's graphics shall support commands to change setpoints, enable/disable equipment and start/stop equipment.
   b. Through the browser interface, operators must be able to navigate through the entire system, and change the value or status of any point in any controller. Changes are effective immediately to the controller, with a record of the change stored in the system database.
3. Alarm Management
   a. Systems requiring additional client software to be installed on a PC for viewing the webstation from that PC will not be considered.
   b. Through the browser interface, a live alarm viewer identical to the alarm viewer on the Administration and Programming workstation shall be presented, if the user's password allows it. Users must be able to receive alarms, silence alarms, and acknowledge alarms through a browser. If

desired, specific operator text must be able to be added to the alarm record before acknowledgement, attachments shall be viewable, and alarm checklists shall be available.

R. Groups and Schedules
   1. Through the browser interface, operators must be able to view pre-defined groups of points, with their values updated automatically.
   2. Through the browser interface, operators must be able to change schedules – change start and stop times, add new times to a schedule, and modify calendars.

S. User Accounts and Audit Trail
   1. The same user accounts shall be used for the browser interface and for the operator workstations. Operators must not be forced to memorize multiple passwords.
   2. All commands and user activity through the browser interface shall be recorded in the system's activity log, which can be later searched and retrieved by user, date, or both.

T. Web Services
   1. The installed system shall be able to use web services to "serve" and "consume" information within both the Network Server/Controllers (NSCs) and the Administration and Programming Workstations (APWs) with other products and systems.

2.4 Network Server Controllers (NSCs)

A. Network Router Controllers shall combine both network routing functions, control functions, and server functions into a single unit.
B. The BACnet NSC shall be classified as a "native" BACnet device, supporting the BACnet Network Server Controller (B-BC) profile. NSCs shall be tested and certified by the BACnet Testing Laboratory (BTL) as BACnet Network Server Controllers (B-BC).
C. The Network Server Controller shall provide the interface between the LAN or WAN and the field control devices, and provide global supervisory control functions over the control devices connected to the NRS.
D. They shall also be responsible for monitoring and controlling their own HVAC equipment such as an AHU or boiler.
E. They shall also contain graphics, trends, trend charts, alarm views, and other similar presentation objects that can be served to workstations or web-based interfaces. A sufficient number of NSCs shall be supplied to fully meet the requirements of this specification and the attached point list.
F. It shall be capable of executing application control programs to provide:
   1. Calendar functions
   2. Scheduling
   3. Trending
   4. Alarm monitoring and routing
   5. Time synchronization by means of an Internet site including automatic synchronization
   6. Native integration of LonWorks controller data and Modbus controller data or BACnet controller data and Modbus controller data
   7. Network Management functions for all LonWorks based devices
G. Hardware Specifications
   1. Memory:

a. The operating system of the controller, application programs, and all other portions of the configuration database, shall be stored in non-volatile, FLASH memory. Servers/Controllers shall contain enough memory for the current application, plus required history logging, plus a minimum of 20% additional free memory.

2. Each NRC shall provide the following on-board hardware for communication:
   a. One 10/100bT Ethernet for communication to Workstations, other NRCs and onto the Internet
   b. Two RS-485 ports for communication to BACnet MSTP bus or serial Modbus (software configurable)
   c. One TP/FT port for communication to LonWorks devices.
   d. One Device USB port
   e. Two host USB Ports

H. Modular Expandability:
   1. The system shall employ a modular I/O design to allow expansion. Input and output capacity is to be provided through plug-in modules of various types. It shall be possible to combine I/O modules as desired to meet the I/O requirements for individual control applications.

I. Hardware Override Switches:
   1. All digital outputs shall, optionally, include three position manual override switches to allow selection of the ON, OFF, or AUTO output state. These switches shall be built into the unit and shall provide feedback to the controller so that the position of the override switch can be obtained through software. In addition each analog output shall be equipped with an override potentiometer to allow manual adjustment of the analog output signal over its full range, when the 3 position manual override switch is placed in the ON position.

J. Local Status Indicator Lamps:
   1. The NSC shall provide as a minimum LED indication of CPU status, Ethernet LAN status, and field bus status. For each input or output, provide LED indication of the value of the point (On/Off). The LED indication shall support software configuration to set whether the illumination of the LED corresponds to On or Off or whether the color when illuminated is Red or Green.

K. Real Time Clock (RTC):
   1. Each NSC shall include a battery-backed, real time clock, accurate to 10 seconds per day. The RTC shall provide the following: time of day, day, month, year, and day of week. Each NSC will allow for its own UTC offset, depending upon the time zone. When the time zone is set, the NSC will also store the appropriate times for daylight savings time.

L. Power Supply:
   1. The 24 VDC power supply for the NSCs shall provide 30 watts of available power for the NSC and associated IO modules. The system shall support the use of more than one power supply if heavily power consuming modules are required.

M. Automatic Restart After Power Failure:
   1. Upon restoration of power after an outage, the NSC shall automatically and without human intervention update all monitored functions, resume operation based on current, synchronize time and status, and implement special start-up strategies as required.

N. Battery backup:

1. The NSC shall include an on-board battery to back up the controller's RAM memory. The battery shall provide accumulated backup of all RAM and clock functions for at least 30 days. In the case of a power failure, the NSC shall first try to restart from the RAM memory. If that memory is corrupted or unusable, then the NSC shall restart itself from its application program stored in its FLASH memory.

O. Software Specifications
1. The operating system of the controller, application programs, and all other portions of the configuration database such as graphics, trends, alarms, views, etc., shall be stored in non-volatile, FLASH memory. There will be no restrictions placed on the type of application programs in the system. Each NSC shall be capable of parallel processing, executing all control programs simultaneously. Any program may affect the operation of any other program. Each program shall have the full access of all I/O facilities of the processor. This execution of control function shall not be interrupted due to normal user communications including interrogation, program entry, printout of the program for storage, etc.
2. Each NSC shall have an available capacity of 4 GB of memory. This shall represent 2 GB for application and historical data and 2 GB dedicated for backup storage.

P. User Programming Language:
1. The application software shall be user programmable. This includes all strategies, sequences of operation, control algorithms, parameters, and setpoints. The source program shall be either a script-based structured text or graphical function block based and fully programmable by the user. The language shall be structured to allow for the configuration of control programs, schedules, alarms, reports, telecommunications, local displays, mathematical calculations, and histories. Users shall be able to place comments anywhere in the body of either script or function block programs.
2. Network Server Controllers that use a "canned" program method will not be accepted.

Q. Control Software:
1. The NSC shall have the ability to perform the following pre-tested control algorithms:
   a. Proportional, Integral plus Derivative Control (PID)
   b. Two Position Control
   c. Digital Filter
   d. Ratio Calculator
   e. Equipment Cycling Protection

R. Mathematical Functions:
1. Each controller shall be capable of performing basic mathematical functions (+, -, *, /), squares, square roots, exponential, logarithms, Boolean logic statements, or combinations of both. The controllers shall be capable of performing complex logical statements including operators such as >, <, =, and, or, exclusive or, etc. These must be able to be used in the same equations with the mathematical operators and nested up to five parentheses deep.

S. NSCs shall have the ability to perform any or all of the following energy management routines:
1. Time of Day Scheduling
2. Calendar Based Scheduling
3. Holiday Scheduling
4. Temporary Schedule Overrides

5. Optimal Start
6. Optimal Stop
7. Night Setback Control
8. Enthalpy Switchover (Economizer)
9. Peak Demand Limiting
10. Temperature Compensated Duty Cycling
11. CFM Tracking
12. Heating/Cooling Interlock
13. Hot/Cold Deck Reset
14. Hot Water Reset
15. Chilled Water Reset
16. Condenser Water Reset
17. Chiller Sequencing

T. History Logging:

1. Each NSC controller shall be capable of LOCALLY logging any input, output, calculated value or other system variable either over user defined time intervals ranging from 1 second to 1440 minutes or based upon a user configurable change of value. A minimum of 1000 values shall be stored in each of these types of logs. Each log can record either the instantaneous, average, minimum or maximum value of the point. Logged data shall be downloadable to a higher level NSC long term archiving based upon user-defined time intervals, or manual command.
2. Management of a power meter replacement to ensure meter log data is accurate shall be possible in the NSC.
3. Every hardware input and output point shall be trended automatically without the requirement for manual creation, and each of these logs shall log values based upon a change of value and store at least 500 trend samples before replacing the oldest sample with new data.
4. The presentation of logged data shall be built into the server capabilities of the NSC Presentation can be in time stamped list formats or in a chart format with fully configurable pen colors, weights, scales and time spans.

U. Alarm Management:

1. For each system point, alarms can be created based on high/low limits or in comparison to other point values. All alarms will be tested each scan of the NSC and can result in the display of one or more alarm messages or reports.
2. There is no limit to the number of alarms that can be created for any point/
3. Alarms can be configured to be generated based upon a single system condition or multiple system conditions.
4. Alarms will be generated based on an evaluation of the alarm conditions and can be presented to the user in a fully configurable order, by priority, by time, by category, etc. These configurable alarm views will be presented to a user upon logging into the system regardless of whether the log in takes place at a WorkStation or a Webstation.
5. The alarm management system shall support the ability to create and select cause and action notes to be selected and associated with an alarm event. Checklists shall also be possible in order to present to an operator a suggested mode of troubleshooting. When acknowledging an alarm, it shall be possible to assign it to a user of the system such that the user is notified of the assignment and is made responsible for the alarm resolution.

6. Alarms must be capable of being routed to any BACnet workstation that conforms to the B-OWS device profile and uses the BACnet/IP protocol.

V. Embedded Web Server

1. Each NSC must have the ability to serve out web pages containing the same information that is available from the WorkStation. The development of the screens to accomplish shall not require any additional engineering labor over that required to show them at the WorkStation itself.

2.5 LON Fieldbus and LON SDCUs

A. IP Network

1. All devices that connect to the WAN shall be capable of operating at 10 megabits per second and 100 megabits per second

B. Field Bus

1. The field busses shall be FTT-10A operating at 78 kilobits per second.
2. The wiring of components shall use a bus or daisy chain concept with no tees, stubs or free topology.
3. The wiring type and length limitations shall conform to Echelon's Junction Box and Wiring Guideline for Twisted Pair LonWorks Networks.
4. Each field bus shall have a termination device at both ends of each segment.

C. IP to Field Bus Router

1. These devices shall perform layer 3 routing of ANSI/EIA 709.1B packets onto the IP network.
2. These devices shall be configurable locally without the use of the IP network (local cross over cable connection is acceptable) and configurable via the IP network.
3. These devices shall be configurable as routers such that only data packets from the field bus devices that need to travel over the IP level of the architecture are forwarded.

D. Network Server Controller

1. These devices shall perform layer 3 routing of ANSI/EIA 709.1B packets onto the IP network.
2. These devices shall be configurable locally without the use of the IP network (local cross over cable connection is acceptable) and configurable via the IP network.
3. These devices shall be configurable as routers such that only data packets from the field bus devices that need to travel over the IP level of the architecture are forwarded.
4. These devices shall provide the following support for the field bus devices that are connected below the Network Server Controller.
   a. Time schedules
   b. Trend logging
   c. Alarm message generation and handling
5. These devices may provide supervisory logic support for the field bus devices that are connected below the Network Server Controller.
6. These devices may have physical inputs and outputs and provide process control for systems using these inputs and outputs.

7. If a Network Server Controller has physical inputs and outputs, it shall also comply with all of the requirements for programmable process controllers.

E. Physical Layer Repeaters (PLR)
1. PLRs are required to connect two segments to create a channel.
2. The design of the PLRs shall conform to LONMark standards.
3. LON to LON routers configured as repeaters may be used as a PLR.
4. Physical layer repeaters shall be installed in an enclosure. The enclosure may be in an interstitial space.

F. Standalone Digital Control Units (SDCUs)
1. General Requirements
a. Devices shall incorporate a service pin which, when pressed, will cause the device to broadcast its 48 bit node ID and its program ID over the network. The service pin shall be distinguishable and accessible.
b. Devices shall have a light indicating that they are powered.
c. Devices shall incorporate a TP/FT-10A transceiver in accordance with ANSI/EIA 709.3 and connections for TP/FT control network wiring.
d. Devices shall be locally powered.
e. Application programs shall be stored in a manner such that a loss of power does not result in a loss of the application program or configuration parameter settings.

2. Programmable Process Controllers (PPC)
a. The key characteristics of a PPC are:
1) They have physical input and output circuits for the connection of analog input devices, binary input devices, pulse input devices, analog output devices and binary output devices. The number and type of input and output devices supported will vary by model.
2) They may or may not provide support for additional input and output devices beyond the number of circuits that are provided on the basic circuit board. Support for additional I/O may be by additional circuit boards that physically connect to the basic controller or by a standalone device that communicates with the basic controller via the FTT-10A field bus.
3) The application to be executed by a PPC is created by an application engineer using the vendor's application programming tool.
4) PPCs shall support embedded time schedules. When time schedules are not embedded in a PPC, an occupancy command shall be an input network variable when time based control is required by the sequence of control. Systems that use a Network Server Controller shall provide time schedule support in the Network Server Controller and the PPCs are not required to support for time schedules. Systems that use LON to IP routers require that PPCs support embedded time schedules.
5) PPCs shall support trend data storage with periodic upload to the data server. When trend data storage is not supported, the variables to be trended shall be broadcast over the field bus to another device that does support embedded trend data storage. Systems that use a Network Server Controller shall provide trend logging support in the Network

Server Controller and the PPCs are not required to support trend logging. Systems that use LON to IP routers require that PPCs support embedded trend logging.

6) PPCs shall support the initiation of an alarm message to the system server. When alarm message initiation is not supported, binary alarm indication variables shall be broadcast over the field bus to another device that does support the initiation of alarm messages to the system server. Systems that use a Network Server Controller shall provide alarm message initiation support in the Network Server Controller and the PPCs are not required to support alarm message initiation. Systems that use LON to IP routers require that PPCs support alarm messaging initiation.

b. Analog Input Circuits
   1) The electrical signals from analog sensors shall be processed by an analog to digital (A/D) converter chip. The output of the A/D chip shall then be processed mathematically to produce data within the controller that has the required engineering units.
   2) The resolution of the A/D chip shall not be greater than 0.01 Volts per increment. For an A/D converter that has a measurement range of 0 to 10 VDC and is 10 bit, the resolution is 10/1024 or 0.00976 Volts per increment.
   3) For non-flow sensors, the control logic shall provide support for the use of a calibration offset such that the raw measured value is added to the (+/-) offset to create a calibration value to be used by the control logic and reported to the Operator Workstation (OWS).
   4) For flow sensors, the control logic shall provide support for the use of an adjustable gain and an adjustable offset such that a two point calibration concept can be executed (both a low range value and a high range value are adjusted to match values determined by a calibration instrument).
   5) For non-linear sensors such as thermistors and flow sensors the PPC shall provide software support for the linearization of the input signal.
c. Binary Input Circuits
   1) Dry contact sensors shall wire to the controller with two wires.
   2) An external power supply in the sensor circuit shall not be required.
d. Pulse Input Circuits
   1) Pulse input sensors shall wire to the controller with two wires.
   2) An external power supply in the sensor circuit shall not be required.
   3) The pulse input circuit shall be able to process up to 50 pulses per second.
e. True Analog Output Circuits
   1) The logical commands shall be processed by a digital to analog (D/A) converter chip. The 0% to 100% control signal shall be scalable to the full output range which shall be either 0 to 10 VDC, 4 to 20 milliamps or 0 to 20 milliamps or to ranges within the full output range (Example: 0 to 100% creates 3 to 6 VDC where the full output range is 0 to 10 VDC).
   2) The resolution of the D/A chip shall not be greater than 0.04 Volts per increment or 0.08 milliamps per increment.
f. Pulse Width Modulation Outputs with PWM transducers

1) The controller shall be able to generate incremental pulses as small as 0.1 seconds.

g. Binary Output Circuits
   1) Single pole single throw or single pole double throw relays with support for up to 230 VAC and a maximum current of 2 amps.
   2) Voltage sourcing or externally powered triacs with support for up to 30 VAC and 0.8 amps.

h. Program Execution
   1) Process control loops shall operate in parallel and not in sequence unless specifically required to operate in sequence by the sequence of control.
   2) The sample rate for a process control loop shall be adjustable and shall support a minimum sample rate of 1 second.
   3) The sample rate for process variables shall be adjustable and shall support a minimum sample rate of 1 second.
   4) The sample rate for algorithm updates shall be adjustable and shall support a minimum sample rate of 1 second.
   5) The application shall have the ability to determine if a power cycle to the controller has occurred, and the application programmer shall be able to use the indication of a power cycle to modify the sequence of control immediately following a power cycle.

i. Local Interface: The controller shall support the connection of a portable interface device such as a laptop computer or vendor unique hand-held device. The ability to execute any tasks other than viewing data shall be password protected. Via this local interface, an operator shall be able to:
   1) Adjust application parameters.
   2) Edit time schedule parameters if time schedules are embedded in the controller.
   3) Execute manual control of input and output points.
   4) View dynamic data.
   5) View alarm messages if alarm messaging is embedded in the controller.

j. Each PPC shall have a network interface port that allows for an external device to connect to the FTT-10A network by plugging into the port. This port shall be built into the controller.

3. Supervisory Logic Controller (SLC)
   a. The key characteristics of an SLC are:
      1) The application to be executed by as SLC is created by an application engineer using the vendor's application programming tool.
      2) SLCs shall support embedded time schedules. When time schedules are not embedded in a SLC, an occupancy command shall be an input network variable when time based control is required by the sequence of control. Systems that use a Network Server Controller shall provide time schedule support in the Network Server Controller and the SLCs do not have to support for time schedules. Systems that use a LON to IP router will provide time schedule support in the SLCs.
      3) SLCs shall support trend data storage with periodic upload to the data server. When trend data storage is not supported, the variables to be trended shall be broadcast over the field bus to another device that

does support embedded trend data storage. Systems that use a Network Server Controller shall provide trend logging support in the Network Server Controller and the SLCs are not required to support trend logging. Systems that use LON to IP routers require that SLCs support embedded trend logging.

4) SLCs may support the initiation of an alarm message to the system server. When alarm message initiation is not supported, binary alarm indication variables shall be broadcast over the field bus to another device that does support the initiation of alarm messages to the system server. Systems that use a Network Server Controller shall provide alarm message initiation support in the Network Server Controller and the SLCs are not required to support alarm message initiation. Systems that use LON to IP routers require that SLCs support alarm messaging initiation.

b. Program Execution
   1) Control algorithms shall operate in parallel and not in sequence unless specifically required to operate in sequence by the sequence of control.
   2) The sample rate for algorithm updates shall be adjustable and shall support a minimum sample rate of 1 second.
   3) The application shall have the ability to determine if a power cycle to the controller has occurred and the application programmer shall be able to use the indication of a power cycle to modify the sequence of control immediately following a power cycle.

c. Local Interface
   1) The controller shall support the connection of a portable interface device such as a laptop computer or vendor unique hand-held device. The ability to execute any tasks other than viewing data shall be password protected. Via this local interface, an operator shall be able to:
      a) Adjust application parameters.
      b) Edit time schedule parameters if time schedules are embedded in the controller.
      c) Execute manual control of input and output network variables.
      d) View dynamic data.
      e) View alarm messages if alarm messaging is embedded in the controller.

d. Each SLC shall have a network interface port that allows for an external device to connect to the FTT-10A network by plugging into the port. This port shall be built into the controller.

e. Programmable Process Controllers (PPCs) with un-used I/O may be used as Supervisory Logic Controllers provided they meet all other requirements.

f. Supervisory logic controllers shall have support a minimum of 200 input network variables and 70 output network variables.
   1) The SNVT for each of the 200 input network variables shall be selectable.
   2) The SNVT for each of the 70 output network variables shall be selectable.

g. For the input and output network variables there shall not be any limitations as to the SNVT selected. (Example: SNVT_temp_p can only be used on 10 input network variables.)

4. Application Specific Devices (ASD)
   a. ASD shall have fixed function configurable applications.
   b. If the application can be altered by the vendor's application programming tool, the device is a programmable controller and not an application specific device.
   c. All input and output network variables shall be formatted with SNVTs.
   d. All input configuration parameters shall be formatted with SNVTs or SCPTs. If UNVTs or UCPTs are used, the device resource files that allow these custom parameters to be read shall be provided to the owner.
   e. The network interface shall conform to the LonMark profile for the application provided by the ASD.
   f. Each ASD shall have a network interface port that allows for an external device to connect to the FTT-10A network by plugging into the port. This port shall be built into the controller.
5. Portable Operating Terminals (POT)
   a. Laptop Computer
   b. Software Requirements: The software requirements for a POT are identical to those for an operator workstation.
   c. Hardware Requirements: The hardware requirements for a POT are identical to those for an operator workstation.

2.6 BACnet Fieldbus and BACnet SDCUs

A. Networking
   1. IP Network: All devices that connect to the WAN shall be capable of operating at 10 megabits per second or 100 megabits per second.
   2. IP To Field Bus Routing Devices
      a. A Network Server Controller shall be used to provide this functionality.
      b. These devices shall be configurable locally with IP crossover cable and configurable via the IP network.
      c. The routing configuration shall be such that only data packets from the field bus devices that need to travel over the IP level of the architecture are forwarded.

B. Field Bus Wiring and Termination
   1. The wiring of components shall use a bus or daisy chain concept with no tees, stubs, or free topology.
   2. Each field bus shall have a termination resistor at both ends of each segment.
   3. The field bus shall support the use of wireless communications.

C. Repeaters
   1. Repeaters are required to connect two segments.
   2. Repeaters shall be installed in an enclosure. The enclosure may be in an interstitial space.

D. Field Bus Devices
   1. General Requirements
      a. Devices shall have a light indicating that they are powered.

b. Devices shall be locally powered.
c. Application programs shall be stored in a manner such that a loss of power does not result in a loss of the application program or configuration parameter settings. (Battery backup, flash memory, etc.)

E. Network Server Controllers (NSCs)
a. If NSCs have embedded I/O, all of the requirements for I/O that are described under Advance Application Controllers shall apply.
b. Shall support the export of data to NSCs from other vendors that support the data sharing, read property service.
c. Shall support the export of data using Change of Value (COV) initiation to NSCs from other vendors that support the subscription to data using the COV concept.
d. Shall support the export of data to any BACnet OWS that supports the data sharing, read property service.
e. Shall support the export of data using Change of Value (COV) initiation to any BACnet OWS that supports the subscription to data using the COV concept.
f. Shall provide trend log support for all of the devices on the field bus. They shall provide sufficient memory to store up to 300 samples for each variable required to be trended by the sequence of control.
g. Shall support the exporting of trend log data to any BACnet OWS that supports the read range BACnet service for trending.
h. Shall provide time schedule support for all of the devices on the field bus.
i. Shall support the editing of time schedule entries from any BACnet OWS that supports the BACnet service for writing of time schedule parameters.
j. Shall provide alarm message initiation for all alarms conditions from any of the field bus devices.
k. Shall deliver alarm messages to any BACnet OWS that supports the BACnet service for receiving alarm messages and is configured to be a recipient of the notification.
l. Shall support alarm acknowledgement from any BACnet OWS that supports the BACnet service for executing alarm/event acknowledgement.
m. Shall support the control of the out of service property and assignment of value or state to analog and binary objects from any BACnet OWS that supports writing to the out of service property and the value property of analog and binary objects.
n. Shall support the receipt and response to Time Synchronization commands from any device that supports the BACnet service for initiating time synchronization commands.
o. Shall support the “Who is?” and “I am.” BACnet service.
p. Shall support the “”Who has?” and “I have.” BACnet service.
q. Shall support Backup and Restore commands from any BACnet OWS that supports the initiation of Backup and Restore commands.
r. Shall be BTL certified.

F. Advance Application Controllers (B-AAC)
1. The key characteristics of a B-AAC are:
a. They have physical input and output circuits for the connection of analog input devices, binary input devices, pulse input devices, analog output

devices, and binary output devices. The number and type of input and output devices supported will vary by model.

b. They may or may not provide support for additional input and output devices beyond the number of circuits that are provided on the basic circuit board. Support for additional I/O shall be provided by additional circuit boards that physically connect to the basic controller.

c. The application to be executed by a B-AAC is created by an application engineer using the vendor's application programming tool.

d. If local time schedules are embedded, the B-AAC shall support the editing of time schedule entries from any BACnet OWS that supports the BACnet service for writing of time schedule parameters.

e. If local trend logging is embedded, the B-AAC shall support the exporting of trend log data to any BACnet OWS that supports the read range BACnet service for trending.

f. If local alarm message initiation is embedded, the B-AAC shall:

1) Deliver alarm messages to any BACnet OWS that supports the BACnet service for receiving alarm messages and is configured to be a recipient off the alarm message.

2) Support alarm acknowledgement from any BACnet OWS that supports the BACnet service for executing alarm/event acknowledgement,

g. Shall support the reading of analog and binary data from any BACnet OWS or Building Controller that supports the BACnet service for the reading of data.

h. Shall support the control of the out of service property and assignment of value or state to analog and binary objects from any BACnet OWS that supports writing to the out of service property and the value property of analog and binary objects.

i. Shall support the receipt and response to Time Synchronization commands from a BACnet Building Controller.

j. Shall support the "Who is" and "I am." BACnet services.

k. Shall support the "Who has" and "I have." BACnet services.

2. Analog Input Circuits

a. The resolution of the A/D chip shall not be greater than 0.01 Volts per increment. For an A/D converter that has a measurement range of 0 to 10 VDC and is 10 bit, the resolution is 10/1024 or 0.00976 Volts per increment.

b. For non-flow sensors, the control logic shall provide support for the use of a calibration offset such that the raw measured value is added to the (+/-) offset to create a calibration value to be used by the control logic and reported to the Operator Workstation (OWS).

c. For flow sensors, the control logic shall provide support for the use of an adjustable gain and an adjustable offset such that a two point calibration concept can be executed (both a low range value and a high range value are adjusted to match values determined by a calibration instrument).

d. For non-linear sensors such as thermistors and flow sensors the B-AAC shall provide software support for the linearization of the input signal.

3. Binary Input Circuits

a. Dry contact sensors shall wire to the controller with two wires.

b. An external power supply in the sensor circuit shall not be required.

4. Pulse Input Circuits

a. Pulse input sensors shall wire to the controller with two wires.
b. An external power supply in the sensor circuit shall not be required.
c. The pulse input circuit shall be able to process up to 20 pulses per second.

5. True Analog Output Circuits
   a. The logical commands shall be processed by a digital to analog (D/A) converter chip. The 0% to 100% control signal shall be scalable to the full output range which shall be either 0 to 10 VDC, 4 to 20 milliamps or 0 to 20 milliamps or to ranges within the full output range (Example: 0 to 100% creates 3 to 6 VDC where the full output range is 0 to 10 VDC).
   b. The resolution of the D/A chip shall not be greater than 0.04 Volts per increment or 0.08 milliamps per increment.
6. Binary Output Circuits
   a. Single pole, single throw or single pole, double throw relays with support for up to 230 VAC and a maximum current of 2 amps.
   b. Voltage sourcing or externally powered triacs with support for up to 30 VAC and 0.5 amps at 24 VAC.
7. Program Execution
   a. Process control loops shall operate in parallel and not in sequence unless specifically required to operate in sequence by the sequence of control.
   b. The sample rate for a process control loop shall be adjustable and shall support a minimum sample rate of 1 second.
   c. The sample rate for process variables shall be adjustable and shall support a minimum sample rate of 1 second.
   d. The sample rate for algorithm updates shall be adjustable and shall support a minimum sample rate of 1 second.
   e. The application shall have the ability to determine if a power cycle to the controller has occurred and the application programmer shall be able to use the indication of a power cycle to modify the sequence of controller immediately following a power cycle.
8. Local Interface
   a. The controller shall support the connection of a portable interface device such as a laptop computer or vendor unique hand-held device. The ability to execute any tasks other than viewing data shall be password protected. Via this local interface, an operator shall be able to:
      1) Adjust application parameters.
      2) Execute manual control of input and output points.
      3) View dynamic data.

G. Application Specific Devices
1. Application specific devices shall have fixed function configurable applications.
2. If the application can be altered by the vendor's application programmable tool, the device is an advanced application controller and not an application specific device.
3. Application specific devices shall be BTL certified.

2.7 NETWORK 8000 Fieldbus SDCUs

A. Local Control Modules (LCMs)
1. Controls shall be microprocessor based, Mechanical System Direct Digital Controllers (LCMs). LCMs shall be provided for air handling units, packaged

rooftops, primary and secondary pumping loop systems and other applications as shown on the drawings. LCMs shall be based on a minimum 16 bit microprocessor working from software program memory which is physically located in the LCM. The application control program shall be resident within the same enclosure as the input/output circuitry which translates sensor signals. All input/output signal conversion shall be performed through a minimum of a 12 Bit A to D converter. All input/output points shall be universal in nature allowing their individual function definition to be assigned through the application software. All unused input/output points must be available as universally definable at the owner's discretion.

2. One LCM controller per mechanical system shall be provided, as shown on the drawings.
3. All input/output signals shall be directly hardwired to the LCM. Trouble shooting of input/output signals shall be easily executed with a volt-ohm meter (VOM). As a result of this intent, it is specified that power line carrier systems, or other systems which command multiple outputs over a single pair of wires, shall not be used.
4. LCM shall be in continuous direct communication with the network that forms the facility-wide Building Automation System (BAS). The LCMs shall communicate with the NSC at a baud rate of not less than 19,200 baud.
5. All control sequences programmed into the LCM shall be stored in non-volatile memory, which is not dependent upon the presence of a battery to be retained. Power failures shall not cause the LCM memory to be lost, nor shall there be any need for batteries to be recharged or replaced to maintain the integrity of the controller database.
6. The LCM shall allow for the creation of unique application control strategies,
7. All control sequences shall be fully field programmable at the LCM controller, allowing for the creation or editing of an application-specific sequence of operations.
8. Each LCM shall be provided with a built-in Operator Interface that has a minimum of a 2 line by 20 character display. The built-in operator interface shall allow the operator to view up to twenty dynamic, scrolling values, without accessing the controller through the keypad. Upon controller reset the scrolling values shall automatically return without operator intervention.
    a. The built-in display shall be mounted securely within the locked enclosure of the LCM, but the display and keypad shall be accessible at all times. The LCM shall be mounted such that the display is at eye level with the average operator (5'9" from the floor).
    b. The built-in display shall allow access to all application program data and real time data within the LCM. All information and commands shall be fully prompted for the operator. Via the built-in operator interface, the operator shall be able to view the operation application program sequence.
    c. The built-in operator interface shall allow the operator to modify or create an application program, on-line, without disrupting the existing operation of the controller.
9. Include additional capacity in every panel, for future installation of desired equipment, at the owner's discretion. Provide expansion capacity of at least 10%

for every panel. Any input/output cards or modules required to utilize the spare points shall be provided. Expansion capacity shall include equal quantities of every point type; Analog input, Digital input, Digital output, and Analog output.

10. All sensing inputs shall be provided via industry standard signals. Temperatures, humidities, differential pressure signals, and other signal inputs shall be one of the following types:
    a. 0-20 ma
    b. 4-20 ma
    c. 0-5 VDC
    d. 0-12 VDC
    e. 1000 ohm platinum (at 32 Def F, 1.45 Ohms/DegF)
    f. 1000 ohm Balco (at 70 Deg F, 2.2 Ohms/DegF)
    g. 10k ohm thermistor (at 77 DegF)
    h. Custom, definable input signals (accept sensor inputs from RTD devices, other than those of the manufacturer).
11. The LCM shall allow for internal processing and reporting of user defined Time of Day Schedules, Alarms, Trend Reports, Run Time Totalizations, Energy Utilization Reports, and Application Program Documentation.
12. The LCM shall provide LED indication of transmit/receive communications performance as well as for the proper/improper operation of the controller itself.
13. The LCM shall be provided with a battery-backed time clock that is capable of maintaining the time of day and calendar for up to thirty days without loss of setting. The battery for the time clock shall be field replaceable by the customer. Integral daily, weekly, holiday and special event scheduling shall be provided, such that all schedules can be custom tailored to the facility. Predefined schedules, with set quantities of on/off cycles are not acceptable.
14. The LCM shall be mounted directly in or on the control compartment of the mechanical system. The LCM shall be provided in a NEMA 1 enclosure to accommodate direct mounting on the equipment to be controlled. The LCM shall be constructed in a modular orientation such that service of the failed components can be performed quickly and easily. The modular construction should limit the quantities of printed circuit boards to a maximum of three. When required to replace a printed circuit board, it shall not be necessary to disconnect any field wiring. The LCM shall allow for the creation of, unique, application control strategies. This shall allow all controls maintenance and troubleshooting to be made while at the unit location.
15. LCM shall be directly wired to sensory devices, staging relays or modulating valves for heating and cooling.
16. LCMs shall be rated for service from -40 Deg. F to 140 Deg. F.
17. LCM operating system software shall be multi-tasking. The multi-tasking capability of the LCM shall provide the capability to simultaneously perform at least, but not limited to, the following functions:
    a. Downloading of application program changes to the LCM without affecting the simultaneous operation of existing operating application programming.
    b. All LCMs shall have as a standard feature of their system software, complete libraries of control algorithms for DDC, Energy Management, and Facilities Management functions. These resident libraries of

algorithms shall be drawn from for the creation of the application programming of each individual LCM.

c. These libraries shall be utilized to satisfy the sequences of operation specified.

d. Each LCM shall be provided with PID control loops that incorporate a self-learning capability to eliminate all setup requirements for the Integral and Derivative of the control loop. Each control loop shall be individually tuned.

B. Application Specific Devices (ASDs) - MICROZONE II Controllers (MZ IIs)

1. MZ IIs shall be provided for Air Handling Units, packaged Rooftops, perimeter radiant loops and other applications as shown on the drawings.
2. MZ IIs shall be based on a minimum 16 bit microprocessor working from software program memory which is physically located in the MZ II.
3. The application control program shall be resident within the same enclosure as the input/output circuitry which translates the sensor signals. All input/output signal conversion shall be performed through a minimum of a 10 bit A to D converter.
4. All input points shall be universal in nature allowing their individual function definition to be assigned through the application software. All unused input points must be available as universally definable at the discretion of the owner.
5. Provide a minimum of one MZ II controller per air handling system as shown on the drawings.
6. All input/output signals shall be directly hardwired to the MZ II. Troubleshooting of input/output signals shall be easily executed with a volt-ohm meter (VOM).
7. MZ IIs shall be in continuous direct communication with the network which forms the facility wide Building Automation System. The MZ IIs shall communicate with the NSC at a baud rate of not less than 19,200 baud.
8. All control sequences programmed into the MZ II shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained. Power failures shall not cause the MZ II memory to be lost, nor shall there be any need for batteries to be recharged or replaced to maintain the integrity of the controller database.
9. All control sequences shall be fully programmable at the MZ II, allowing for the creation and editing of an application control sequence, while at the unit. The MZ II shall allow for the creation of unique application control sequences.
10. The MZ II shall be provided with an interface port for the PSI. The interface port shall allow the PSI to have full functionality as described in the PSI section of this specification. From the interface port, the PSI shall be able to directly access any ASD in the network.
11. The MZ II shall provide an input/output point trending utility that is capable of accumulating 48 analog point samples and 10 digital point samples, per input/output point. Each sample shall be taken on a user defined interval, ranging from 1 second to 255 hours per sample. The digital readings shall be on a change of state occurrence for the digital points. All samples shall be recorded with the engineering units for the value, along with a time and date identifier for each sample taken. The samples shall be protected against loss due to power

interruptions through a battery or capacitor backup method for a minimum of 30 days.

12. The MZ II shall provide LED indication of transmit/receive communications performance, as well as for the proper/improper operation of the controller itself.
13, The MZ II shall be provided with a battery-backed time clock that is capable of maintaining the time of day and calendar for up to thirty days, upon loss of power to the MZ II, without loss of setting. The battery for the time clock shall be replaceable by the customer.
14. The MZ II shall be provided with integral time schedules; as a minimum, two seven day schedules with eight on/off periods per day shall be provided.
15. Holiday override of weekly schedules shall be provided for pre-scheduling of holidays, for the year in advance.
16. The MZ II shall be mounted directly in or on the controls compartment of the air handling system. The MZ II shall be provided in a NEMA 1 enclosure to accommodate direct mounting on the equipment to be controlled. The MZ II shall be constructed in a modular orientation such that service of the failed components can be done quickly and easily. The modular construction should limit the quantities of printed circuit boards to a maximum of two. All logic, control system, power supply and input/output circuitry shall be contained on a single plug-in circuit board. When required to replace a printed circuit board, it shall not be necessary to disconnect any field wiring. This shall allow all controls maintenance and troubleshooting to be made while at the air handling unit. The MZ II shall be directly wired to sensory devices, staging relays or modulating valves for heating and cooling.
17. MZ IIs shall be rated for service from -40 Deg. F to 140 Deg. F.

C. Application Specific Devices (ASDs) - Packaged Equipment Module (PEM)

1. Microprocessor based Unitary Digital Controllers (PEMs). PEMs shall be provided for Unit Ventilators, Fan Coils, Heat Pumps and other applications as shown on the drawings.
2. PEMs shall be based on a minimum 16 bit microprocessor working from software program memory which is physically located in the PEM. The application control program shall be resident within the same enclosure as the input/output circuitry which translates the sensor signals.
3. All input/output signal conversion shall be performed through a minimum of a 10 bit A to D converter.
4. Provide one PEM controller per unitary system as shown on the drawings. A single PEM controller shall not be used to serve more than one unitary system.
5. All input/output signals shall be directly hardwired to the PEM. Troubleshooting of input/output signals shall be easily executed with a volt-ohm meter (VOM). Power line carrier systems, or other systems which command multiple outputs over a single pair of wires, shall not be utilized.
6. PEMs shall be in continuous, direct communication with the network which forms the facility wide building automation system. The PEMs shall communicate with the NSC at a baud rate of not less than 9,600 baud.
7. All control sequences programmed into the PEM shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained. Power failures shall not cause the PEM memory to be lost, nor shall there be any

need for batteries to be recharged or replaced to maintain the integrity of the controller database. The PEM shall allow for the creation of unique application control sequences. Systems that allow only selection of sequences from a library or table are not acceptable.

8. All control sequences shall be fully programmable at the PEM, allowing for the creation and editing of an application control sequence, while at the unit. The PEM shall allow for the creation of unique application control sequences.
9. PEMs shall provide the ability to interface with the PSI. The interface port shall be provided at the wall sensor or within the unitary equipment, as specified on the plans. The interface port shall allow the PSI to have full functionality as described in PSI section of this specification. From the interface port, the PSI shall be able to directly access any ASD in the network.
10. PEMs shall provide an input/output point trending utility that is capable of accumulating 48 analog point samples and 10 digital point samples per input/output point. Each sample shall be taken on a user defined interval, ranging from 1 second to 255 hours per sample. The digital readings shall be on a change of state occurrence for the digital points. All samples shall be recorded with the engineering units for the value, along with a time and date identifier for each sample taken.
11. PEMs shall provide LED indication of transmit/receive communication performance, as well as for the proper/improper operation of the controller itself.
12. PEMs shall be mounted directly in the controls compartment of the unitary system. The PEM shall be provided with a sheet metal or polymeric enclosure that is constructed of material allowing for the direct mounting within the primary air stream, as defined by UL-465. The direct mounting shall allow all controls maintenance and troubleshooting to be made while at the unitary equipment. The PEM shall be directly wired to sensory devices, staging relays or modulating valves for heating and cooling.
13. PEMs shall be rated for service from 32 Deg. F to 140 Deg. F..

D. Application Specific Devices (ASDs) - Variable Air Volume Digital Controller (MNFLO)

1. Provide microprocessor based Pressure Independent Variable Air Volume Digital Controllers (MNFLO), as shown in the drawings. The MNFLO shall be based on a microprocessor working from software program memory which is physically located in the MNFLO controller. The VAV controller "intelligence" shall be resident within the same enclosure which translates sensor signals into digital information.
2. MNFLOs shall consist of a microprocessor, power supply, actuator, differential pressure transducer, field terminations, field adjustments and operation/application system software in a single integrated package. All input/output signals shall be directly hardwired to the MNFLO controller. Troubleshooting of input/output signals shall be easily executed through the wall sensor or PSI connected at the wall sensor location.
3. All control sequences programmed in the VAV controller shall be stored in non-volatile memory, which is not dependent upon the presence of a battery to be retained. Power failures shall not cause the VAV controller memory to be lost, nor shall there be any need for batteries to be recharged or replaced. The MNFLO shall meet UL-916, FCC Class A, and CSA agency approvals.

4. MNFLOs shall be provided by the BAS contractor, to the VAV box manufacturer, for factory mounting. The VAV terminal unit supplier shall include all costs for mounting a single integrated package MNFLO controller, connection of actuator to damper shaft, wiring of device power, wiring of MNFLO to fan (fan powered terminal) and wiring to electric reheat coils or reheat valve actuator as specified on drawing.
5. The VAV terminal manufacturer shall provide a multi-point, averaging, differential pressure sensor mounted on the inlet to each VAV box. The VAV terminal unit manufacturer shall supply a line to low voltage transformer, of sufficient capacity, to power the MNFLO plus all reheat valves and/or contactors and fan circuits associated with the VAV terminal and actuator assemblies. The BAS contractor shall provide all reheat control valves to the mechanical contractor for mounting and piping. The BAS contractor shall provide and install all wiring between the valve and MNFLO controller and between the room sensor and the MNFLO controller.
6. MNFLO shall be provided with the ability to interface with the PSI. The interface port shall be provided at the wall sensor or at the controller, as shown on the plans. The interface port shall allow the PSI to have full functionality as described in this specification. From the interface port, the PSI shall be able to directly access any MNFLO under the same parent controller.
7. MNFLOs shall provide manual positioning of the actuator and include a visual indication of the position of the actuator.
8. MNFLOs shall provide LED indication of transmit/receive communications performance, as well as for the proper/improper operation of the controller itself.
9. MNFLOs shall be capable of supporting a peer to peer network using two wire type independent topologies without regard for the polarity of wiring. Wiring of communications shall support "Ts", "Stars", "Active Ts", "Active Stars", and "Distributed Stars" and other configurations without the use of termination resistors.
10. MNFLOs shall be in continuous, direct communication with the network which forms the facility wide building automation system.
11. MNFLO control algorithms shall be designed to limit the frequency of damper repositioning, to assure a minimum 10 year life from all components of the MNFLO. The MNFLO shall provide zone temperature control of +/- 1 Deg F from setpoint.
12. MNFLOs shall provide internal differential pressure transducer for pressure independent applications with an accuracy of ± 5 %. Flow-through transducers requiring filter maintenance are not acceptable.
13. All components of the VAV controller shall be mounted directly at the Variable Air Volume terminal box. Enclosure assembly shall be mounted and positioned so that it is easily accessible to operational personnel.
14. MNFLOs shall be powered by a 24 VAC power source and shall comply with Class 2 wiring requirements.
15. MNFLOs shall be rated for service from 32 Deg. F to 131 Deg. F..
16. MNFLOs shall meet or exceed IEC 801.5 and ANSI C62.41 (IEEE-587, Category A & B) for surge immunity, IEC 801.4 for transient compliance and IEC 801.2 for electrostatic discharge.
17. Where mounted in supply or return air plenums, the MNFLO enclosures shall comply with the requirements of UL 94-5V.

18. MNFLO Input/Output
    a. Self-calibrating Velocity Pressure input (0-2" WC). The velocity pressure transducer shall be a continuously self-calibrating unit, which determines the zero velocity pressure point, by equalizing the pressure across the sensing element, every 10-15 seconds.
    b. Room Temperature Input
    c. Occupancy Override Input
    d. VAV Box Damper Output: Unless otherwise specified, the controller shall provide a minimum 6 N-m/53 lb./inch integral electric actuator, having a 90 degree stroke rotation in a time of 3 minutes maximum.
    e. Occupancy or Status Input
    f. 0-100% Position Indication of Primary Damper Actuator, to be direct feedback from damper actuator
    g. Room Setpoint Input
    h. Auxiliary Temperature Input
    i. PSI Interface
    j. In addition to the inputs and output points described above, MNFLO controllers for fan assisted and/or reheat configurations, provide the following additional control points:
        i. 3 digital outputs for fan control, up to 3 stages of electric reheat, floating valve actuator control or occupancy control of blinds, lights, etc.
        ii. Digital outputs shall be pilot duty and directly control 24 VAC loads.

2.8 DDC Sensors and Point Hardware

A. Temperature Sensors
1. All temperature devices shall use precision thermistors accurate to +/- 1 degree F over a range of –30 to 230 degrees F. Space temperature sensors shall be accurate to +/- .5 degrees F over a range of 40 to 100 degrees F.
2. Standard space sensors shall be available in an off white enclosure for mounting on a standard electrical box.
3. Where manual overrides are required, the sensor housing shall feature both an optional sliding mechanism for adjusting the space temperature setpoint, as well as a push button for selecting after hours operation.
4. Where a local display is specified, the sensor shall incorporate either an LED or LCD display for viewing the space temperature, setpoint and other operator selectable parameters. Using built in buttons, operators shall be able to adjust setpoints directly from the sensor.
5. Duct temperature sensors shall incorporate a thermistor bead embedded at the tip of a stainless steel tube. Probe style duct sensors are useable in air handling applications where the coil or duct area is less than 14 square feet.
6. Averaging sensors shall be employed in ducts which are larger than 14 square feet. The averaging sensor tube must contain at least one thermistor for every 3 feet, with a minimum tube length of 12 feet.
7. Immersion sensors shall be employed for measurement of temperature in all chilled and hot water applications as well as refrigerant applications. Thermal wells

shall be brass or stainless steel for non-corrosive fluids below 250 degrees F and 300 series stainless steel for all other applications.

8. A pneumatic signal shall not be allowed for sensing temperature.

B. Humidity Sensors
   1. Humidity devices shall be accurate to +/- 2% at full scale for space and +/- 2% for duct and outside air applications.
   2. As an option, provide a hand held field calibration tool that both reads the output of the sensor and contains a reference sensor for ongoing calibration.

C. Pressure Sensors
   1. Air pressure measurements in the range of 0 to 10” water column will be accurate to +/- 1% using a solid-state sensing element. Acceptable manufacturers include Veris.
   2. Differential pressure measurements of liquids or gases shall be accurate to =/- 0.5% of range.

D. Current and KW Sensors
   1. Current status switches shall be used to monitor fans, pumps, motors and electrical loads. Current switches shall be available in split core models, and offer either a digital or an analog signal to the automation system. Acceptable manufacturer is Veris or approved equal.
   2. Measurement of three phase power shall be accomplished with a kW/kWH transducer. This device shall utilize direct current transformer inputs to calculate the instantaneous value (kW) and a pulsed output proportional to the energy usage (kWH). Provide Veris Model 6000 Power Transducer or approved equal.

E. Flow Sensors
   1. Provide an insertion vortex flowmeter for measurement of liquid, gas or steam flows in pipe sizes above 3 inches.
   2. Install the flow meter on an isolation valve to permit removal without process shutdown.
   3. Sensors shall be manufactured by Veris or approved equal.

F. Control Valves
   1. Provide automatic control valves suitable for the specified controlled media (steam, water or glycol). Provide valves which mate and match the material of the connected piping. Equip control valves with the actuators of required input power type and control signal type to accurately position the flow control element and provide sufficient force to achieve required leakage specification.
   2. Control valves shall meet the heating and cooling loads specified, and close off against the differential pressure conditions within the application. Valves should be sized to operate accurately and with stability from 10 to 100% of the maximum design flow.
   3. Trim material shall be stainless steel for steam and high differential pressure applications.
   4. Electric actuation should be provided on all terminal unit reheat applications unless electric heat is provided.

G. Dampers
   1. Automatic dampers, furnished by the Building Automation Contractor shall be single or multiple blade as required. Dampers are to be installed by the HVAC Contractor under the supervision of the BAS Contractor. All blank-off plates and conversions necessary to install smaller than duct size dampers are the responsibility of the Sheet Metal Contractor.

2. Damper frames are to be constructed of 13 gauge galvanized sheet steel mechanically joined with linkage concealed in the side channel to eliminate noise as friction. Compressible spring stainless steel side seals and acetyl or bronze bearings shall also be provided.
3. Damper blade width shall not exceed eight inches. Seals and 3/8 inch square steel zinc plated pins are required. Blade rotation is to be parallel or opposed as shown on the schedules.
4. For high performance applications, control dampers will meet or exceed the UL Class I leakage rating.
5. Control and smoke dampers shall be Ruskin, or approved equal.
6. Provide opposed blade dampers for modulating applications and parallel blade for two position control.

H. Damper Actuators

1. Damper actuators shall be electronic, and shall be direct coupled over the shaft, without the need for connecting linkage. The actuator shall have electronic overload circuitry to prevent damage. For power-failure/safety applications, an internal mechanical, spring return mechanism shall be built into the actuator housing. Non-spring return actuators shall have an external manual gear release to allow positioning of the damper when the actuator is not powered.

I. Smoke Detectors

1. Air duct smoke detectors shall be by Air Products & Controls or approved equal. The detectors shall operate at air velocities from 300 feet per minute to 4000 feet per minute.
2. The smoke detector shall utilize a photoelectric detector head.
3. The housing shall permit mechanical installation without removal of the detector cover.
4. The detectors shall be listed by Underwriters Laboratories and meet the requirements of UL 268A.

J. Airflow Measuring Stations

1. Provide a thermal anemometer using instrument grade self heated thermistor sensors with thermistor temperature sensors.
2. The flow station shall operate over a range of 0 to 5,000 feet/min with an accuracy of +/- 2% over 500 feet/min and +/- 10 ft/min for reading less than 500 feet/min.
3. The output signal shall be linear with field selectable ranges including 0-5 VDC, 0-10VDC and 4-20 mA.

PART 3 - Execution

3.1 Contractor Responsibilities

A. General

1. Installation of the building automation system shall be performed by the Contractor or a subcontractor. However, all installation shall be under the personal supervision of the Contractor. The Contractor shall certify all work as proper and complete. Under no circumstances shall the design, scheduling, coordination, programming, training, and warranty requirements for the project be delegated to a subcontractor.

B. Demolition

1. Remove controls which do not remain as part of the building automation system, all associated abandoned wiring and conduit, and all associated pneumatic tubing. The Owner will inform the Contractor of any equipment which is to be removed that will remain the property of the Owner. All other equipment which is removed will be disposed of by the Contractor.

C. Access to Site
1. Unless notified otherwise, entrance to building is restricted. No one will be permitted to enter the building unless their names have been cleared with the Owner or the Owner's Representative.

D. Code Compliance
1. All wiring shall be installed in accordance with all applicable electrical codes and will comply with equipment manufacturer's recommendations. Should any discrepancy be found between wiring specifications in Division 17 and Division 16, wiring requirements of Division 17 will prevail for work specified in Division 17.

E. Cleanup
1. At the completion of the work, all equipment pertinent to this contract shall be checked and thoroughly cleaned, and all other areas shall be cleaned around equipment provided under this contract.

3.2 Wiring, Conduit, and Cable

A. All wire will be copper and meet the minimum wire size and insulation class listed below:

Wire Class	Wire Size	Isolation Class
Power	12 Gauge	600 Volt
Class One	14 Gauge Std.	600 Volt
Class Two	18 Gauge Std.	300 Volt
Class Three	18 Gauge Std.	300 Volt
Communications	Per Mfr.	Per Mfr.

B. Power and Class One wiring may be run in the same conduit. Class Two and Three wiring and communications wiring may be run in the same conduit.

C. Where different wiring classes terminate within the same enclosure, maintain clearances and install barriers per the National Electric Code.

D. Where wiring is required to be installed in conduit, EMT shall be used. Conduit shall be minimum 1/2 inch galvanized EMT. Set screw fittings are acceptable for dry interior locations. Watertight compression fittings shall be used for exterior locations and interior locations subject to moisture. Provide conduit seal-off fitting where exterior conduits enter the building or between areas of high temperature/moisture differential.

E. Flexible metallic conduit (max. 3 feet) shall be used for connections to motors, actuators, controllers, and sensors mounted on vibration producing equipment. Liquid-tight flexible conduit shall be use in exterior locations and interior locations subject to moisture.

F. Junction boxes shall be provided at all cable splices, equipment termination, and transitions from EMT to flexible conduit. Interior dry location J-boxes shall be galvanized pressed steel, nominal four-inch square with blank cover. Exterior and damp location JH-boxes shall be cast alloy FS boxes with threaded hubs and gasketed covers.

G. Where the space above the ceiling is a supply or return air plenum, the wiring shall be plenum rated. Teflon wiring can be run without conduit above suspended ceilings. EXCEPTION: Any

wire run in suspended ceilings that is used to control outside air dampers or to connect the system to the fire management system shall be in conduit.

H. Fiber optic cable shall include the following sizes; 50/125, 62.5/125 or 100/140.
I. Only glass fiber is acceptable, no plastic.
J. Fiber optic cable shall only be installed and terminated by an experienced contractor. The BAS contractor shall submit to the Engineer the name of the intended contractor of the fiber optic cable with his submittal documents.

3.3 Hardware Installation

A. Installation Practices for Wiring
B. All controllers are to be mounted vertically and per the manufacturer's installation documentation.
C. The 120VAC power wiring to each Ethernet or Remote Site controller shall be a dedicated run, with a separate breaker. Each run will include a separate hot, neutral and ground wire. The ground wire will terminate at the breaker panel ground. This circuit will not feed any other circuit or device.
D. A true earth ground must be available in the building. Do not use a corroded or galvanized pipe, or structural steel.
E. Wires are to be attached to the building proper at regular intervals such that wiring does not droop. Wires are not to be affixed to or supported by pipes, conduit, etc.
F. Conduit in finished areas will be concealed in ceiling cavity spaces, plenums, furred spaces and wall construction. Exception; metallic surface raceway may be used in finished areas on masonry walls. All surface raceway in finished areas must be color matched to the existing finish within the limitations of standard manufactured colors.
G. Conduit, in non-finished areas where possible, will be concealed in ceiling cavity spaces, plenums, furred spaces, and wall construction. Exposed conduit will run parallel to or at right angles to the building structure.
H. Wires are to be kept a minimum of three (3) inches from hot water, steam, or condensate piping.
I. Where sensor wires leave the conduit system, they are to be protected by a plastic insert.
J. Wire will not be allowed to run across telephone equipment areas.

3.4 Installation Practices for Field Devices

A. Well-mounted sensors will include thermal conducting compound within the well to insure good heat transfer to the sensor.
B. Actuators will be firmly mounted to give positive movement and linkage will be adjusted to give smooth continuous movement throughout 100 percent of the stroke.
C. Relay outputs will include transient suppression across all coils. Suppression devices shall limit transients to 150% of the rated coil voltage.
D. Water line mounted sensors shall be removable without shutting down the system in which they are installed.
E. For duct static pressure sensors, the high pressure port shall be connected to a metal static pressure probe inserted into the duct pointing upstream. The low pressure port shall be left open to the plenum area at the point that the high pressure port is tapped into the ductwork.
F. For building static pressure sensors, the high pressure port shall be inserted into the space via a metal tube. Pipe the low pressure port to the outside of the building.

3.5 Enclosures

A. For all I/O requiring field interface devices, these devices where practical will be mounted in a field interface panel (FIP). The Contractor shall provide an enclosure which protects the device(s) from dust, moisture, conceals integral wiring and moving parts.
B. FIPs shall contain power supplies for sensors, interface relays and contactors, and safety circuits.
C. The FIP enclosure shall be of steel construction with baked enamel finish; NEMA 1 rated with a hinged door and keyed lock. The enclosure will be sized for twenty percent spare mounting space. All locks will be keyed identically.
D. All wiring to and from the FIP will be to screw type terminals. Analog or communications wiring may use the FIP as a raceway without terminating. The use of wire nuts within the FIP is prohibited.
E. All outside mounted enclosures shall meet the NEMA-4 rating.
F. The wiring within all enclosures shall be run in plastic track. Wiring within controllers shall be wrapped and secured.

3.6 Identification

A. Identify all control wires with labeling tape or sleeves using words, letters, or numbers that can be exactly cross-referenced with as-built drawings.
B. All field enclosures, other than controllers, shall be identified with a Bakelite nameplate. The lettering shall be in white against a black or blue background.
C. Junction box covers will be marked to indicate that they are a part of the BAS system.
D. All I/O field devices (except space sensors) that are not mounted within FIP's shall be identified with name plates.
E. All I/O field devices inside FIP's shall be labeled.

3.7 Existing Controls.

A. Existing controls which are to be reused must each be tested and calibrated for proper operation. Existing controls which are to be reused and are found to be defective requiring replacement, will be noted to the Owner. The Owner will be responsible for all material and labor costs associated with their repair.

3.8 Control System Switch-over

A. Demolition of the existing control system will occur after the new temperature control system is in place including new sensors and new field interface devices.
B. Switch-over from the existing control system to the new system will be fully coordinated with the Owner. A representative of the Owner will be on site during switch-over.
C. The Contractor shall minimize control system downtime during switch-over. Sufficient installation mechanics will be on site so that the entire switch-over can be accomplished in a reasonable time frame.

3.9 Location

A. The location of sensors is per mechanical and architectural drawings.
B. Space humidity or temperature sensors will be mounted away from machinery generating heat, direct light and diffuser air streams.
C. Outdoor air sensors will be mounted on the north building face directly in the outside air. Install these sensors such that the effects of heat radiated from the building or sunlight is minimized.

D. Field enclosures shall be located immediately adjacent to the controller panel(s) to which it is being interfaced.

3.10 Software Installation

A. General.
   1. The Contractor shall provide all labor necessary to install, initialize, start-up and debug all system software as described in this section. This includes any operating system software or other third party software necessary for successful operation of the system.

3.11 Database Configuration.

A. The Contractor will provide all labor to configure those portions of the database that are required by the points list and sequence of operation.

3.12 Color Graphic Displays.

A. Unless otherwise directed by the owner, the Contractor will provide color graphic displays as depicted in the mechanical drawings for each system and floor plan. For each system or floor plan, the display shall contain the associated points identified in the point list and allow for setpoint changes as required by the owner.

3.13 Reports.

A. The Contractor will configure a minimum of 4 reports for the owner. These reports shall, at a minimum, be able to provide:
   1. Trend comparison data
   2. Alarm status and prevalence information
   3. Energy Consumption data
   4. System user data

3.14 Documentation

A. As built software documentation will include the following:
   1. Descriptive point lists
   2. Application program listing
   3. Application programs with comments.
   4. Printouts of all reports.
   5. Alarm list.
   6. Printouts of all graphics
   7. Commissioning and System Startup

3.15 Point to Point Checkout.

A. Each I/O device (both field mounted as well as those located in FIPs) shall be inspected and verified for proper installation and functionality. A checkout sheet itemizing each device shall be filled out, dated and approved by the Project Manager for submission to the owner or owner's representative.

3.16 Controller and Workstation Checkout.

A. A field checkout of all controllers and front end equipment (computers, printers, modems, etc.) shall be conducted to verify proper operation of both hardware and software. A checkout sheet itemizing each device and a description of the associated tests shall be prepared and submitted to the owner or owner's representative by the completion of the project.

3.17 System Acceptance Testing

A. All application software will be verified and compared against the sequences of operation.
    1. Boiler Control
    2. Make-Up Air Units
    3. Packaged Roof Top Control
B. Control loops will be exercised by inducing a setpoint shift of at least 10% and observing whether the system successfully returns the process variable to setpoint. Record all test results and attach to the Test Results Sheet.
C. Test each alarm in the system and validate that the system generates the appropriate alarm message, that the message appears at all prescribed destinations (workstations or printers), and that any other related actions occur as defined (i.e. graphic panels are invoked, reports are generated, etc.). Submit a Test Results Sheet to the owner.
D. Perform an operational test of each unique graphic display and report to verify that the item exists, that the appearance and content are correct, and that any special features work as intended. Submit a Test Results Sheet to the owner.
E. Perform an operational test of each third party interface that has been included as part of the automation system. Verify that all points are properly polled, that alarms have been configured, and that any associated graphics and reports have been completed. If the interface involves a file transfer over Ethernet, test any logic that controls the transmission of the file, and verify the content of the specified information.

SECTION 23 2113 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes piping, special-duty valves, and hydronic specialties for hot-water heating, chilled-water cooling, and condenser water systems; makeup water for these systems; blowdown drain lines; and condensate drain piping.

1.3 DEFINITIONS

A. CPVC: Chlorinated polyvinyl chloride.

B. PVC: Polyvinyl chloride.

1.4 SUBMITTALS

A. Product Data: For each type of special-duty valve indicated. Include flow and pressure drop curves based on manufacturer's testing for diverting fittings, calibrated balancing valves, and automatic flow-control valves.

B. Shop Drawings: Detail fabrication of pipe anchors, hangers, special pipe support assemblies, alignment guides, expansion joints and loops, and their attachment to the building structure. Detail location of anchors, alignment guides, and expansion joints and loops.

C. Welding Certificates: Copies of certificates for welding procedures and personnel.

D. Field Test Reports: Written reports of tests specified in Part 3 of this Section. Include the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Failed test results and corrective action taken to achieve requirements.

E. Maintenance Data: For hydronic specialties and special-duty valves to include in maintenance manuals specified in Division 1.

1.5 QUALITY ASSURANCE

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

B. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

1.6 COORDINATION

A. Coordinate layout and installation of hydronic piping and suspension system components with other construction, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

B. Coordinate pipe sleeve installations for foundation wall penetrations.

C. Coordinate piping installation with roof curbs, equipment supports, and roof penetrations. Roof specialties are specified in Division 7 Sections.

D. Coordinate pipe fitting pressure classes with products specified in related Sections.

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

F. Coordinate installation of pipe sleeves for penetrations through exterior walls and floor assemblies. Coordinate with requirements for firestopping specified in Division 7 Section "Through-Penetration Firestop Systems" for fire and smoke wall and floor assemblies.

1.7 EXTRA MATERIALS

A. Water Treatment Chemicals: Furnish sufficient chemicals for initial system startup and for preventive maintenance for one year from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Steel Pipe Grooved Mechanical-Joint Fittings and Couplings:

    a. Central Grooved Piping Products.
    b. Grinnell Corporation.
    c. Victaulic Company of America.

2. Copper Grooved End, Pressure-Seal or Mechanically Formed Tee:

    a. Stadler-Viega
    b. Grinnell Corporation.
    c. Victaulic Company of America.
    d. T-Drill Industries, Inc.

3. Calibrated Balancing Valves:

    a. Armstrong Pumps, Inc.
    b. Flow Design, Inc.
    c. Griswold Controls.
    d. ITT Bell & Gossett; ITT Fluid Technology Corp.
    e. Taco, Inc.
    f. Nexus Valve

4. Pressure-Reducing Valves:

    a. Amtrol, Inc.
    b. Armstrong Pumps, Inc.
    c. ITT Bell & Gossett; ITT Fluid Technology Corp.
    d. Spence Engineering Company, Inc.
    e. Watts Industries, Inc.; Watts Regulators.

5. Safety Valves:

    a. Amtrol, Inc.
    b. Armstrong Pumps, Inc.
    c. ITT McDonnell & Miller Div.; ITT Fluid Technology Corp.
    d. Kunkle Valve Division.
    e. Spence Engineering Company, Inc.

6. Automatic Flow-Control Valves:

    a. Flow Design, Inc.
    b. Griswold Controls.
    c. Nexus Valve
    d. ITT Bell & Gossett; ITT Fluid Technology Corp.

7. Expansion Tanks:

    a. Amtrol, Inc.
    b. Armstrong Pumps, Inc.
    c. ITT Bell & Gossett; ITT Fluid Technology Corp.
    d. Taco, Inc.

8. Air Separators and Air Purgers:

    a. Amtrol, Inc.
    b. Armstrong Pumps, Inc.
    c. ITT Bell & Gossett; ITT Fluid Technology Corp.

d. Taco, Inc.
e. Wessels Company

2.2 PIPING MATERIALS

A. General: Refer to Part 3 "Piping Applications" Article for applications of pipe and fitting materials.

2.3 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type L soft temper is used for underground installations.

B. Wrought-Copper Fittings: ASME B16.22.

C. Wrought-Copper Unions: ASME B16.22.

D. Solder Filler Metals: ASTM B 32, 95-5 tin antimony.

E. Brazing Filler Metals: AWS A5.8, Classification BAg-1 (silver).

F. Grooved-End Copper Fittings: ASTM B 75, copper tube or ASTM B 584, bronze casting.

G. Grooved-End-Tube Couplings: Rigid pattern, unless otherwise indicated; gasketed fitting. Ductile iron housing with keys matching pipe and fitting grooves, EPDM gasket rated for minimum 230 degree F for use with housing and steel bolts and nuts.

H. Copper or Bronze Pressure-Seal Fittings: Housing shall be copper with EPDM O-rings and pipe stops, manufacturer’s press-seal tools and minimum 200-psig working pressure at 250 degree F.

I. Copper, Mechanically Formed Tee: Used for forming t-branch on copper water tubing.

2.4 STEEL PIPE AND FITTINGS

A. Steel Pipe, NPS 2-1/2 through NPS 12: ASTM A 53, Type E (electric-resistance welded), Grade B, Schedule 40, black steel, plain ends.

B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250.

C. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300.

D. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced.

E. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

F. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

1. Material Group: 1.1.
2. End Connections: Butt welding.
3. Facings: Raised face.

G. Flexible Connectors: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket; 150-psig minimum working pressure and 250 deg F maximum operating temperature. Connectors shall have flanged or threaded-end connections to match equipment connected and shall be capable of 3/4-inch misalignment.

H. Spherical, Rubber, Flexible Connectors: Fiber-reinforced rubber body with steel flanges drilled to align with Classes 150 and 300 steel flanges; operating temperatures up to 250 deg F and pressures up to 150 psig.

I. Welding Materials: Comply with Section II, Part C, of the ASME Boiler and Pressure Vessel Code for welding materials appropriate for wall thickness and for chemical analysis of pipe being welded.

J. Gasket Material: Thickness, material, and type suitable for fluid to be handled; and design temperatures and pressures.

K. Grooved Mechanical-Joint Fittings: ASTM A 536, Grade 65-45-12 ductile iron; ASTM A 47, Grade 32510 malleable iron; ASTM A 53, Type F, E, or S, Grade B fabricated steel; or ASTM A 106, Grade B steel fittings with grooves or shoulders designed to accept grooved end couplings.

L. Grooved Mechanical-Joint Couplings: Ductile- or malleable-iron housing and synthetic rubber gasket of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.

2.5 VALVES

A. Hydronic systems shall utilize full port quarter turn ball valve for isolation up to and including 2”. Utilize butterfly valves for 2-1/2” and above. Trim, seat and valve material shall be appropriate for application.

B. Refer to Part 3 "Valve Applications" Article for applications of each valve.

C. Calibrated Balancing Valves, NPS 2 and Smaller: Bronze body, ball type, 125-psig working pressure, 250 deg F maximum operating temperature, and having threaded ends. Valves shall have calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, and be equipped with a memory stop to retain set position.

D. Calibrated Balancing Valves, NPS 2-1/2 and Larger: Cast-iron or steel body, ball type, 125-psig working pressure, 250 deg F maximum operating temperature, and having flanged or grooved connections. Valves shall have calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, and be equipped with a memory stop to retain set position.

E. Pressure-Reducing Valves: Diaphragm-operated, bronze or brass body with low inlet pressure check valve, inlet strainer removable without system shutdown, and noncorrosive valve seat and

stem. Select valve size, capacity, and operating pressure to suit system. Valve shall be factory set at operating pressure and have capability for field adjustment.

F. Safety Valves: Diaphragm-operated, bronze or brass body with brass and rubber, wetted, internal working parts; shall suit system pressure and heat capacity and shall comply with the ASME Boiler and Pressure Vessel Code, Section IV.

G. Automatic Flow-Control Valves: Gray-iron body, factory set to maintain constant flow with plus or minus 5 percent over system pressure fluctuations, and equipped with a readout kit including flow meter, probes, hoses, flow charts, and carrying case. Each valve shall have an identification tag attached by chain, and be factory marked with the zone identification, valve number, and flow rate. Valve shall be line size and one of the following designs:

1. Gray-iron or brass body, designed for 175 psig at 200 deg F with stainless-steel piston and spring.
2. Brass or ferrous-metal body, designed for 300 psig at 250 deg F with corrosion-resistant, tamperproof, self-cleaning, piston-spring assembly easily removable for inspection or replacement.
3. Combination assemblies, including bronze ball valve and brass alloy control valve, with stainless-steel piston and spring, fitted with pressure and temperature test valves, and designed for 300 psig at 250 deg F.

2.6 HYDRONIC SPECIALTIES

A. Manual Air Vent: Bronze body and nonferrous internal parts; 150-psig working pressure; 225 deg F operating temperature; manually operated with screwdriver or thumbscrew; with NPS 1/8 discharge connection and NPS 1/2 inlet connection.

B. Automatic Air Vent: Designed to vent automatically with float principle; bronze body and nonferrous internal parts; 150-psig working pressure; 240 deg F operating temperature; with NPS 1/4 discharge connection and NPS 1/2 inlet connection.

C. Expansion Tanks: Welded carbon steel, rated for 125-psig working pressure and 375 deg F maximum operating temperature. Separate air charge from system water to maintain design expansion capacity by a flexible diaphragm securely sealed into tank. Include drain fitting and taps for pressure gage and air-charging fitting. Support vertical tanks with steel legs or base; support horizontal tanks with steel saddles. Factory fabricate and test tank with taps and supports installed and labeled according to the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

D. In-Line Air Separators: One-piece cast iron with an integral weir designed to decelerate system flow to maximize air separation at a working pressure up to 175 psig and liquid temperature up to 300 deg F.

E. Air Purgers: Cast-iron body with internal baffles that slow the water velocity to separate the air from solution and divert it to the vent for quick removal. Maximum working pressure of 150 psig and temperature of 250 deg F.

F. Bypass Chemical Feeder: Welded steel construction; 125-psig working pressure; 5-gal. capacity; with fill funnel and inlet, outlet, and drain valves.

1. Chemicals: Specially formulated, based on analysis of makeup water, to prevent accumulation of scale and corrosion in piping and connected equipment.

G. Y-Pattern Strainers: 125-psig working pressure; cast-iron body (ASTM A 126, Class B), flanged ends for NPS 2-1/2 and larger, threaded connections for NPS 2 and smaller, bolted cover, perforated stainless-steel basket, and bottom drain connection.

H. Basket Strainers: 125-psig working pressure; high-tensile cast-iron body (ASTM A 126, Class B), flanged-end connections, bolted cover, perforated stainless-steel basket, and bottom drain connection.

I. Flexible Connectors: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket; 150-psig minimum working pressure and 250 deg F maximum operating temperature. Connectors shall have flanged- or threaded-end connections to match equipment connected and shall be capable of 3/4-inch misalignment.

J. Spherical, Rubber, Flexible Connectors: Fiber-reinforced rubber body with steel flanges drilled to align with Classes 150 and 300 steel flanges; operating temperatures up to 250 deg F and pressures up to 150 psig.

K. Packed, Slip, Expansion Joints: 150-psig minimum working pressure, steel pipe fitting consisting of telescoping body and slip-pipe sections, packing ring, packing, limit rods, flanged ends, and chrome-plated finish on slip-pipe telescoping section.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Hot and Chilled Water, NPS 2 and Smaller: Aboveground, use Type L drawn-temper copper tubing with soldered joints. Belowground or within slabs, use Type K annealed-temper copper tubing with soldered joints. Use the fewest possible joints belowground and within floor slabs.

B. Hot and Chilled Water, NPS 2-1/2 and Larger: Schedule 40 steel pipe with welded and flanged joints.

C. Condensate Drain Lines: Type L drawn-temper copper tubing with soldered joints or Schedule 40, PVC pipe with solvent-welded joints.

3.2 VALVE APPLICATIONS

A. General-Duty Valve Applications: Unless otherwise indicated, use the following valve types:

1. Shutoff Duty: Gate, ball, and butterfly valves.
2. Throttling Duty: Globe, ball, and butterfly valves.

B. Install shutoff duty valves at each branch connection to supply mains, at supply connection to each piece of equipment, unless only one piece of equipment is connected in the branch line.

Install throttling duty valves at each branch connection to return mains, at return connections to each piece of equipment, and elsewhere as indicated.

C. Install calibrated balancing valves in the return water line of each heating or cooling element and elsewhere as required to facilitate system balancing.

D. Install check valves at each pump discharge and elsewhere as required to control flow direction.

E. Install safety valves on hot-water generators and elsewhere as required by the ASME Boiler and Pressure Vessel Code. Install safety-valve discharge piping, without valves, to floor. Comply with the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, for installation requirements.

F. Install pressure-reducing valves on hot-water generators and elsewhere as required to regulate system pressure.

G. All three way valves shall be full port in all directions.

3.3 PIPING INSTALLATIONS

A. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for basic piping installation requirements.

B. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

C. Install flushing drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

D. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

E. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

F. Unless otherwise indicated, install branch connections to mains using tee fittings in main pipe, with the takeoff coming out the bottom of the main pipe. For up-feed risers, install the takeoff coming out the top of the main pipe.

G. Install strainers on supply side of each control valve, pressure-reducing valve, solenoid valve, in-line pump, and elsewhere as indicated. Install NPS 3/4 nipple and ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.

H. Anchor piping for proper direction of expansion and contraction.

3.4 HANGERS AND SUPPORTS

A. Hanger, support, and anchor devices are specified in Division 15 Section "Hangers and Supports." Comply with requirements below for maximum spacing of supports.

B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.

C. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 3/4: Maximum span, 7 feet; minimum rod size, 1/4 inch.
2. NPS 1: Maximum span, 7 feet; minimum rod size, 1/4 inch.
3. NPS 1-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
4. NPS 2: Maximum span, 10 feet; minimum rod size, 3/8 inch.
5. NPS 2-1/2: Maximum span, 11 feet; minimum rod size, 3/8 inch.
6. NPS 3: Maximum span, 12 feet; minimum rod size, 3/8 inch.
7. NPS 4: Maximum span, 14 feet; minimum rod size, 1/2 inch.
8. NPS 6: Maximum span, 17 feet; minimum rod size, 1/2 inch.
9. NPS 8: Maximum span, 19 feet; minimum rod size, 5/8 inch.

D. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:

1. NPS 3/4: Maximum span, 5 feet; minimum rod size, 1/4 inch.
2. NPS 1: Maximum span, 6 feet; minimum rod size, 1/4 inch.
3. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
4. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
5. NPS 2-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
6. NPS 3: Maximum span, 10 feet; minimum rod size, 3/8 inch.

E. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

3.5 PIPE JOINT CONSTRUCTION

A. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for joint construction requirements for soldered and brazed joints in copper tubing; threaded, welded, and flanged joints in steel piping; and solvent-welded joints for PVC and CPVC piping.

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

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

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

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

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

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

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

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

I. Grooved Joints: Assemble joints with coupling and gasket, lubricant, and bolts. Cut or roll grooves in ends of pipe based on pipe and coupling manufacturer's written instructions for pipe wall thickness. Use grooved-end fittings and rigid, grooved-end-pipe couplings.

J. Mechanically Formed, Copper-Tube-Outlet Joints: Use manufacturer-recommended tool and procedure, and brazed joints.

K. Pressure-Sealed Joints: Use manufacturer-recommended tool and procedure. Leave insertion marks on pipe after assembly.

3.6 HYDRONIC SPECIALTIES INSTALLATION

A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.

B. Install automatic air vents in mechanical equipment rooms only at high points of system piping, at heat-transfer coils, and elsewhere as required for system air venting.

C. Install dip-tube fittings in boiler outlet. Install piping to expansion tank with a 2 percent upward slope toward tank. Connect boiler-outlet piping.

D. Install in-line air separators in pump suction lines. Install piping to compression tank with a 2 percent upward slope toward tank. Install drain valve on units NPS 2 (DN 50) and larger.

E. Install combination air separator and strainer in pump suction lines. Install piping to compression tank with a 2 percent upward slope toward tank. Install blowdown piping with gate valve; extend to nearest drain.

F. Install bypass chemical feeders in each hydronic system where indicated, in upright position with top of funnel not more than 48 inches above floor. Install feeder in bypass line, off main, using globe valves on each side of feeder and in the main between bypass connections. Pipe drain, with ball valve, to nearest equipment drain.

G. Install expansion tanks above air separator. Install gage glass and cocks on end of tank. Install tank fitting in tank bottom and charge tank. Use manual vent for initial fill to establish proper water level in tank.

1. Support tank from floor or structure above with sufficient strength to carry weight of tank, piping connections, and fittings, plus weight of a full tank of water. Do not overload building components and structural members.

H. Install expansion tanks on floor. Vent and purge air from hydronic system, and ensure tank is properly charged with air to suit system design requirements.

3.7 TERMINAL EQUIPMENT CONNECTIONS

A. Size for supply and return piping connections shall be same as for equipment connections.

B. Install control valves in accessible locations close to connected equipment.

C. Install bypass piping with globe valve around control valve. If multiple, parallel control valves are installed, only one bypass is required.

D. Install ports for pressure and temperature gages at coil inlet connections.

3.8 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush system with clean water. Clean strainers.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release trapped air. Use drains installed at low points for complete draining of liquid.
3. Check expansion tanks to determine that they are not air bound and that system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the design pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of

vertical runs does not exceed either 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A of ASME B31.9, "Building Services Piping."

5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

3.9 ADJUSTING

A. Mark calibrated nameplates of pump discharge valves after hydronic system balancing has been completed, to permanently indicate final balanced position.

B. Perform these adjustments before operating the system:

1. Open valves to fully open position. Close coil bypass valves.
2. Check pump for proper direction of rotation.
3. Set automatic fill valves for required system pressure.
4. Check air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Check operation of automatic bypass valves.
7. Check and set operating temperatures of boilers, chillers, and cooling towers to design requirements.
8. Lubricate motors and bearings.

3.10 CLEANING

A. Flush hydronic piping systems with clean water. Remove and clean or replace strainer screens. After cleaning and flushing hydronic piping systems, but before balancing, remove disposable fine-mesh strainers in pump suction diffusers.

END OF SECTION 232113

SECTION 23 2123 - HYDRONIC PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Close-coupled, in-line centrifugal pumps.
2. Separately coupled, base-mounted, end-suction centrifugal pumps.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of pump.

B. Shop Drawings: For each pump.

1. Show pump layout and connections.
2. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
3. Include diagrams for power, signal, and control wiring.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 CLOSE-COUPLED, IN-LINE CENTRIFUGAL PUMPS

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

1. Armstrong Pumps Inc.
2. Aurora Pump; Division of Pentair Pump Group.
3. Crane Pumps & Systems.
4. ITT Corporation; Bell & Gossett.
5. PACO Pumps.
6. Patterson Pump Co.; a subsidiary of the Gorman-Rupp Co.
7. Peerless Pump Company.
8. TACO Incorporated.

B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally or vertically.

C. Pump Construction:

1. Casing: Radially split, cast iron, with threaded gage tappings at inlet and outlet, replaceable bronze wear rings, and threaded connections.
2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For constant-speed pumps, trim impeller to match specified performance.
3. Pump Shaft: Stainless steel.
4. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N EPT bellows and gasket. Include water slinger on shaft between motor and seal.
5. Seal: Packing seal consisting of stuffing box with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
6. Pump Bearings: Permanently lubricated ball bearings.

D. Motor: Single speed and rigidly mounted to pump casing.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

2.2 SEPARATELY COUPLED, BASE-MOUNTED, END-SUCTION CENTRIFUGAL PUMPS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Armstrong Pumps Inc.
2. Crane Pumps & Systems.
3. ITT Corporation; Bell & Gossett.
4. PACO Pumps.
5. Peerless Pump Company.
6. TACO Incorporated.

B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, end-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for base mounting, with pump and motor shafts horizontal.

C. Pump Construction:

1. Casing: Radially split, cast iron, with replaceable bronze wear rings, threaded gage tappings at inlet and outlet, drain plug at bottom and air vent at top of volute, and flanged connections. Provide integral mount on volute to support the casing, and provide attached piping to allow removal and replacement of impeller without disconnecting piping or requiring the realignment of pump and motor shaft.
2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For pumps not frequency-drive controlled, trim impeller to match specified performance.

3. Pump Shaft: Stainless steel.
4. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless-steel spring, and EPT bellows and gasket.
5. Seal: Packing seal consisting of stuffing box with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
6. Pump Bearings: Grease-lubricated ball bearings in cast-iron housing with grease fittings.

D. Shaft Coupling: Molded-rubber insert and interlocking spider capable of absorbing vibration. Couplings shall be drop-out type to allow disassembly and removal without removing pump shaft or motor. EPDM coupling sleeve for variable-speed applications.

E. Coupling Guard: Dual rated; ANSI B15.1, Section 8; OSHA 1910.219 approved; steel; removable; attached to mounting frame.

F. Mounting Frame: Welded-steel frame and cross members, factory fabricated from ASTM A 36/A 36M channels and angles. Fabricate to mount pump casing, coupling guard, and motor.

G. Motor: Single speed, secured to mounting frame, with adjustable alignment.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

2.3 PUMP SPECIALTY FITTINGS

A. Suction Diffuser:

1. Angle pattern.
2. 175-psig (1204-kPa) pressure rating, ductile-iron body and end cap, pump-inlet fitting.
3. Bronze startup and bronze or stainless-steel permanent strainers.
4. Bronze or stainless-steel straightening vanes.
5. Drain plug.
6. Factory-fabricated support.

B. Triple-Duty Valve:

1. Angle or straight pattern.
2. 175-psig (1204-kPa) pressure rating, ductile-iron body, pump-discharge fitting.
3. Drain plug and bronze-fitted shutoff, balancing, and check valve features.
4. Brass gage ports with integral check valve and orifice for flow measurement.

PART 3 - EXECUTION

3.1 PUMP INSTALLATION

A. Comply with HI 1.4.

B. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.

C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.

D. Automatic Condensate Pump Units: Install units for collecting condensate and extend to open drain.

E. Equipment Mounting: Install base-mounted pumps on cast-in-place concrete equipment bases. Comply with requirements for equipment bases specified in Section 033053 "Miscellaneous Cast-in-Place Concrete."

1. Coordinate sizes and locations of concrete bases with actual equipment provided.
2. Construct bases to withstand, without damage to equipment, seismic force required by code.
3. Construct concrete bases 4 inches (100 mm) high and extend base not less than 6 inches (150 mm) in all directions beyond the maximum dimensions of base-mounted pumps unless otherwise indicated or unless required for seismic-anchor support.
4. Minimum Compressive Strength: 5000 psi (34.5 MPa) at 28 days.

F. Equipment Mounting: Install in-line pumps with continuous-thread hanger rods and spring hangers with vertical-limit stop of size required to support weight of in-line pumps.

1. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."
2. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

3.2 ALIGNMENT

A. Engage a factory-authorized service representative to perform alignment service.

B. Comply with requirements in Hydronics Institute standards for alignment of pump and motor shaft. Add shims to the motor feet and bolt motor to base frame. Do not use grout between motor feet and base frame.

C. Comply with pump and coupling manufacturers' written instructions.

D. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with nonshrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

3.3 CONNECTIONS

A. Comply with requirements for piping specified in Section 232213 "Steam and Condensate Heating Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to pump, allow space for service and maintenance.

C. Connect piping to pumps. Install valves that are same size as piping connected to pumps.

D. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.

E. Install triple-duty valve on discharge side of pumps.

F. Install suction diffuser and shutoff valve on suction side of pumps.

G. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.

H. Install pressure gages on pump suction and discharge or at integral pressure-gage tapping, or install single gage with multiple-input selector valve.

I. Install check valve and gate or ball valve on each condensate pump unit discharge.

J. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

K. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

L. Pumps shall be laser aligned.

M. All pump openings shall be covered during construction.

END OF SECTION 232123

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SECTION 23 2500 - HVAC WATER TREATMENT

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following HVAC water-treatment systems:

1. Bypass chemical-feed equipment and controls.
2. Biocide chemical-feed equipment and controls.
3. Chemical treatment test equipment.
4. HVAC water-treatment chemicals.

1.2 PERFORMANCE REQUIREMENTS

A. Water quality for HVAC systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of HVAC equipment without creating a hazard to operating personnel or the environment.

B. Base HVAC water treatment on quality of water available at Project site, HVAC system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: Pretreatment and chemical treatment equipment showing tanks, maintenance space required, and piping connections to HVAC systems. Include plans, elevations, sections, details, and attachments to other work.

1. Wiring Diagrams: Power and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control test reports.

B. Other Informational Submittals:

1. Water-Treatment Program: Written sequence of operation on an annual basis for the application equipment required to achieve water quality defined in the "Performance Requirements" Article above.
2. Water Analysis: Illustrate water quality available at Project site.
3. Passivation Confirmation Report: Verify passivation of galvanized-steel surfaces, and confirm this observation in a letter to Architect.

1.5 QUALITY ASSURANCE

A. HVAC Water-Treatment Service Provider Qualifications: An experienced HVAC water-treatment service provider capable of analyzing water qualities, installing water-treatment equipment, and applying water treatment as specified in this Section.

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Ampion Corp.
2. Anderson Chemical Co, Inc.
3. Aqua-Chem, Inc.; Cleaver-Brooks Div.
4. Barclay Chemical Co.; Water Management, Inc.
5. Boland Trane Services.
6. GE Betz.
7. GE Osmonics.
8. H-O-H Chemicals, Inc.
9. Metro Group. Inc. (The); Metropolitan Refining Div.
10. ONDEO Nalco Company.
11. Watcon, Inc.

2.2 MANUAL CHEMICAL-FEED EQUIPMENT

A. Bypass Feeders: Steel, with corrosion-resistant exterior coating, minimum 3-1/2-inch (89-mm) fill opening in the top, and NPS 3/4 (DN 20) bottom inlet and top side outlet. Quarter turn or threaded fill cap with gasket seal and diaphragm to lock the top on the feeder when exposed to system pressure in the vessel.

2.3 AUTOMATIC CHEMICAL-FEED EQUIPMENT

A. Water Meter:

1. AWWA C700, oscillating-piston, magnetic-drive, totalization meter.
2. Body: Bronze.
3. Maximum Pressure Loss at Design Flow: 3 psig (20 kPa).
4. Registration: Gallons (Liters) or cubic feet (cubic meters).
5. Controls: Flow-control switch with normally open contacts; rated for maximum 10 A, 250-V ac; and that will close at adjustable increments of total flow.

B. Inhibitor Injection Timers:

1. Microprocessor-based controller with LCD display in NEMA 250, Type 12 enclosure with gasketed and lockable door.
2. Programmable timers with infinite adjustment over full range, and mounted in cabinet with hand-off-auto switches and status lights.
3. Test switch.
4. Hand-off-auto switch for chemical pump.
5. Illuminated legend to indicate feed when pump is activated.
6. Programmable lockout timer with indicator light. Lockout timer to deactivate the pump and activate alarm circuits.
7. LCD makeup totalizer to measure amount of makeup and bleed-off water from two water meter inputs.

C. Chemical Solution Injection Pumps:

1. Self-priming, positive-displacement; rated for intended chemical with minimum 25 percent safety factor for design pressure and temperature.
2. Adjustable flow rate.
3. Metal and thermoplastic construction.
4. Built-in relief valve.
5. Fully enclosed, continuous-duty, single-phase motor. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."

D. Chemical Solution Tubing: Polyethylene tubing with compression fittings and joints.

E. Injection Assembly:

1. Quill: Minimum NPS 1/2 (DN 15) with insertion length sufficient to discharge into at least 25 percent of pipe diameter.
2. Ball Valve: Two-piece, stainless steel; selected to fit quill.
3. Packing Gland: Mechanical seal on quill of sufficient length to allow quill removal during system operation.
4. Assembly Pressure/Temperature Rating: Minimum 600 psig (4137 kPa) at 200 deg F (93 deg C).

2.4 CHEMICAL TREATMENT TEST EQUIPMENT

A. Test Kit: Manufacturer-recommended equipment and chemicals in a wall-mounting cabinet for testing pH, TDS, inhibitor, chloride, alkalinity, and hardness; sulfite and testable polymer tests for high-pressure boilers, and oxidizing biocide test for open cooling systems.

B. Corrosion Test-Coupon Assembly: Constructed of corrosive-resistant material, complete with piping, valves, and mild steel and copper coupons. Locate copper coupon downstream from mild steel coupon in the test-coupon assembly.

1. Two station rack for closed-loop systems.

2.5 CHEMICALS

A. Chemicals shall be as recommended by water-treatment system manufacturer that are compatible with piping system components and connected equipment, and that can attain water quality specified in Part 1 "Performance Requirements" Article.

B. Water Softener Chemicals:

1. Mineral: High-capacity, sulfonated-polystyrene ion-exchange resin that is stable over entire pH range with good resistance to bead fracture from attrition or shock. Resin exchange capacity minimum 30,000 grains/cu. ft. (69 kg/cu. m) of calcium carbonate of resin when regenerated with 15 lb (6.8 kg) of salt.
2. Salt for Brine Tanks: High-purity sodium chloride, free of dirt and foreign material. Rock and granulated forms are not acceptable.

PART 3 - EXECUTION

3.1 WATER ANALYSIS

A. Perform an analysis of supply water to determine quality of water available at Project site.

3.2 INSTALLATION

A. Install chemical application equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor chemical tanks and floor-mounting accessories to substrate.

B. Install water testing equipment on wall near water chemical application equipment.

C. Install interconnecting control wiring for chemical treatment controls and sensors.

D. Mount sensors and injectors in piping circuits.

E. Bypass Feeders: Install in closed hydronic systems, including hot-water heating, and equipped with the following:

1. Install bypass feeder in a bypass circuit around circulating pumps, unless otherwise indicated on Drawings.
2. Install water meter in makeup water supply.
3. Install test-coupon assembly in bypass circuit around circulating pumps, unless otherwise indicated on Drawings.
4. Install a gate or full-port ball isolation valves on inlet, outlet, and drain below feeder inlet.
5. Install a swing check on inlet after the isolation valve.

3.3 CONNECTIONS

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

B. Install piping adjacent to equipment to allow service and maintenance.

C. Make piping connections between HVAC water-treatment equipment and dissimilar-metal piping with dielectric fittings. Dielectric fittings are specified in

D. Install shutoff valves on HVAC water-treatment equipment inlet and outlet. Metal general-duty valves are specified in Section 230523 "General-Duty Valves for HVAC Piping."

E. Refer to Section 221119 "Domestic Water Piping Specialties" for backflow preventers required in makeup water connections to potable-water systems.

F. Confirm applicable electrical requirements in electrical Sections for connecting electrical equipment.

G. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

H. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

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

B. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:

1. Inspect field-assembled components and equipment installation, including piping and electrical connections.
2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
3. Place HVAC water-treatment system into operation and calibrate controls during the preliminary phase of HVAC systems' startup procedures.
4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
5. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.

6. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
7. Cap and subject piping to static water pressure of 50 psig (345 kPa) above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
8. Repair leaks and defects with new materials and retest piping until no leaks exist.

D. Remove and replace malfunctioning units and retest as specified above.

E. At six week intervals following Substantial Completion, perform separate water analyses on hydronic systems to show that automatic chemical-feed systems are maintaining water quality within performance requirements specified in this Section. Submit written reports of water analysis advising Owner of changes necessary to adhere to Part 1 "Performance Requirements" Article.

F. Comply with ASTM D 3370 and with the following standards:

1. Silica: ASTM D 859.
2. Acidity and Alkalinity: ASTM D 1067.
3. Iron: ASTM D 1068.
4. Water Hardness: ASTM D 1126.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC water-treatment systems and equipment. Refer to Section 017900 "Demonstration and Training."

END OF SECTION 232500

SECTION 23 3113 - METAL DUCTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Rectangular ducts and fittings.
2. Round ducts and fittings.
3. Sheet metal materials.
4. Sealants and gaskets.
5. Hangers and supports.
6. Seismic-restraint devices.

1.2 PERFORMANCE REQUIREMENTS

A. Structural Performance: Duct hangers and supports shall withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"

1. Seismic Hazard Level A: Seismic force to weight ratio, 0.48.
2. Seismic Hazard Level B: Seismic force to weight ratio, 0.30.
3. Seismic Hazard Level C: Seismic force to weight ratio, 0.15.

B. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

C. Ductwork sizes indicated on drawing are inside clearance dimensions of ductwork. Contractor shall add internal liner thickness where required.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. LEED Submittals:

1. Product Data for Prerequisite IEQ 1: Documentation indicating that duct systems comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
2. Product Data for Prerequisite EA 2: Documentation indicating that duct systems comply with ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."
3. Duct-Cleaning Test Report for Prerequisite IEQ 1: Documentation of work performed for compliance with ASHRAE 62.1, Section 7.2.4 - "Ventilation System Start-up."
4. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.

5. Laboratory Test Reports for Credit IEQ 4: For adhesives and sealants, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.
3. Duct layout indicating sizes, configuration, and static-pressure classes.
4. Elevation of top of ducts.
5. Dimensions of main duct runs from building grid lines.
6. Fittings.
7. Reinforcement and spacing.
8. Seam and joint construction.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment[, seismic restraints,] and vibration isolation.
13. <Insert lists of areas or systems requiring Shop Drawings.>

D. Delegated-Design Submittal:

1. Sheet metal thicknesses.
2. Joint and seam construction and sealing.
3. Reinforcement details and spacing.
4. Materials, fabrication, assembly, and spacing of hangers and supports.
5. Design Calculations: Calculations[, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation] for selecting hangers and supports[and seismic restraints].

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
2. Suspended ceiling components.
3. Structural members to which duct will be attached.
4. Size and location of initial access modules for acoustical tile.
5. Penetrations of smoke barriers and fire-rated construction.
6. Items penetrating finished ceiling including the following:

    a. Lighting fixtures.
    b. Air outlets and inlets.

c. Speakers.
d. Sprinklers.
e. Access panels.
f. Perimeter moldings.
g. <Insert item>.

B. Welding certificates.

1.5 QUALITY ASSURANCE

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

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum supports.
3. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

C. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

PART 2 - PRODUCTS

2.1 RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.2 ROUND DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

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

a. Lindab Inc.
b. McGill AirFlow LLC.
c. SEMCO Incorporated.
d. Sheet Metal Connectors, Inc.
e. Spiral Manufacturing Co., Inc.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Fabricate round ducts larger Than 90 inches (2286 mm) in diameter with butt-welded longitudinal seams.

D. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G90.
2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Carbon-Steel Sheets: Comply with ASTM A 1008/A 1008M, with oiled, matte finish for exposed ducts.

D. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.

E. Aluminum Sheets: Comply with ASTM B 209 (ASTM B 209M) Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.

F. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

G. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

2.4 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Two-Part Tape Sealing System:

1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
2. Tape Width: 4 inches.
3. Sealant: Modified styrene acrylic.
4. Water resistant.
5. Mold and mildew resistant.
6. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive and negative.
7. Service: Indoor and outdoor.
8. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
10. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
11. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.

3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. Flanged Joint Sealant: Comply with ASTM C 920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.
6. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

F. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum leakage class of3 cfm/100 sq. ft. at 1-inch wg (0.14 L/s per sq. m) and shall be rated for10-inch wg (2500-Pa) static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.5 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.

F. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

H. Trapeze and Riser Supports:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install round ducts in maximum practical lengths.

D. Install ducts with fewest possible joints.

E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

H. Install ducts with a clearance of 1 inch (25 mm), plus allowance for insulation thickness.

I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches (38 mm).

K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Section 233300 "Air Duct Accessories" for fire and smoke dampers.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

3.2 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 DUCT SEALING

A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

B. Seal ducts to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":

1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
2. Outdoor, Supply-Air Ducts: Seal Class A.
3. Outdoor, Exhaust Ducts: Seal Class C.
4. Outdoor, Return-Air Ducts: Seal Class C.
5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg (500 Pa) and Lower: Seal Class B.
6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg (500 Pa): Seal Class A.
7. Unconditioned Space, Exhaust Ducts: Seal Class C.
8. Unconditioned Space, Return-Air Ducts: Seal Class B.
9. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg (500 Pa) and Lower: Seal Class C.
10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg (500 Pa): Seal Class B.
11. Conditioned Space, Exhaust Ducts: Seal Class B.
12. Conditioned Space, Return-Air Ducts: Seal Class C.

3.4 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches (100 mm) thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches (100 mm) thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches (610 mm) of each elbow and within 48 inches (1200 mm) of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet (5 m).

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.5 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Section 233300 "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.6 DUCT CLEANING

A. Clean duct system(s) before testing, adjusting, and balancing.

B. Clean the following components by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.

3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
4. Coils and related components.
5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.
7. Dedicated exhaust and ventilation components and makeup air systems.

3.7 START UP

A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.8 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:

B. Supply Ducts:

a. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units Class: Positive 2-inch wg (500 Pa)
b. Minimum SMACNA Seal Class: C.
c. SMACNA Leakage Class for Rectangular: 24
d. SMACNA Leakage Class for Round and Flat Oval: 24

C. Return Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:

a. Pressure Class: Positive or negative 2-inch wg (500 Pa)
b. Minimum SMACNA Seal Class: C.
c. SMACNA Leakage Class for Rectangular: 24.
d. SMACNA Leakage Class for Round and Flat Oval: 24.

D. Exhaust Ducts:

1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:

a. Pressure Class: Negative 1-inch wg (250 Pa).
b. Minimum SMACNA Seal Class: C if negative pressure, and A if positive pressure.
c. SMACNA Leakage Class for Rectangular: 24.
d. SMACNA Leakage Class for Round and Flat Oval: 24.

2. Ducts Connected to Fans Exhausting Laboratory and Process (ASHRAE 62.1, Class 3 and 4) Air:

a. Type 316, stainless-steel sheet.

1) Exposed to View: No. 4 finish.
2) Concealed: No. 2B finish.

b. PVC-coated, galvanized sheet steel with thicker coating on duct interior.
c. Pressure Class: Positive or negative 2-inch wg (750 Pa)
d. Minimum SMACNA Seal Class: A Welded seams, joints, and penetrations.
e. SMACNA Leakage Class: 3.

E. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units

a. Pressure Class: Positive or negative 2-inch wg (500 Pa) .
b. Minimum SMACNA Seal Class: C.
c. SMACNA Leakage Class for Rectangular: 24.
d. SMACNA Leakage Class for Round and Flat Oval: 24.

F. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

a. Velocity 1000 fpm (5 m/s) or Lower:

1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
2) Mitered Type RE 4 without vanes.

b. Velocity 1000 to 1500 fpm (5 to 7.6 m/s):

1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

c. Velocity 1500 fpm (7.6 m/s) or Higher:

1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.

c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."

a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.

1) Velocity 1000 fpm (5 m/s) or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
2) Velocity 1000 to 1500 fpm (5 to 7.6 m/s): 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
3) Velocity 1500 fpm (7.6 m/s) or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
4) Radius-to Diameter Ratio: 1.5.

b. Round Elbows, 12 Inches (305 mm) and Smaller in Diameter: Stamped or pleated.
c. Round Elbows, 14 Inches (356 mm) and Larger in Diameter: Welded.

G. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."

a. Rectangular Main to Rectangular Branch: 45-degree entry.
b. Rectangular Main to Round Branch: Spin in.

2. Round: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.

a. Velocity 1000 fpm (5 m/s) or Lower: 90-degree tap.
b. Velocity 1000 to 1500 fpm (5 to 7.6 m/s): Conical tap.
c. Velocity 1500 fpm (7.6 m/s) or Higher: 45-degree lateral.

END OF SECTION 233113

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SECTION 23 5100 - BREECHINGS, CHIMNEYS, AND STACKS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. Listed double-wall.

B. See Section 235113 "Draft Control Devices" for induced-draft and mechanical fans and for motorized and barometric dampers.

1.2 ACTION SUBMITTALS

A. Product Data: For the following:
   1. Type B and BW vents.

B. Shop Drawings: For vents, breechings, chimneys, and stacks. Include plans, elevations, sections, details, and attachments to other work.

PART 2 - PRODUCTS

2.1 LISTED TYPE B AND BW VENTS

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

   1. American Metal Products; MASCO Corporation.
   2. Cleaver-Brooks; Div. of Aqua-Chem Inc.
   3. FAMCO.
   4. Hart & Cooley, Inc.
   5. Heat-Fab, Inc.
   6. Industrial Chimney Company.
   7. LSP Products Group, Inc.
   8. Metal-Fab, Inc.
   9. Schebler Co. (The).
   10. Selkirk Inc.; Selkirk Metalbestos and Air Mate.
   11. Simpson Dura-Vent Co., Inc.; Subsidiary of Simpson Manufacturing Co.
   12. Tru-Flex Metal Hose Corp.
   13. Van-Packer Company, Inc.

B. Description: Double-wall metal vents tested according to UL 441 and rated for 480 deg F (248 deg C) continuously for Type B, or 550 deg F (288 deg C) continuously for Type BW; with neutral or negative flue pressure complying with NFPA 211.

C. Construction: Inner shell and outer jacket separated by at least a 1/4-inch (6-mm) airspace.

D. Inner Shell: ASTM A 666, Type 430 stainless steel.

E. Outer Jacket: Galvanized steel.

F. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.

1. Termination: Stack cap designed to exclude minimum 90 percent of rainfall.
2. Termination: Round chimney top designed to exclude minimum 98 percent of rainfall.
3. Termination: Exit cone with drain section incorporated into riser.
4. Termination: Antibackdraft.

PART 3 - EXECUTION

3.1 APPLICATION

A. Listed Chimney Liners: High-efficiency boiler or furnace vents in masonry chimney, dishwasher exhaust, or Type II commercial kitchen hood.

B. Listed Type B and BW Vents: Vents for certified gas appliances.

C. Listed Type L Vents: Vents for low-heat appliances.

D. Listed Special Gas Vents: Condensing gas appliances.

E. Listed Building-Heating-Appliance Chimneys: Dual-fuel boilers, oven vents, water heaters, and exhaust for engines. Fireplaces and other solid-fuel-burning appliances.

F. Listed Grease Ducts: Type I commercial kitchen grease duct.

3.2 INSTALLATION OF LISTED VENTS AND CHIMNEYS

A. Locate to comply with minimum clearances from combustibles and minimum termination heights according to product listing or NFPA 211, whichever is most stringent.

B. Seal between sections of positive-pressure vents and grease exhaust ducts according to manufacturer's written installation instructions, using sealants recommended by manufacturer.

C. Support vents at intervals recommended by manufacturer to support weight of vents and all accessories, without exceeding appliance loading.

D. Slope breechings down in direction of appliance, with condensate drain connection at lowest point piped to nearest drain.

E. Lap joints in direction of flow.

F. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

G. Clean breechings internally, during and after installation, to remove dust and debris. Clean external surfaces to remove welding slag and mill film. Grind welds smooth and apply touchup finish to match factory or shop finish.

H. Provide temporary closures at ends of breechings, chimneys, and stacks that are not completed or connected to equipment.

END OF SECTION 235100

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SECTION 23 5216 - CONDENSING BOILERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes packaged, factory-fabricated and [field]-assembled, [atmospheric-gas] forced-draft gas-fired, water-tube boilers, trim, and accessories for generating hot water.

1.3 SUBMITTALS

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

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

1. Wiring Diagrams: Detail power, signal, and control wiring.

C. Source quality-control test reports.

D. ASME "A" Stamp Certification and Report: Submit "A" stamp certificate of authorization, and document hydrostatic testing of piping external to boiler.

E. Startup service reports.

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

G. Warranties: Warranties as specified in this Section.

1.4 QUALITY ASSURANCE

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

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

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

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

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

1.5 COORDINATION

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

1.6 WARRANTY

A. The pressure vessel shall be guaranteed against thermal shock for 20 years when utilized in a closed loop hydronic heating system with a temperature differential of 170 °F or less. The boiler pressure vessel shall be guaranteed accordingly without a minimum flow rate or return water temperature requirement. The boiler shall not require the use of flow switches or other devices to ensure minimum flow.

B. The pressure vessel, tubes and tube sheets (heat exchanger) shall be guaranteed against flue gas corrosion and materials/workmanship for a period of 10 years. The condensate collection box shall be guaranteed for 20 years.

C. All parts not covered by the above warranties shall carry a 1 year warranty from startup, or 18 months from shipment, whichever occurs first. This shall include all electrical components and burner components.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Fulton, Pulse Pak
2. Hydrotherm, KN Series
3. Cleaver-Brooks, MCF Series
4. Patterson Kelly
5. Lochinvar

2.2 PACKAGED CONDENSING BOILERS

A. Each unit shall be a Down-fired Firetube type complete with boiler fittings and automatic controls. The boiler, with all piping and wiring, shall be factory packaged. Each boiler shall be

neatly finished, thoroughly tested and properly packaged for shipping. Boiler design and construction shall be in accordance with Section IV of the ASME Code for hot water heating boilers with a maximum working pressure of 60 PSIG. The boiler shall be CSA (formerly AGA/CGA) certified as an indirect or direct vent boiler and comply with ASME CSD-1 Code requirements.

2.3 PACKAGED CONDENSING BOILER DESIGN & PERFORMANCE

A. Performance: Boiler Size and Ratings:

1. The capacity of each unit shall be indicated in the Schedule on the Drawings.
2. Performance Criteria:

    a. NOX emissions (maximum) at 20 PPM (corrected to 3% CO2)
    b. CO Emissions (maximum) at 10 PPM (corrected to 3% O2)
    c. Noise Level at 70 dBA maximum, based on ABMA test code for packaged boilers measured @ 4 1/2 feet vertically above the bottom of the base and 3'0" horizontally in front of the end of the burner or front surface of control cabinet. Sound levels dBA on the scale in reference to 0.0002 microbars.

B. Boiler Design:

1. Boiler shall be a compact, single-pass, vertical down-fired Firetube type, with stainless steel tubes and tube sheets. The boiler pressure vessel shall be completely insulated with a minimum of 2" of insulation and shall be encased in an 18 gauge metal cabinet with powder coated finish. To prevent installation damage, the casing shall be packaged separately and shall ship loose for field installation by the manufacturer's service representative.
2. The tubes shall be 316Ti Stainless Steel and shall be fitted with Aluminum internal heat transfer fins creating no less than 10 square feet of fireside heating surface per boiler horsepower.
3. The Vessel shall be mounted on a structural steel stand with exhaust gasses collected in a polymer drain collection box complete with drain fitting for draining condensation from the products of combustion. As an option, a condensate neutralizing box complete with limestone granules shall be shipped loose for field installation by contractor. Note: A condensate trap assembly shall be furnished if a condensate collection tray is not provided due to operating conditions.
4. The top tubesheet shall be fully accessible by lifting the burner assembly which shall come complete with lifting hinges and pneumatic lifters. The boiler shall have a built in hinged platform allowing the operator to access the tubesheet, burner, ignition assembly and flame rod without the use of a ladder.
5. The vessel shall be fully insulated with a minimum of 2" of insulation, guaranteeing external convection and radiation heat losses to the boiler room from the boiler shall be less than 0.5% of the rated input.
6. The condensing capability shall allow the boiler to be operated without the use of a 3-way valve for the boiler supply water temperature reset. No minimum boiler return water temperature or secondary pump or minimum flow rate shall be required.
7. Boiler shall be built to seismic zone C requirements and manufacturer shall provide seismic calculations showing tie-down requirements for bolt diameters. Bolts and tie-down shall be by contractor.

8. Each boiler shall be constructed in accordance with the A.S.M.E. Section IV Code and bear the "H" stamp and shall be manufactured within an ISO 9001 Certified facility to ensure high quality standards.
9. The boiler shall be designed for top rear water outlet and bottom rear water inlet; the water inlet [return] shall be equipped with internal baffling. The maximum pressure drop through the boiler shall not exceed 0.45 psi with a 20-degree differential and less than 0.05 psi with a 60-degree differential.
10. A threaded air vent connection shall be furnished at the top rear of the boiler for field piping to an expansion tank or for the addition of an auto-vent valve when a bladder type expansion tank is utilized.
11. To drain the boiler, a bottom-threaded connection shall be provided at the front of the boiler and field piped by the installing contractor with a manual full size shutoff valve to drain.

C. Burner Design:

1. General: Forced draft burner mounted in and integral with the boiler hinged top door so when the door is opened the burner head, furnace, tubesheet, and tubes are exposed. The burner door shall utilize easy removable threaded handles, and the burner shall swing upward on hydraulic piston arms, one on each side to provide open support of the burner assembly.
2. A drop down hinged service platform shall be furnished to provide service personnel an easy means of accessing the burner and controls for service and maintenance. When out of use, this platform shall fold up beneath the front service boiler panel.
3. The burner shall be of the Unitized Venturi, Gas Valve, Blower, and burner head design. This pre-mix design shall utilize a variable speed fan connected to a venturi to simultaneously modulate fuel and air for a minimum a 5:1 turndown ratio. The venturi design shall also act as a method for compensating for changes in barometric pressure, temperature and humidity so the excess air levels are not adversely affected by changes in atmospheric conditions. External linkages, damper motor drives and single speed fans shall not be acceptable.
4. Burner head shall be constructed of a Fecralloy-metal fiber for solid body radiation of the burner flame. Combustion shall take place on the surface of the burner mantle, which shall be constructed of a woven fecralloy material creating a 360 degree low temperature radiant flame.
5. Emissions: The boiler(s) burner shall be guaranteed to limit NOx emissions to 20 PPM or less, as certified by an independent testing lab. NOx emissions shall be at full operating conditions. Proof of such certification shall be made available to the engineer and purchaser. External flue gas recirculation shall not be accepted for emission control.
6. Gas Train - As a minimum, the gas train shall meet the requirements of CSA and ASME CSD-1 and shall include:

    a. Low Gas Pressure Interlock, manual reset.
    b. High Gas Pressure Interlock, manual reset.
    c. Upstream and downstream manual test cocks.
    d. Ball Type manual shutoff valve upstream of the main gas valve.
    e. Unibody double safety gas valve assembly.
    f. Gas Pressure Regulator
    g. Union connection to permit burner servicing.

7. Combustion Air Proving Switch shall be furnished to ensure sufficient combustion airflow is present for burner firing.
8. To ensure that proper draft is not blocked in the stack, the burner shall include a High Air Pressure Switch sensing the outlet pressure connection relative to stack back draft.

D. Boiler Trim:

1. Safety valve(s) shall be ASME Section IV approved side outlet type mounted on the boiler water outlet. Size shall be in accordance with code requirements and set to open at 60 psig.
2. Temperature and pressure gauge shall be mounted on the water outlet.
3. Solid State Low water cut-off probe with manual reset and test switch.
4. Manual Reset High Limit Temperature control; range not to exceed 210.0 F.
5. Outlet water supply sensing probe for operating water limit setpoint.
6. Return water-sensing probe for operating water limit setpoint.

E. Boiler Controls:

1. The Boiler shall include a Computerized Boiler Burner control which shall be an integrated, solid state digital micro-processing modulating device, complete with sequence indication, fault reset, mode selection, and parameter set-point switches. It shall be mounted at the front of the boiler panel for easy access and viewing.
2. Controller shall provide for both flame safeguard and boiler control and shall perform the following functions:
    a. Burner sequencing with safe start check, pre-purge, Electronic direct spark ignition, and post purge. Flame rod to prove combustion.
    b. Flame Supervision. The control shall provide pre-purge and post-purge and shall maintain a running history of operating hours, number of cycles, and the most recent six faults. The control shall be connected to a keyboard display module that will retrieve this information.
    c. Safety Shutdown with display of error.
    d. Modulating control of the variable speed fan for fuel/air input relative to load requirements.
    e. Gas pressure supervision, high and low.
    f. Combustion Air Proving Supervision.
    g. High Air Pressure [back draft too high] Supervision.
    h. The supply temperature and set-point temperature shall be displayed at all times by an LED readout. Output shall be continuous PID via 4 -20 mA current.
    i. Controller shall have an option for communication device to a laptop computer interface service and troubleshooting.
    j. Include the programming of system circulating pump and provide the programming of 2 heating loops.
3. All parameter input control set-points shall be factory downloaded with jobsite conditions programmed at the time of initial jobsite operation.
4. All controls to be panel mounted and so located on the boiler as to provide ease of servicing the boiler without disturbing the controls and also located to prevent possible damage by water according to CSA requirements.
5. Electrical power supply shall be 220 volts, 60 Hertz, single phase for the fan motor and 120 volts, 60 Hertz, single phase for the control circuit.
6. This project utilizes multiple boilers. The staging and control of the boilers shall be by the Temperature Control Contractor. The boiler manufacturer shall provide a 4-20 mA

input for use by the Control Contractor and interface capabilities to the building's management System, BACnet MS/TP or BACnet IP. The boiler manufacturer shall also provide a terminal strip for hardwired start, stop alarm and output.

F. Boiler Flue Venting:

1. The Boiler shall be CSA certified as an indirect or direct vent boiler. Venting shall be accomplished with a category IV vent piping installed in accordance with applicable national and local codes.
2. For direct venting, the boiler shall have a combustion air intake supply with PVC pipe capable of being piped from the outside. Vibration isolation components are not required.

2.4 SOURCE QUALITY CONTROL

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

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

C. Allow Owner access to source quality-control testing of water-tube boilers. Notify Engineer 14 days in advance of testing.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Before boiler installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting boiler performance, maintenance, and operations. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

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

3.2 BOILER INSTALLATION

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

B. Concrete Bases: Anchor boilers to concrete bases.

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of base.

2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.
5. Cast-in-place concrete materials and placement requirements are specified in Division 3.

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

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

3.3 CONNECTIONS

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

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

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

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

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

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

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

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

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

J. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.4 STARTUP SERVICE

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

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

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

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

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

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

G. Adjust initial temperature set points.

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

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

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

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain water-tube boilers. Refer to Division 1 for close-out procedures.

END OF SECTION 23 515

SECTION 237333 INDIRECT-FUEL-FIRED HEATING AND VENTILATING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes indirect-fired make up air units (MAU).

1.3 SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, and method of field assembly, components, and location and size of each field connection. Prepare the following by or under the supervision of a qualified professional engineer:

1. Design Calculations: Calculate requirements for selecting vibration isolators and for designing vibration isolation bases.
2. Mounting Details: For securing and flashing roof curb to roof structure. Indicate coordinating requirements with roof membrane system.
3. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.
4. Wiring Diagrams: Power, signal, and control wiring.

C. Coordination Drawings: Roof-mounted units and roof-curb mounting details drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Size and location of rooftop unit mounting rails and anchor points and methods for anchoring units to curb.
2. Required roof penetrations for ducts, pipes, and electrical raceways, including size and location of each penetration.

D. Startup service reports.

E. Operation and Maintenance Data: For indirect-fired make up air units to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of indirect-fired make up air units and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."

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

C. Comply with NFPA 70.

1.5 COORDINATION

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

B. Coordinate size, location, installation, and structural capacity of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 7.

C. Coordinate size, location and installation of unit manufacturer's roof curbs and equipment supports with roof Installer.

1. Coordinate installation of restrained vibration isolation roof-curb rails, which are specified in Division 15 Section "Mechanical Vibration and Seismic Controls."

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to replace components listed below of indirect-fired MAKE-UP AIR units that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Heat Exchangers: Manufacturer's standard, but not less than five years from date of Substantial Completion.

1.7 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Filters: Two sets for each unit.
2. Fan Belts: One set for each unit.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

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

1. Airwise, Inc.
2. Engineered Air.
3. Greenheck.
4. Rapid Engineering Inc.
5. Weather-Rite
6. Trane
7. McQuay/Dainkin

2.2 PACKAGED UNITS

A. Factory-assembled, prewired, self-contained unit consisting of cabinet, supply fan, controls, filters and indirect-fired gas furnace. Outdoor units are to be installed on concrete pad.

2.3 CABINET

A. Cabinet: Double-wall galvanized-steel panels, formed to ensure rigidity and supported by galvanized-steel channels or structural channel supports with lifting lugs. Cabinet shall be fully weatherized for outside installation.

B. Access Panels: Piano hinged with cam-lock fasteners for furnace and fan motor assemblies on both sides of unit.

C. Internal Insulation: Fibrous-glass duct lining, comply with ASTM C 1071, Type II, applied on furnace and fan sections only.

1. Thickness 2 inches
2. Insulation Adhesive: Comply with ASTM C 916, Type I.
3. Mechanical Fasteners: Galvanized steel suitable for adhesive attachment, mechanical attachment, or welding attachment to casing without damaging liner when applied as recommended by manufacturer and without causing air leakage.

D. Finish: Heat-resistant, baked enamel.

E. Discharge: Horizontal

2.4 SUPPLY-AIR FAN

A. Fan Type: Centrifugal, rated according to AMCA 210; statically and dynamically balanced, galvanized steel; mounted on solid-steel shaft with heavy-duty pillow-block bearings rated for L50 or 200,000 hours with external grease fittings.

B. Motor: Totally enclosed single -speed motor.

C. Drive: V-belt drive with matching fan pulley and adjustable motor sheaves and belt assembly.

D. Mounting: Fan wheel, motor, and drives shall be mounted in fan casing with elastomeric or spring isolators.

2.5 MOUNTING

A. Mounting Curb: 16” High

B. Suspended from roof with necessary support bracings, rods, isolators and angles per manufacturers requirements.

2.6 OUTDOOR-AIR INTAKE

A. Outdoor-Air Hood: Galvanized steel with rain baffles, bird screen, and finish to match cabinet; and sized to supply maximum 100 percent outdoor air.

2.7 AIR FILTERS

A. Comply with NFPA 90A.

B. Disposable Panel Filters: 2-inch thick, factory-fabricated, flat-panel-type, disposable air filters with holding frames, with a minimum efficiency report value of 6 according to ASHRAE 52.2 and 90 percent average arrestance according to ASHRAE 52.1.

1. Media: Interlaced glass or polyester fibers.
2. Frame: Galvanized steel.

2.8 DAMPERS

A. Outdoor-Air Damper: Galvanized-steel, opposed-blade dampers with vinyl blade seals and stainless steel jamb seals, having a maximum leakage of 10 cfm/sq. ft of damper area, at differential pressure of 2-inch wg.

B. Damper Operator: Direct coupled, electronic with spring return or fully modulating or fixed as required by the control sequence.

2.9 INDIRECT-FIRED GAS FURNACE

A. Description: Factory assembled, piped, and wired; and complying with ANSI Z83.4, "Indirect Gas-Fired Make-Up Air Heaters"; ANSI Z83.18, "Indirect Gas-Fired Industrial Air Heaters"; and NFPA 54, "National Fuel Gas Code."

B. Inside Unit External Housing: Steel cabinet with integral support inserts.

C. Outside Unit External Housing: Weatherproof steel cabinet with integral support inserts.

1. External Casing and Cabinet Finish: Baked enamel over corrosion-resistant-treated surface in color to match fan section.

D. Burners: Cast-iron burner with stainless-steel mixing plates.

1. Control Valve: Modulating
2. Fuel: Natural gas.
3. Pilot: Electrically ignited by hot-surface ceramic igniter.

E. Safety Controls:

1. Gas Manifold: Safety switches and controls to comply with ANSI standards and IRI.
2. Purge-Period Timer: Automatically delays burner ignition and bypasses low-limit control.
3. Airflow Proving Switch: Dual pressure switch senses correct airflow before energizing pilot and requires airflow to be maintained within minimum and maximum pressure settings across burner.
4. Manual-Reset, High-Limit Control Device: Stops burner and closes main gas valve if high-limit temperature is exceeded.
5. Gas Train: Redundant, automatic main gas valves, electric pilot valve, electronic-modulating temperature control valve, main and pilot gas regulators, main and pilot manual shutoff valves, main and pilot pressure taps, and high-low gas pressure switches to comply with IRI requirements.
6. Safety Lockout Switch: Locks out ignition sequence if burner fails to light after three tries. Controls are reset manually by turning the unit off and on.
7. Control Transformer: Integrally mounted 24-V ac.

2.10 CONTROLS

A. Factory-wired, fuse-protected control transformer, connection for power supply and field-wired unit to remote control panel.

B. Control Panel: Surface-mounted remote panel, with engraved plastic cover, and the following lights and switches:

1. off-auto-hand switch.
2. Summer-Winter switch
3. Supply-fan operation indicating light.
4. Heating operation-indicating light.
5. Damper position potentiometer.

6. Thermostat.
7. Dirty-filter indicating light operated by unit-mounted differential pressure switch.
8. Safety-lockout indicating light.

C. Refer to Division 15 Section "HVAC Instrumentation and Controls" for control equipment and sequence of operation.

D. Control Devices:

1. Remote Thermostat: Adjustable room thermostat with temperature readout.
2. Static-Pressure Transmitter: Non-directional sensor with suitable range for expected input, and temperature compensated.
3. Timers: Solid-state, programmable time control with 4 separate programs; 24-hour battery carryover; individual on-off-auto switches for each program; 365-day calendar with 20 programmable holidays; choice of fail-safe operation for each program; and system fault alarm.
4. Ionization-Type Smoke Detectors: 24-V dc, nominal; self-restoring; plug-in arrangement; integral visual-indicating light; sensitivity that can be tested and adjusted in place after installation; integral addressable module; remote controllability; responsive to both visible and invisible products of combustion; self-compensating for changes in environmental conditions.

E. Fan Control: Timer starts and stops indirect-fired make up air unit and exhaust fan(s).

1. Fan-Discharge Thermostat: Stops fan when discharge-air temperature is less than 40 deg F (4 deg C).
2. Smoke detectors, located in supply air, shall stop fans when the presence of smoke is detected.

F. Outdoor-Air Damper Control, Full modulation or fixed position based on design drawings

G. Temperature Control: Operates gas valve to maintain supply-air or room temperature.

1. Operates gas valve to maintain discharge-air temperature with factory-mounted sensor in fan outlet.
2. Operates gas valve to maintain space temperature with wall-mounting, field-wired sensor with temperature adjustment, and unit-mounted control adjustment and adjustment on remote control panel.
3. Timer shall select remote setback thermostat to maintain space temperature at 50 deg F.

2.11 MOTORS

A. Comply with requirements in Division 23 Section "Common Motors."

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 of indirect-fired make up air units.

B. Examine roughing-in for piping, ducts, and electrical systems to verify actual locations of connections before equipment installation.

C. Examine roof curbs and equipment supports for suitable conditions where rooftop replacement-air units will be installed.

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

3.2 INSTALLATION

A. Install gas-fired units according to NFPA 54, "National Fuel Gas Code."

B. Install controls and equipment shipped by manufacturer for field installation with indirect-fired make up air units.

3.3 CONNECTIONS

A. Piping Connections: Drawings indicate general arrangement of piping, fittings, and specialties. Install piping adjacent to machine to allow service and maintenance.

1. Gas Piping: Comply with requirements in Division 15 Section "Fuel Gas Piping." Connect gas piping with shutoff valve and union and with sufficient clearance for burner removal and service. Provide AGA-approved flexible connectors.

B. Duct Connections: Duct installation requirements are specified in Division 15 Section "Metal Ducts." Drawings indicate the general arrangement of ducts. Connect supply ducts to indirect-fired make up air units with flexible duct connectors. Flexible duct connectors are specified in Division 15 Section "Duct Accessories."

C. Ground equipment according to Division 16 Section "Grounding and Bonding."

D. Connect wiring according to Division 16 Section "Conductors and Cables."

3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Complete installation and startup checks according to manufacturer's written instructions and perform the following:

1. Inspect for visible damage to furnace combustion chamber.
2. Inspect casing insulation for integrity, moisture content, and adhesion.
3. Verify that clearances have been provided for servicing.
4. Verify that controls are connected and operable.
5. Verify that filters are installed.
6. Purge gas line.
7. Inspect and adjust vibration isolators.
8. Verify bearing lubrication.
9. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
10. Adjust fan belts to proper alignment and tension.
11. Start unit according to manufacturer's written instructions.
12. Complete startup sheets and attach copy with Contractor's startup report.
13. Inspect and record performance of interlocks and protective devices; verify sequences.
14. Operate unit for run-in period recommended by manufacturer.
15. Perform the following operations for both minimum and maximum firing and adjust burner for peak efficiency:

    a. Measure gas pressure on manifold.
    b. Measure combustion-air temperature at inlet to combustion chamber.
    c. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.

16. Calibrate thermostats.
17. Adjust and inspect high-temperature limits.
18. Inspect dampers, if any, for proper stroke and interlock with return-air dampers.
19. Inspect controls for correct sequencing of heating, mixing dampers, and normal and emergency shutdown.
20. Measure and record airflow. Plot fan volumes on fan curve.
21. Verify operation of remote panel, including pilot-operation and failure modes. Inspect the following:

    a. High-limit heat.
    b. Alarms.

22. After startup and performance testing, change filters, verify bearing lubrication, and adjust belt tension.

C. Remove and replace malfunctioning components that do not pass tests and inspections and retest as specified above.

D. Prepare written report of the results of startup services.

3.5 ADJUSTING

A. Adjust initial temperature set points.

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

C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain indirect-fired make up air units. Refer to Division 1 Section Closeout Procedures, Demonstration and Training.

END OF SECTION

PART 4 - GENERAL

4.1 RELATED DOCUMENTS

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

4.2 SUMMARY

A. This Section includes indirect-fired make up air units (HVU).

4.3 SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, and method of field assembly, components, and location and size of each field connection. Prepare the following by or under the supervision of a qualified professional engineer:

1. Design Calculations: Calculate requirements for selecting vibration isolators and for designing vibration isolation bases.
2. Mounting Details: For securing and flashing roof curb to roof structure. Indicate coordinating requirements with roof membrane system.
3. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.
4. Wiring Diagrams: Power, signal, and control wiring.

C. Coordination Drawings: Roof-mounted units and roof-curb mounting details drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Size and location of rooftop unit mounting rails and anchor points and methods for anchoring units to curb.
2. Required roof penetrations for ducts, pipes, and electrical raceways, including size and location of each penetration.

D. Startup service reports.

E. Operation and Maintenance Data: For indirect-fired make up air units to include in emergency, operation, and maintenance manuals.

4.4 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of indirect-fired make up air units and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."

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

C. Comply with NFPA 70.

4.5 COORDINATION

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

B. Coordinate size, location, installation, and structural capacity of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 7.

C. Coordinate size, location and installation of unit manufacturer's roof curbs and equipment supports with roof Installer.

1. Coordinate installation of restrained vibration isolation roof-curb rails, which are specified in Division 15 Section "Mechanical Vibration and Seismic Controls."

4.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to replace components listed below of indirect-fired MAKE-UP AIR units that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Heat Exchangers: Manufacturer's standard, but not less than five years from date of Substantial Completion.

4.7 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Filters: Two sets for each unit.
2. Fan Belts: One set for each unit.

PART 5 - PRODUCTS

5.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

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

1. Airwise, Inc.
2. Engineered Air.
3. Greenheck.
4. Rapid Engineering Inc.
5. Weather-Rite
6. Trane
7. McQuay/Dainkin

5.2 PACKAGED UNITS

A. Factory-assembled, prewired, self-contained unit consisting of cabinet, supply fan, controls, filters and indirect-fired gas furnace. Outdoor units are to be installed on concrete pad.

5.3 CABINET

A. Cabinet: Double-wall galvanized-steel panels, formed to ensure rigidity and supported by galvanized-steel channels or structural channel supports with lifting lugs. Cabinet shall be fully weatherized for outside installation.

B. Access Panels: Piano hinged with cam-lock fasteners for furnace and fan motor assemblies on both sides of unit.

C. Internal Insulation: Fibrous-glass duct lining, comply with ASTM C 1071, Type II, applied on furnace and fan sections only.

1. Thickness 2 inches
2. Insulation Adhesive: Comply with ASTM C 916, Type I.

3. Mechanical Fasteners: Galvanized steel suitable for adhesive attachment, mechanical attachment, or welding attachment to casing without damaging liner when applied as recommended by manufacturer and without causing air leakage.

D. Finish: Heat-resistant, baked enamel.

E. Discharge: Vertical

5.4 SUPPLY-AIR FAN

A. Fan Type: Centrifugal, rated according to AMCA 210; statically and dynamically balanced, galvanized steel; mounted on solid-steel shaft with heavy-duty pillow-block bearings rated for L50 or 200,000 hours with external grease fittings.

B. Motor: Totally enclosed single -speed motor.

C. Drive: V-belt drive with matching fan pulley and adjustable motor sheaves and belt assembly.

D. Mounting: Fan wheel, motor, and drives shall be mounted in fan casing with elastomeric or spring isolators.

5.5 MOUNTING

A. Mounting Curb: 24” High

B. Suspended from roof with necessary support bracings, rods, isolators and angles per manufacturers requirements.

5.6 OUTDOOR-AIR INTAKE

A. Outdoor-Air Hood: Galvanized steel with rain baffles, bird screen, and finish to match cabinet; and sized to supply maximum 100 percent outdoor air.

5.7 AIR FILTERS

A. Comply with NFPA 90A.

B. Disposable Panel Filters: 2-inch thick, factory-fabricated, flat-panel-type, disposable air filters with holding frames, with a minimum efficiency report value of 6 according to ASHRAE 52.2 and 90 percent average arrestance according to ASHRAE 52.1.

1. Media: Interlaced glass or polyester fibers.
2. Frame: Galvanized steel.

5.8 DAMPERS

A. Outdoor-Air Damper: Galvanized-steel, opposed-blade dampers with vinyl blade seals and stainless steel jamb seals, having a maximum leakage of 10 cfm/sq. ft of damper area, at differential pressure of 2-inch wg.

B. Damper Operator: Direct coupled, electronic with spring return or fully modulating or fixed as required by the control sequence.

5.9 INDIRECT-FIRED GAS FURNACE

A. Description: Factory assembled, piped, and wired; and complying with ANSI Z83.4, "Indirect Gas-Fired Make-Up Air Heaters"; ANSI Z83.18, "Indirect Gas-Fired Industrial Air Heaters"; and NFPA 54, "National Fuel Gas Code."

B. Inside Unit External Housing: Steel cabinet with integral support inserts.

C. Outside Unit External Housing: Weatherproof steel cabinet with integral support inserts.

1. External Casing and Cabinet Finish: Baked enamel over corrosion-resistant-treated surface in color to match fan section.

D. Burners: Cast-iron burner with stainless-steel mixing plates.

1. Control Valve: Modulating
2. Fuel: Natural gas.
3. Pilot: Electrically ignited by hot-surface ceramic igniter.

E. Safety Controls:

1. Gas Manifold: Safety switches and controls to comply with ANSI standards and IRI.
2. Purge-Period Timer: Automatically delays burner ignition and bypasses low-limit control.
3. Airflow Proving Switch: Dual pressure switch senses correct airflow before energizing pilot and requires airflow to be maintained within minimum and maximum pressure settings across burner.
4. Manual-Reset, High-Limit Control Device: Stops burner and closes main gas valve if high-limit temperature is exceeded.
5. Gas Train: Redundant, automatic main gas valves, electric pilot valve, electronic-modulating temperature control valve, main and pilot gas regulators, main and pilot manual shutoff valves, main and pilot pressure taps, and high-low gas pressure switches to comply with IRI requirements.
6. Safety Lockout Switch: Locks out ignition sequence if burner fails to light after three tries. Controls are reset manually by turning the unit off and on.
7. Control Transformer: Integrally mounted 24-V ac.

5.10 CONTROLS

A. Factory-wired, fuse-protected control transformer, connection for power supply and field-wired unit to remote control panel.

B. Control Panel: Surface-mounted remote panel, with engraved plastic cover, and the following lights and switches:

1. off-auto-hand switch.
2. Summer-Winter switch
3. Supply-fan operation indicating light.
4. Heating operation-indicating light.
5. Damper position potentiometer.
6. Thermostat.
7. Dirty-filter indicating light operated by unit-mounted differential pressure switch.
8. Safety-lockout indicating light.

C. Refer to Division 15 Section "HVAC Instrumentation and Controls" for control equipment and sequence of operation.

D. Control Devices:

1. Remote Thermostat: Adjustable room thermostat with temperature readout.
2. Static-Pressure Transmitter: Non-directional sensor with suitable range for expected input, and temperature compensated.
3. Timers: Solid-state, programmable time control with 4 separate programs; 24-hour battery carryover; individual on-off-auto switches for each program; 365-day calendar with 20 programmable holidays; choice of fail-safe operation for each program; and system fault alarm.
4. Ionization-Type Smoke Detectors: 24-V dc, nominal; self-restoring; plug-in arrangement; integral visual-indicating light; sensitivity that can be tested and adjusted in place after installation; integral addressable module; remote controllability; responsive to both visible and invisible products of combustion; self-compensating for changes in environmental conditions.

E. Fan Control: Timer starts and stops indirect-fired make up air unit and exhaust fan(s).

1. Fan-Discharge Thermostat: Stops fan when discharge-air temperature is less than 40 deg F (4 deg C).
2. Smoke detectors, located in supply air, shall stop fans when the presence of smoke is detected.

F. Outdoor-Air Damper Control, Full modulation or fixed position based on design drawings

G. Temperature Control: Operates gas valve to maintain supply-air or room temperature.

1. Operates gas valve to maintain discharge-air temperature with factory-mounted sensor in fan outlet.
2. Operates gas valve to maintain space temperature with wall-mounting, field-wired sensor with temperature adjustment, and unit-mounted control adjustment and adjustment on remote control panel.

3. Timer shall select remote setback thermostat to maintain space temperature at 50 deg F.

5.11 MOTORS

A. Comply with requirements in Division 15 Section "Motors."

PART 6 - EXECUTION

6.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting installation of indirect-fired make up air units.

B. Examine roughing-in for piping, ducts, and electrical systems to verify actual locations of connections before equipment installation.

C. Examine roof curbs and equipment supports for suitable conditions where rooftop replacement-air units will be installed.

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

6.2 INSTALLATION

A. Install gas-fired units according to NFPA 54, "National Fuel Gas Code."

B. Install controls and equipment shipped by manufacturer for field installation with indirect-fired make up air units.

6.3 CONNECTIONS

A. Piping Connections: Drawings indicate general arrangement of piping, fittings, and specialties. Install piping adjacent to machine to allow service and maintenance.

1. Gas Piping: Comply with requirements in Division 15 Section "Fuel Gas Piping." Connect gas piping with shutoff valve and union and with sufficient clearance for burner removal and service. Provide AGA-approved flexible connectors.

B. Duct Connections: Duct installation requirements are specified in Division 15 Section "Metal Ducts." Drawings indicate the general arrangement of ducts. Connect supply ducts to indirect-fired make up air units with flexible duct connectors. Flexible duct connectors are specified in Division 15 Section "Duct Accessories."

C. Ground equipment according to Division 16 Section "Grounding and Bonding."

D. Connect wiring according to Division 16 Section "Conductors and Cables."

6.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Complete installation and startup checks according to manufacturer's written instructions and perform the following:

1. Inspect for visible damage to furnace combustion chamber.
2. Inspect casing insulation for integrity, moisture content, and adhesion.
3. Verify that clearances have been provided for servicing.
4. Verify that controls are connected and operable.
5. Verify that filters are installed.
6. Purge gas line.
7. Inspect and adjust vibration isolators.
8. Verify bearing lubrication.
9. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
10. Adjust fan belts to proper alignment and tension.
11. Start unit according to manufacturer's written instructions.
12. Complete startup sheets and attach copy with Contractor's startup report.
13. Inspect and record performance of interlocks and protective devices; verify sequences.
14. Operate unit for run-in period recommended by manufacturer.
15. Perform the following operations for both minimum and maximum firing and adjust burner for peak efficiency:

    a. Measure gas pressure on manifold.
    b. Measure combustion-air temperature at inlet to combustion chamber.
    c. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.

16. Calibrate thermostats.
17. Adjust and inspect high-temperature limits.
18. Inspect dampers, if any, for proper stroke and interlock with return-air dampers.

19. Inspect controls for correct sequencing of heating, mixing dampers, and normal and emergency shutdown.
20. Measure and record airflow. Plot fan volumes on fan curve.
21. Verify operation of remote panel, including pilot-operation and failure modes. Inspect the following:

    a. High-limit heat.
    b. Alarms.

22. After startup and performance testing, change filters, verify bearing lubrication, and adjust belt tension.

C. Remove and replace malfunctioning components that do not pass tests and inspections and retest as specified above.

D. Prepare written report of the results of startup services.

6.5 ADJUSTING

A. Adjust initial temperature set points.

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

C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

6.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain indirect-fired make up air units. Refer to Division 1 Section Closeout Procedures, Demonstration and Training.

END OF SECTION

SECTION 15563 - PACKAGED AIR CONDITIONERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following rooftop air conditioners:
   1. Cooling and Heating units (RTU).

B. Related Sections include the following:
   1. Division 23 Section "Indirect-Fired, Packaged H&V Units" for outside units providing 100 percent tempered outside air with heat exchangers.

1.3 DEFINITIONS

A. DDC: Direct-digital controls.

1.4 SUBMITTALS

A. Product Data: Include manufacturer's technical data for each model indicated, including rated capacities, dimensions, required clearances, characteristics, furnished specialties, and accessories.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, and method of field assembly, components, and location and size of each field connection. Prepare the following by or under the supervision of a qualified professional engineer:

   1. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
   2. Detail mounting, securing, and flashing of roof curb to roof structure. Indicate coordinating requirements with roof membrane system.
   3. Wiring Diagrams: Power, signal, and control wiring.

C. Manufacturer Seismic Qualification Certification: Submit certification that rooftop air conditioners, accessories, and components will withstand seismic forces defined in Division 15 Section "Mechanical Vibration and Seismic Controls." Include the following:

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

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

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

D. Field quality-control test reports.

E. Operation and Maintenance Data: For rooftop air conditioners to include in emergency, operation, and maintenance manuals.

F. Warranties: Special warranties specified in this Section.

1.5 QUALITY ASSURANCE

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

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

C. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Code for Mechanical Refrigeration."

D. Energy-Efficiency Ratio: Equal to or greater than prescribed by ASHRAE 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."

E. Coefficient of Performance: Equal to or greater than prescribed by ASHRAE 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."

F. Comply with NFPA 54 for gas-fired furnace section.

G. ARI Certification: Units shall be ARI certified and listed.

H. ARI Compliance for Units with Capacities Less Than 135,000 Btuh (39.6 kW): Rate rooftop air-conditioner capacity according to ARI 210/240, "Unitary Air-Conditioning and Air-Source Heat Pump Equipment."

1. Sound Power Level Ratings: Comply with ARI 270, "Sound Rating of Outdoor Unitary Equipment."

I. ARI Compliance for Units with Capacities 135,000 Btuh (39.6 kW) and More: Rate rooftop air-conditioner capacity according to ARI 340/360, "Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment."

1. Sound Power Level Ratings: Comply with ARI 270, "Sound Rating of Outdoor Unitary Equipment."

1.6 COORDINATION

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

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 7 Section "Roof Accessories."

C. Coordinate size, location, and installation of rooftop air-conditioner manufacturer's roof curbs and equipment supports with roof installer.

1. Coordinate installation of restrained vibration isolation roof-curb rails.

1.7 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to replace components of rooftop air conditioners that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Compressors: Manufacturer's standard, but not less than five years from date of Substantial Completion.
2. Warranty Period for Heat Exchangers: Manufacturer's standard, but not less than five years from date of Substantial Completion.
3. Warranty Period for Solid-State Ignition Modules: Manufacturer's standard, but not less than one year from date of Substantial Completion.
4. Warranty Period for Control Boards: Manufacturer's standard, but not less than one year from date of Substantial Completion.
5. Warranty Period for Electronic Thermostats: Manufacturer's standard, but not less than one year from date of Substantial Completion.

1.8 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fan Belts**:** One set for each belt-drive fan.
2. Filters: One set of filters for each unit.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the manufacturers specified.

2.2 ROOFTOP AIR CONDITIONERS (RTU).

A. Available Manufacturers:
1. Carrier Corp.
2. Trane Company (The); North American Commercial Group.
3. YORK International Corporation.
4. McQuay/Daikin

B. Description: Factory assembled and tested; designed for exterior installation; consisting of compressor, indoor and outside refrigerant coils, indoor fan and outside coil fan, refrigeration and temperature controls, filters, and dampers.

C. Casing: Galvanized-steel construction with enamel paint finish, removable panels or access doors with neoprene gaskets for inspection and access to internal parts, minimum 1/2-inch thick thermal insulation, knockouts for electrical and piping connections, exterior condensate drain connection, and lifting lugs.

D. Indoor Fan: Forward curved, centrifugal, belt driven with adjustable motor sheaves, grease-lubricated ball bearings, and motor.

E. Outside Coil Fan: Propeller type, directly driven by permanently lubricated motor.

F. Refrigerant Coils: Aluminum-plate fin and seamless copper tube in steel casing with equalizing-type vertical distributor**.** Provide phenolic epoxy corrosion-protection coating to both coils.

G. Compressor(s): Two hermetic scroll compressors with integral vibration isolators, internal over current and over temperature protection, internal pressure relief, and crankcase heater(s).

H. Refrigeration System:

1. Compressor(s).
2. Outside coil and fan.
3. Indoor coil and fan.
4. Four-way reversing valve and suction line accumulator.
5. Check valves.
6. Expansion valves with replaceable thermostatic elements.
7. Refrigerant dryers.
8. High-pressure switches.
9. Low-pressure switches.
10. Thermostats for coil freeze-up protection during low-ambient temperature operation or loss of air.
11. Independent refrigerant circuits.
12. Brass service valves installed in discharge and liquid lines.
13. Charge of refrigerant.
14. Hot-Gas Bypass: Factory-installed valve.
15. Timed Off Control: Automatic-reset control shuts compressor off after five minutes.

I. Filters: 2-inch- (50-mm-) thick, fiberglass, and pleated throwaway filters in filter rack.

J. Heat Exchanger: Stainless-steel construction for natural gas-fired burners with the following controls:

1. Redundant dual gas valve with manual shutoff.
2. Direct-spark pilot ignition.
3. Electronic flame sensor.
4. Induced-draft blower.
5. Flame rollout switch.

K. Outside-Air Damper: Linked damper blades, for 0 to 50 percent outside air, with fully modulating, spring-return damper motor and hood.

L. Economizer: Return- and outside-air dampers with neoprene seals, outside-air filter, and hood.

1. Damper Motor: Fully modulating spring return with adjustable minimum position.
2. Control: Electronic-control system uses outside-air temperature, mixed-air and outside-air temperature and outside-air enthalpy to adjust mixing dampers.

3. Relief Damper: Gravity actuated with bird screen and hood.

M. Power Connection: Provide for single connection of power to unit with unit-mounted disconnect switch accessible from outside unit and control-circuit transformer with built-in circuit breaker.

N. Unit Controls: Solid-state control board and components contain at least the following features:

1. Indoor fan on/off delay.
2. Default control to ensure proper operation after power interruption.
3. Service relay output.
4. Unit diagnostics and diagnostic code storage.
5. Field-adjustable control parameters.
6. Defrost control.
7. Economizer control.
8. Gas valve delay between first- and second-stage firing.
9. Low-ambient control, allowing operation down to 0 deg F (minus 18 deg C).
10. Minimum run time.
11. Night setback mode.
12. Return-air temperature limit.
13. Smoke alarm with smoke detector installed in return air.
14. Low-refrigerant pressure control.
15. Digital display of outside temperature, supply-air temperature, return-air temperature, economizer damper position, indoor-air quality, and control parameters.

O. Thermostat: Programmable, electronic; with heating setback and cooling setup with seven-day programming; and the following:

1. Touch sensitive keyboard.
2. Automatic switching.
3. Deg F readout.
4. LED indicators.
5. Hour/day programming.
6. Manual override capability.
7. Time and operational mode readout.
8. Status indicator.
9. Battery backup.
10. Subbase with manual system switch (on-heat-auto-cool) and fan switch (auto-on).
11. Fan-proving switch to lock out unit if fan fails.
12. Dirty-filter switch.

P. Optional Accessories:

1. Cold-Weather Kit: Electric heater maintains temperature in gas burner compartment.
2. Service Outlets: Two, 115-V, ground-fault, and circuit-interrupter type.
3. PVC condensate drain trap.
4. Dirty-filter switch.
5. Coil guards of painted, galvanized-steel wire and Hail guards of steel, painted to match casing.
6. Power exhaust fan centrifugal type.
7. Vertical vent extension.

Q. Roof Curb: Steel with corrosion-protection coating, gasketing, and factory-installed wood nailer; complying with NRCA standards; minimum height of 24 inches.

R. Isolation Curb: Rigid upper and lower steel structure with vibration isolation springs having 2 inches static deflection and vertical and horizontal restraints; with elastomeric waterproof membrane.

2.3 MOTORS

A. Comply with requirements in Division 16

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units level and plumb, maintaining manufacturer's recommended clearances. Install according to ARI Guideline B

B. Curb Support: Install roof curb on roof structure, level and secure, according to NRCA's "Low-Slope Membrane Roofing Construction Details Manual," Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts," and ARI Guideline B. Install and secure rooftop air conditioners on curbs and coordinate roof penetrations and flashing with roof construction. Secure units to curb support with anchor bolts.

C. Unit Support: Install unit level on structural curbs. Coordinate wall penetrations and flashing with wall construction. Secure units to structural support with anchor bolts**.**

D. Isolation Curb Support: Install units on isolation curbs according to NRCA's "Low-Slope Membrane Roofing Construction Details Manual," Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts." ARI Guideline B.

E. Install restrained vibration isolation roof-curb rails on roof structure according to NRCA's "Low-Slope Membrane Roofing Construction Details Manual," Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts," and ARI Guideline B. Install and secure rooftop air conditioners on rails and coordinate roof penetrations and flashing with roof construction. Restrained isolation roof-curb rails are specified in Division 15 Section "Mechanical Vibration and Seismic Controls."

3.2 CONNECTIONS

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

B. Install piping adjacent to machine to allow service and maintenance.

1. Gas Piping: Comply with applicable requirements in Division 15 Section "Fuel Gas Piping." Connect gas piping to burner, full size of gas train inlet, and connect with union and shutoff valve with sufficient clearance for burner removal and service.
2. Hot-Water Heating Piping: Comply with applicable requirements in Division 15 Section "Hydronic Piping." Connect to supply and return coil tappings with shutoff or balancing valve and union or flange at each connection.
3. Steam and Condensate Piping: Comply with applicable requirements in Division 15 Section "Steam and Condensate Piping." Connect to supply and return coil tappings with shutoff or balancing valve and union or flange at each connection.

C. Duct installation requirements are specified in other Division 15 Sections. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:

1. Install ducts to termination in roof curb.

2. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
3. Connect supply ducts to rooftop unit with flexible duct connectors specified in Division 15 Section "Duct Accessories."
4. Terminate return-air duct through roof structure and insulate space between roof and bottom of unit with 2-inch- (50-mm-) thick, acoustic duct liner.
5. Install normal-weight, 3000 psi (20.7 MPa), compressive strength (28-day) concrete mix inside roof curb, 4 inches thick. Concrete, formwork, and reinforcement are specified in Division 3.

D. Electrical System Connections: Comply with applicable requirements in Division 16 Sections for power wiring, switches, and motor controls.

E. Ground equipment according to Division 16 Section "Grounding and Bonding."

F. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.3 FIELD QUALITY CONTROL

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

B. Perform the following field quality-control tests and inspections and prepare test reports:

1. After installing rooftop air conditioners and after electrical circuitry has been energized, test units for compliance with requirements.
2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove malfunctioning units, replace with new units, and retest as specified above.

3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Complete installation and startup checks according to manufacturer's written instructions and do the following:

1. Inspect for visible damage to unit casing.
2. Inspect for visible damage to furnace combustion chamber.
3. Inspect for visible damage to compressor, air-cooled outside coil, and fans.
4. Inspect internal insulation.
5. Verify that labels are clearly visible.
6. Verify that clearances have been provided for servicing.
7. Verify that controls are connected and operable.
8. Verify that filters are installed.
9. Clean outside coil and inspect for construction debris.
10. Clean furnace flue and inspect for construction debris.
11. Connect and purge gas line.

12. Adjust vibration isolators.
13. Inspect operation of barometric dampers.
14. Lubricate bearings on fan.
15. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
16. Adjust fan belts to proper alignment and tension.
17. Start unit according to manufacturer's written instructions.

    a. Start refrigeration system in summer only.
    b. Complete startup sheets and attach copy with Contractor's startup report.

18. Inspect and record performance of interlocks and protective devices; verify sequences.
19. Operate unit for an initial period as recommended or required by manufacturer.
20. Perform the following operations for both minimum and maximum firing and adjust burner for peak efficiency. Adjust pilot to stable flame.

    a. Measure gas pressure on manifold.
    b. Measure combustion-air temperature at inlet to combustion chamber.
    c. Measure flue-gas temperature at furnace discharge.
    d. Perform flue-gas analysis. Measure and record flue-gas carbon dioxide and oxygen concentration.
    e. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.

21. Calibrate thermostats.
22. Adjust and inspect high-temperature limits.
23. Inspect outside-air dampers for proper stroke and interlock with return-air dampers.
24. Start refrigeration system and measure and record the following:

    a. Coil leaving-air, dry- and wet-bulb temperatures.
    b. Coil entering-air, dry- and wet-bulb temperatures.
    c. Outside-air, dry-bulb temperature.
    d. Outside-air-coil, discharge-air, dry-bulb temperature.

25. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
26. Measure and record the following minimum and maximum airflow. Plot fan volumes on fan curve.

    a. Supply-air volume.
    b. Return-air volume.
    c. Relief-air volume.
    d. Outside-air intake volume.

27. Simulate maximum cooling demand and inspect the following:

    a. Compressor refrigerant suction and hot-gas pressures.
    b. Short circuiting of air through outside coil or from outside coil to outside-air intake.

28. Verify operation of remote panel, including pilot-light operation and failure modes. Inspect the following:

    a. High-limit heat exchanger.
    b. Warm-up for morning cycle.
    c. Freezestat operation.
    d. Economizer to limited outside-air changeover.

e. Alarms.

29. After startup and performance testing, change filters, vacuum heat exchanger and cooling and outside coils, lubricate bearings, adjust belt tension, and inspect operation of power vents.

3.5 ADJUSTING

A. Adjust initial temperature and humidity set points.

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

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

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain rooftop air conditioners. Refer to Division 1 Section "Closeout Procedures and Demonstration and Training."

END OF SECTION