Oregon State University

AUGUST 13, 2024

Project Manual

Oregon State University

Burt Hall 3 HVAC Upgrade Design

100% Construction Documents

SYSTEMS WEST ENGINEERS

V015.22

725 A Street Springfield, OR 97477
550 NW Franklin Blvd., Suite 448, Bend, OR 97703

SystemsWestEngineers.com
(541) 342-7210

PROJECT MANUAL V015.22

Oregon State University

Burt Hall 3 HVAC Upgrade Design

100% Construction Documents

August 13, 2024

Owner:
Oregon State University
850 SW 35th Street
Corvallis, Oregon 97333
Phone: (503) 779-3488
Contact: Ryan Wilson
Capital Renewal Project Manager
ryan.wilson@oregonstate.edu

Mechanical & Electrical Engineer:
Systems West Engineers, Inc.
725 A Street
Springfield, Oregon 97477
Phone: (541) 342-7210
Contact: Nate Jenkins, PE
Project Manager
njenkins@systemswestengineers.com

DIVISION 01 – GENERAL REQUIREMENTS

DIVISION 07 – THERMAL AND MOISTURE PROTECTION

DIVISION 23 – HVAC

DIVISION 26 – ELECTRICAL

SECTION 011100

SUMMARY OF WORK

PART 1 - GENERAL

1.1 SUMMARY OF WORK

A. The Work Contract consists of the replacement of the main building chiller, a BSL-3 lab chiller, full building controls replacement, lab airflow controls replacement, modifications to room 197B Wood Treatment Lab, various mechanical system upgrades and associated electrical work on the Oregon State University Campus, Corvallis, Oregon.

B. Work shall be started within ten (10) calendar days after signing of Contract on behalf of Oregon State University. The Contract may not be signed prior to approval of the Contractor's Certificate of Insurance by Construction Contract Administration (CCA), Oregon State University. Work shall be completed within 600 calendar days of date of executed Contract. Substantial Completion is expected to be October 17, 2025.

1.2 CONTRACTORS USE OF PREMISES

A. Contractor shall limit use of the Premises for work and storage to allow for:
1. Owner occupancy, day and night.
2. Public use, day and night.
3. Security.
4. Safe entry and exit for vehicles and pedestrians.
5. Fire egress.

B. Coordinate all operations with the Owner's Authorized Representative during the construction period. A 96-hour notification is required prior to scheduled utility shutdowns or street closures, but more lead time is often required to schedule around other critical activities.

C. Limit Contractor's employee parking to locations designated at the Pre-construction Conference.

1.3 OWNER OCCUPANCY

A. The Owner will occupy the Premises during the entire period of construction for the conduct of normal operations. Cooperate with Owner's Authorized Representative in construction operations to minimize conflict and to facilitate the Owner's usage especially in the following areas:
1. Restricted access and parking.
2. Use of stairs.
3. Storage space availability.

B. Conduct operations in such a way to ensure the least inconvenience to the general public, including:
1. Limitations and easements.
2. Emergency vehicle access.
3. Building access to the public, day and night.

1.4 ASBESTOS AND OTHER HAZARDOUS MATERIAL

A. The Owner has made a reasonable attempt to locate and identify asbestos or other hazardous material that may be encountered during the course of the Work.

B. If the Contractor observes or suspects the existence of asbestos, polychlorinated biphenyl (PCB) or other hazardous materials in the structure or components of the building, the Contractor shall immediately stop work and notify the Owner's Authorized Representative.

C. The Owner will arrange for the removal of asbestos, polychlorinated biphenyl (PCB) or other hazardous materials as required by Facilities Services personnel or by separate contract.

D. Schedule ten (10) days of slack or "down" time for the removal of hazardous materials without penalty to Owner for the delay of the Contract.

1.5 LEAD BASED PAINT

A. The Owner may have tested existing paint in the project area and if levels are found the following conditions apply.

B. Contractor shall remove paint as specified for surface preparation and capture removed material for disposal.

C. Contractor shall follow OSHA guidelines involving exposure to workers.

D. Owner will provide containers for Contractor's use at project site.

E. Contractor shall comply with the requirements of DEQ and EPA and shall submit a lead abatement plan.

F. Contractor shall separate lead contaminated material from effluent and water.

G. Owner will dispose of lead paint and effluent resulting from stripping operation.

H. Soil contaminated by stripping operations shall be replaced with topsoil.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION

SECTION 012300

ALTERNATES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. The alternates described in this Section may be exercised at the option of the Owner within 60 days of the execution of the Contract.

B. It is generally the practice of the Owner to exercise alternates in numerical order.

C. The Owner reserves the right to accept the alternates without regard to order or sequence; but, such acceptance shall not impair the selection of a low, responsible and responsive bidder to whom the Contract may be awarded under an equitable bid procedure.

1.2 QUALITY ASSURANCE

A. For each alternate which is accepted, coordinate the work of the various trades involved, and modify surrounding work as required to complete the project as intended.

B. In the change-in-price figure for each alternate, include incidental costs which are attributable to adjustments in the work of other trades which may be required to achieve the contemplated and final conditions.

C. Questions:

1. If there is a question regarding the extent, scope, nature, or intent of the alternates, contact the Owner's Authorized Representative for clarification.
2. Failure on the part of the Contractor to clarify any unclear items shall not relieve the Contractor of the responsibility for performing the selected alternates in accordance with the intent and requirements of the Project Manual and Drawings.
3. The description of the alternates hereinafter is qualitative and not quantitative; the Contractor shall determine the quantities of labor and materials and the extent of same required to execute the selected alternates in accordance with the intent and requirements of the Project Manual and Drawings.
4. The applicable Sections of the Specifications apply to the work under each alternate.

1.3 LIST OF ALTERNATES

A. Alternate 1: Replacement of supply diffusers in office spaces and as noted on the drawings in lab spaces.

B. Alternate 2: Addition of chilled water fan coil units FC-379 and FC-386 and associated controls, piping and air distribution.

PART 2 – PRODUCTS (Not Used)

PART 3 – EXECUTION (Not Used)

END OF SECTION

SECTION 012476

APPLICATIONS FOR PAYMENT

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Work of this Section includes forms and procedures for progress payments.

B. Related work specified elsewhere.
1. For the primary discussion of payments, refer to OSU General Conditions, Section E, as supplemented.
2. In compliance with OSU General Conditions, Section K, no payments beyond 75% will be made by the Owner before draft Operation and Maintenance Manuals have been received for review by the Owner.

1.2 APPLICATION FORMS

A. For applications for payment, use sample Contract Payment Request (see below), contract payment request on company letterhead, or AIA Document G702, supported by AIA Document G703, Continuation Sheet, or similar document.

B. Prepare the Schedule of Values in such a manner that each major item of Work and each subcontracted item of Work is shown as a line item broken down in terms of material and labor costs on AIA Document G703, Application Certification of Payment, Continuation Sheet or similar format. The sample continuation sheet shall be the minimum Schedule of Values breakdown.

C. The Schedule of Values shall be submitted for review by the Owner prior to the first application for payment; and may be used when, and only when, accepted in writing by the Owner.

D. Payment request is to include the Contractor's Federal Tax Identification number and return address.

1.3 PAYMENTS

A. The Owner will make progress payments on account of the Contract once monthly for the scheduled duration of the project (i.e. three (3) payments on a three-month project), based on the value of work accomplished or materials on the job site, as stated in the Schedule of Values on the Application and Certificate Payment.

B. Complete and forward Application to the Owner on or about the 15th day of each month for work performed the previous month and include certified payroll statements as specified in the OSU General Conditions.

C. Submit one (1) copy of forms requesting payment to the Owner.

D. Payments will be made on protected materials on hand at the job site properly stored, protected, and insured.

E. Estimated quantities shall be subject to the Owner's review and judgment.

1.4 EARLY PURCHASE AND PAYMENT OF MATERIALS AND EQUIPMENT

A. Order materials and equipment requiring a long lead or waiting time early so as not to delay progress of the Work.

B. The Contractor will be reimbursed for early order materials or equipment upon receipt

and verification of quality and quantity against submittals and shipping documents by the Owner's Authorized Representative.

C. Receipt shall be to the job site or stored at Owner's other premises in an orderly and safe manner, secured from normal weather damage.

D. Security remains the responsibility of the Contractor.

PART 2 – PRODUCTS (Not Used)

PART 3 – EXECUTION (Not Used)

END OF SECTION

CONTRACT PAYMENT REQUEST

DATE: _____

TO: University Financial Services
Oregon State University
850 SW 35th St.
Corvallis, OR 97333
FacServContracts@oregonstate.edu

Payment Request No. _____Contract No. _____ Period from _____ to _____

Project: _____

Original Contract Amount ..... $_____

Change Orders (Net Amount)..... $_____

Contract Total to Date..... $_____

==========

Total Completed and Stored to Date ..... $_____

Less Retainage (5%), if applicable ..... $_____

Total Earned, Less Retainage (if applicable) ..... $_____

Less Previous Payments ..... $_____

Net Amount Due this Request..... $_____

The undersigned Contractor certifies that, to the best of his/her knowledge, information, and belief, the Work covered by this request has been completed in accordance with the Contract Documents, that all amounts have been paid for Work for which previous applications for Payment were issued and payments received from the Owner, and that the amount shown herein is now due.

Contractor:_____

By: _____Date: _____

Federal Tax ID Number:_____

Address:_____

_____

CONTINUATION SHEET

Project Name:

Application No.:

Date:

Period To:

WRN No.:

NOTES:
Amounts are stated to the nearest penny.
Use Column I on Contracts where variable retainage for line items may apply, or if retainage is required.
Change Orders are usually listed as the last items of the basic schedule.

A	B	C	D	E	F	G		H	I
Item No.	**Description of work**	**Scheduled Value**	**Work Completed** From Previous Applications	**Work Completed** This Period	**Materials Presently Stored (Not in D or E)**	**TOTAL Completed & Stored (D+E+F)**	**% Completed (G/C)**	**Balance to Finish (C-G)**	**Retainage**
TOTALS									

SECTION 012500

PRODUCT SUBSTITUTION PROCEDURES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. General requirements for the Work in relation to substitutions and product options.

B. Submit to the Owner's property insurance carrier shop drawings, samples, and product data (such as manufacturer's standard schematic drawings and other literature) when required by individual Specifications sections.

C. Related Work Specified Elsewhere
1. Invitation to Bid.
2. OSU General Conditions.

1.2 REQUESTS FOR SUBSTITUTIONS

A. Requests for substitution of products in place of those specified shall be in accordance with Invitation to Bid, and as specified herein.

1.3 CONTRACTOR'S RESPONSIBILITIES

A. Investigate proposed products and determine that they are equal or superior in all respects to products specified.

B. Provide same guarantee for accepted substitutions as for products specified.

C. Coordinate installation of accepted substitutions into the Work, making such changes as may be required for the Work to be complete in all respects.

1.4 SUBSTITUTIONS DURING BIDDING

A. Submit one electronic copy of the following information with each request to the Owner:
1. Substitution request form provided below.
2. Comparison of proposed substitution with product, material or system specified.
3. Complete data, substantiating compliance of proposed substitution with the Contract Documents.
4. Test numbers and supporting reports, indicating compliance with referenced standards.
5. Evidence that warranty requirements are acceptable.
6. Details indicating specific deviations proposed for the substitution.
7. Reference and applicable Specification sections.
8. Applicable product samples.

B. All substitution requests shall be received in the Owner's office prior to the deadline for questions as identified in the Invitation to Bid. Requests received after this date will not be considered.

1.5 SUBSTITUTIONS DURING CONSTRUCTION

A. Substitutions will normally not be considered after date of Contract except when required

due to unforeseen circumstances.

B. Within a period of thirty (30) days after date of Contract, the Owner may, at its option, consider formal written requests for substitution of products in place of those specified, when submitted in accordance with the requirements stipulated herein.

C. One or more of the following conditions must be documented in any such request:
1. Required for compliance with final interpretation of code or insurance requirements.
2. Required due to unavailability of a specified product.
3. Required because of the inability of the specified product to perform properly or to fit in the designated space.
4. Substitution would be substantially in the best interest of the Owner in terms of cost, time, or other considerations.

1.6 SUBSTITUTIONS NOT PERMITTED

A. If implied on submittals without first requesting approval thereof.

B. If acceptance will require substantial revision of the Contract Documents.

PART 2 – PRODUCTS (Not Used)

PART 3 – EXECUTION (Not Used)

END OF SECTION

SUBSTITUTION REQUEST FORM

TO:

_____

PROJECT:

_____

SPECIFIED ITEM:

_____ _____ _____

_____

Section Page Paragraph Description

The undersigned requests consideration of the following:

PROPOSED SUBSTITUTION: _____

Attached data includes product description, specifications, drawings, photographs, performance and test data adequate for evaluation of the request; applicable portions of the data are clearly identified.

Attached data also includes description of changes to Contract Documents which proposed substitution will require for its proper installation.

The undersigned states that the following paragraphs, unless modified on attachments, are correct:

1. The proposed substitution does not affect dimensions shown on Drawings.

2. The undersigned will pay for changes to the building design, including engineering design, detailing and construction costs caused by the requested substitution.

3. The proposed substitution will have no adverse effect on other trades, the construction schedule, or specified warranty requirements.

4. Maintenance and service parts will be locally available for the proposed substitution.

The undersigned further states that the function, appearance and quality of the Proposed Substitution are equivalent or superior to the Specified Item.

Submitted by:

Signature _____

Firm _____

Address _____

_____

By _____

Date _____

Date _____

Telephone _____

Remarks _____

Attachments:

For use by Design Consultant:

☐ Accepted ☐ Accepted as noted

☐Not Accepted ☐ Received too late

SECTION 013119

PROJECT MEETINGS

PART 1 - GENERAL

1.1 PRE-CONSTRUCTION MEETING

A. Architect/Engineer/Designer, Contractor and Owner will meet prior to start of the Work (within seven (7) days after notice to proceed) to discuss at least the following topics and any others of mutual interest.

1. Schedule of Values
2. Permit Status/tree protection/erosion control
3. List of sub-contractors
4. Job inspections.
5. Early purchase of, and/or lead time requirements for material and equipment/prepurchase of equipment
6. Monthly payment date/SOP for pay requests
7. Portion of site to be occupied by construction.
8. Parking/Staging areas
9. Non-smoking campus requirements
10. Maintenance of access and safety.
11. Processing of field decisions and change orders
12. Labor provisions/labor rates for subs
13. Material submittals/deferred submittals
14. Owner access during construction.
15. Review of Contract Documents/review ADA requirements/cross-slopes
16. Coordination procedures and separate contracts.
17. Progress schedules.
18. Critical Work sequencing.
19. Safety and emergency procedures/24 hour contact numbers
20. Security procedures.
21. Hazardous materials.
22. Progress meetings.
23. Contract close-out.

B. Location of Meeting: Project site

1.2 PROGRESS MEETINGS

A. The Contractor will schedule and administer progress meetings and will:

1. Prepare agendas.
2. Schedule progress meetings, frequency, time and day to be determined during pre-construction meeting.
3. Make physical arrangements for and preside at meetings.
4. Record minutes and include decisions.
5. Distribute copies of minutes to participants within four (4) days after meetings.

B. Location of Meetings: Project site.

C. Attendance:

1. The Owner or Owner’s Authorized Representative.
2. Contractor.
3. Subcontractors affected by agenda.
4. Project Architect/Engineer/as necessary.
5. Owner will attend meeting to ascertain Work is expedited consistent with progress schedule and with Contract Documents.

D. Minimum Agenda:
   1. Review and approve minutes from previous meeting.
   2. Review Work progress since previous meeting.
   3. Discuss field observations, and problems.
   4. Review delivery schedules, construction schedule, and identify problems which impede planned progress.
   5. Review proposed changes.
   6. Material submittals.
   7. Note all new subcontractors performing Work at the job site.

PART 2 – PRODUCTS (Not Used)

PART 3 – EXECUTION (Not Used)

END OF SECTION

SECTION 013323

SHOP DRAWINGS, PRODUCT DATA, SAMPLES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Submit to the Owner shop drawings, samples, and product data (such as manufacturer's standard schematic drawings and other literature) when required by individual Specifications sections.

B. Related Work Specified Elsewhere
1. OSU General Conditions.

1.2 SUBMITTAL SCHEDULING

A. For items requiring review by the Owner only, submittals shall be sent to the Owner at least 15 calendar days before the date each is required for fabrication or installation.

B. Submittals to be reviewed by Owner's consultants shall be sent to the Owner at least 20 calendar days before the date each is required for fabrication or installation.

C. Submittals to be reviewed by Owner's property insurance carrier shall be sent to Owner as directed in individual specification sections.

D. Submittals involving Substitution requests or other modifications requiring review by the Owner and/or the Owner's consultants shall be sent to the Owner at least 20 calendar days before the date each is required for fabrication or installation.

1.3 SUBMITTAL CONTENT AND FORMAT

A. General Requirements:
1. Shop Drawings: Submit in electronic format and, if requested by Owner's Authorized Representative, submit one reproducible transparency and 1 print of each drawing.
2. Product Data: Submit electronically, and if requested by Owner's Authorized Representative, up to 6 hard copies.
3. Samples: Submit the number and type stated in each Specification Section. Submit a minimum of three sets of color samples where color selection is required.
4. Submittals shall include:
   a. Date and revision dates return date requested.
   b. Project title and number.
   c. The names of the Contractor, subcontractor, supplier, and manufacturer.
   d. Identification of product or material, with Specification Section number.
   e. Relation to adjacent critical features of work or materials.
   f. Field dimensions, clearly identified as such.
   g. Applicable standards, such as ASTM number or Federal Specification.
   h. Identification of deviations from Contract Documents, and for products accompanied by Substitution request as required by Section 01 25 00.
   i. Contractor's stamp legibly signed, essentially as follows:
      1) The undersigned, acting on behalf of the Contractor, certifies that this submittal has been reviewed and is approved; products have been verified as being as specified, field measurements and field construction criteria have been or will be coordinated, and the submittal is in compliance with Contract Documents.
5. Re-submission Requirements:
   a. Revise initial drawings as required and resubmit as specified for initial submittal.
   b. Indicate on drawings any changes which have been made other than those

requested by the Owner or the owner's consultants.

6. The Owner may return without review any submittal not meeting the requirements listed above.

B. Shop Drawings:
   1. Present data in a clear and thorough manner.
   2. Details shall be identified by reference to sheet and detail, schedule or room numbers shown on Contract Documents.
   3. Structural items shall be identified by location in the completed structure. Identify details by reference to contract sheet and detail numbers.
   4. Minimum sheet Size: 8 ½ x 11".

C. Product Data:
   1. Manufacturer's catalog sheets, brochures, diagrams, schedules, performance charts, illustrations and other standard descriptive data:
      a. Clearly mark each copy to identify pertinent product or models.
      b. Show dimensions, weights, and clearances required.
      c. Show performance data consisting of capabilities, ROM, KW, pressure drops, design characteristics and consumption; conforming as closely as possible to the test methods referenced in the Plans and Specifications.
      d. Show wiring or piping diagrams and controls.
   2. Manufacturer's standard schematic drawings and diagrams:
      a. Modify to delete information which is not applicable.
      b. Supplement standard information to provide information specifically applicable to the Work.

D. Samples:
   1. Insure that samples are of sufficient size to indicate the general visual effect or color.
   2. Where samples must show a range of color, texture, finish, graining, or other property, submit sets of pairs illustrating the full scope of this range.
   3. One (1) sample or one (1) set of approved samples will be retained by the Owner; final work will be measured against approved samples.

1.4 QUALITY ASSURANCE

A. Process submittals in ample time for review, as applicable, so as to not delay the Work. All submittals shall be received by the Owner within ten (10) days after pre-construction.

1.5 DEFINITIONS

A. The Owner will mark reviewed materials as follows:
   1. "No Exception Taken," which means fabrication, manufacture and/or installation may proceed.
   2. "Make Revisions Noted," which means fabrication, manufacture and/or installation may proceed with revisions as noted.
   3. "Revise and Resubmit," which means that fabrication, manufacture and/or installation may not proceed.
   4. "Rejected," which means do not proceed; make arrangements for the review of the proposed Work with the Owner as soon as possible.

1.6 PROCESSING

A. Review submittals, make necessary corrections, and become familiar with the content of the submittals.

B. Mark each item with Contractor's stamp.

C. Accompany submittals with a transmittal letter bearing the project name, Contractor's name, number of items, and other pertinent data.

D. Keep one copy of each reviewed submittal on the job site at all times.

E. Be responsible for obtaining and distributing prints of shop drawings to the various suppliers, and the Owner once review process has been completed. Make prints of reviewed shop drawings only from transparencies which carry the appropriate stamp and endorsement.

PART 2 – PRODUCTS (Not Used)

PART 3 – EXECUTION (Not Used)

END OF SECTION

SECTION 01300

SPECIAL PROCEDURES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Protection of work

B. Maintaining systems operational

C. Owner access and use

D. Noise, dust, and odor control

F. Furnishings to remain in work area.

G. Ground penetrating radar

1.2 PROTECTION OF WORK

A. Protect from damage any existing finishes, equipment, and adjacent work which is scheduled to remain.

1.3 MAINTAINING SYSTEMS OPERATIONAL

A. All systems currently operating including lighting, HVAC equipment, critical building systems and other systems in use, which serve Owner occupied areas, must be maintained operational during construction. As systems currently in use must be turned off to perform work, permission must be obtained, and owner notified prior to performing any work.

1.4 OWNER ACCESS AND USE

A. Occupancy
   1. The facility operates 24 hours per day, 7 days per week, although primary occupancy hours are from 7:00 a.m. to 5:00 p.m. from Monday through Friday. The Owner will occupy the facility during the entire course of the project.

B. Where necessary to keep areas operational during occupied hours, schedule work during unoccupied hours and weekends. Where absolutely necessary, such areas may be vacated during working hours for brief periods with prior notification and approval of the Owner. Coordinate and sequence work through the facility through construction manager/general contractor.

1.5 NOISE, DUST, AND ODOR CONTROL

A. Construction noise and odor must be controlled to allow normal facility use by the Owner. Areas are separated into three classifications as shown on the drawings depending on sensitivity.

1. Areas Which Are Not Sensitive: In areas which are not sensitive, the Contractor may perform any work during occupied or unoccupied hours provided that noise and odor produced by the work is not objectionable in adjacent areas.

2. Areas Where Noise and Odor Must Be Reduced But Not Eliminated: In this area, work may be completed during occupied hours provided that noise and odor levels are reasonable and not objectionable in adjacent spaces. No repetitive high impact noise is permitted.
3. Noise and Odor Sensitive Areas: Construction noise and odor will not be acceptable in sensitive areas when they are occupied. If absolutely necessary, some noise produced in adjacent areas may be acceptable for brief periods with the prior notification and approval of the Owner.

B. Dust resulting from construction must be contained within the work area. Where dust sensitive equipment, such as computers, is present in the work area, cover or otherwise enclose equipment to prevent damage.

C. Where necessary to maintain construction noise, dust, and odor levels below acceptable limits, schedule work during unoccupied hours.

D. The Owners representative will be responsible for determining if noise, dust, and odor levels are objectionable in any area and has the authority to stop work to ensure compliance.

E. Shields, physical barriers, or enclosures for noise-producing machinery are recommended during occupied hours.

F. Conduct truck loading and unloading so that noise is kept to a minimum.

1.6 FURNISHINGS TO REMAIN IN WORK AREA

A. Staff, equipment, and materials will primarily remain in existing locations. Contractor shall take precautions to protect Owner equipment, furnishings, and other materials left in workspace from damage. Contractor is responsible for all damage to Owner equipment, furnishings, and materials resulting from work. Notify Owner a minimum of two weeks in advance where room contents preclude completion of work without moving room contents or belongings.

B. Facility contains unique equipment and processes. Ensure that extraordinary precautions are utilized during execution of the work.

1.7 GROUND PENETRATING RADAR

A. Existing Concrete Structure: First floor up through roof slabs are post-tensioned concrete with embedded reinforcing steel. Do not drill or penetrate without first identifying locations having sufficient depth or clearance available to prevent harm.

B. Employ an experienced Ground Penetrating Radar (GPR) service to identify all existing reinforcing steel in any existing concrete structural member to be drilled or cut.

C. Submit to Engineer a drawing showing size and location of existing reinforcing prior to drilling or cutting any existing concrete.
1. Post tensioned wires, tendons, or rods in floor and roof slabs are not to be cut or severed under any circumstances.

2. Reinforcing steel in cast in place concrete floors and walls are to be cut or severed only with permission of the Engineer.

PART 2 – PRODUCTS (Not Used)

PART 3 – EXECUTION (Not Used)

END OF SECTION

SECTION 01 42 13

ABBREVIATIONS AND SYMBOLS

PART 1 - GENERAL

1.1 REQUIREMENTS INCLUDED

A. Words which may be found elsewhere in the Project Manual and Drawings are abbreviated in accordance with the standards set forth in the following table:

A/C	air conditioning
AB	anchor bolt
AC	asphaltic concrete
ACT	acoustical tile
AD	area drain
ADD	addendum
ADD'L	additional
ADH	adhesive
AFF	above finish floor
AGG	aggregate
AL	aluminum
ALLOW	allowable
ALT	alternate
ANOD	anodized
AP	access panel
APPRX	approximate
ARCH	architect(ural)
ASPH	asphalt
AUTO	automatic
AVE	avenue
BD	board
BIT	bituminous
BLDG	building
BLKG	blocking
BM	bench mark, beam(s)
BOT	bottom
BRZ	bronze
BS	both side
CB	catch basin
CEM	cement
CF	cubic foot
CFOI	contractor furnished owner installed
CG	corner guard
CH	ceiling height
CI	cast iron
CJ	control joint
CKBD	chalkboard
CL	centerline
CLG	ceiling
CLR	clear(ance)
CM	construction manager
CMT	ceramic mosaic (tile)
CMU	concrete masonry unit
COL	column
COM	communications
CONC	concrete
CONN	connect(ion)
CONST	construction
CONT	continuous or continue
CONTR	contract(or)
CPT	carpet
CRS	course(s)
CS	countersink
CSMT	casement
CT	ceramic tile
CTR	center
CVG	clear vertical grain
CW	cold water
CWT	ceramic wall tile
CY	cubic yard
D	depth
DEMO	demolish, demolition
DEP	depressed
DF	drinking fountain
DIA	diameter
DIAG	diagonal
DIM	dimension
DISP	dispenser
DIV	division
DL	dead load
DMT	demountable
DN	down
DP	dampproofing
DR	door
DS	downspout
DT	drain tile
DTL	detail
DW	dumbwaiter
DWG	drawing(s)
DWR	drawer
EA	each
EB	expansion bolt

EF	each face
EJ	expansion joint
EL	elevation
ELEC	electric(al)
EMBED	embedment
EMER	emergency
ENCL	enclose(ure)
EP	electrical panel board
EQ	equal
EQUIP	equipment
EST	estimate
EVT	equiviscious temperature
EW	each way
EWC	electric water cooler
EX.EXIT	existing
EXH	exhaust
EXP	exposed
EXT	exterior
FA	fire alarm
FAF	fluid applied flooring
FARF	fluid applied resilient floor
FAS	fasten, fastener
FBD	fiberboard
FBT	finished blowing temperature
FD	floor drain, fire damper
FE	fire extinguisher
FEC	fire extinguisher cabinet
FF	factory finish
FGL	fiberglass
FHMS	flathead machine screw
FHWS	flathead wood screw
FIN	finish(ed)
FLCO	floor cleanout
FLR	floor(ing)
FLUR	fluorescent
FND	foundation
FOC	face of concrete
FOIC	furnished by owner/installed by contractor
FOIO	furnished by owner/installed by owner
FOM	face of masonry
FP	fireproofing, flash point
FPHB	freeze-proof hose bib
FR	fire resistive, fire rated
FRM	frame(d), (ing)
FS	full size
FSS	finished structural slab
FT	foot
FTG	footing
FTS	finished topping slab
GA	gage, gauge
GALV	galvanized
GB	grab bar or gypsum board
GC	general contractor
GI	galvanized iron
GL	glass, glazing
GLS	glass resin wall surfacing
GP	gypsum
HB	hose bib
HBD	hardboard
HC	hollow core
HD	heavy duty
HDR	header
HDW	hardware
HM	hollow metal
HOR	horizontal
HP	high point
HR	hour
HT	height
HTG	heating
HVAC	heating, ventilating, air conditioning
HWD	hardwood
HWH	hot water heater
ID	inside diameter, identification
IN	inch
INCIN	incinerator
INCL	include(d), ion)
INT	interior
INV	invert
JB	junction box
JC	janitor’s closet
JT	joint
KD	kiln dried
KCP	Keene’s cement plaster
KO	knockout
KP	kick plate
LAB	laboratory
LAM	laminate(d)
LAV	lavatory
LBS	pounds
LH	left hand
LL	live load
LONGIT	longitudinal
LP	low point
LW	lightweight
MAX	maximum
MB	machine bolt
M. MECH	mechanic(al)
MFR	manufacture(r)

MH	manhole
Min	minimum, minute
MISC	miscellaneous
MO	masonry opening
MO#	model number
MOD	modular
MPH	miles per hour
MS	machine screw
MTL	metal
MULL	mullion
MWP	membrane waterproofing
NAT	natural, natural finish
NIC	not in contract
NO	number
NOM	nominal
NTS	not to scale
OA	overall
OBS	obscure
OC	on center(s)
OD	outside diameter
OF	overflow
OFCI	owner furnished contractor installed
OFOI	owner furnished owner installed
OHMS	ovalhead machine screw
OHWS	ovalhead wood screw
OPG	opening
OPP	opposite
OZ	ounce(s)
P	paint(ed)
PB	push button
PCF	pounds per cubic foot
PCP	putting coat plaster
PERF	perforate(d)
PL	plate, property line
PLAM	plastic laminate
PLAS	plaster
PNL	panel
PP	push plate
PR	pair
PREP	prepare
PSF	pounds per square foot
PSI	pounds per square inch
PT	point, pressure treated
PTN	partition
PVC	polyvinyl chloride
PWD	plywood
QT	quarry tile
R	rise
RA	return air
RAD	radius
RCP	reflected ceiling plan
RD	roof drain
REF	reference
REFR	refrigerator
REINF	reinforce(ing)
REQ	required
RET'G	retaining
REV	revision(s), revised
RH	right had
RM	room
RO	rough opening
RSF	resilient sheet flooring
SC	solid core
SCHED	schedule
SEC	section
SF	square feet (foot)
SHT	sheet
SHTHG	sheathing
SIM	similar
SL	sleeve
SOG	slab on grade
SPEC	specification(s)
SQ	square
SS	storm sewer
S4S	finished 4 sides
SD	storm drain
ST	steel, street
ST ST	stainless steel
STD	standard
STR	structural
SUPP	supplement
SUPT	support
SUSP	suspended
SV	sheet vinyl
T	tread
TBM	top bench mark
T&G	tongue and groove
TB	towel bar
TC	top of curb
TEL	telephone
TEMP	tempered
THK	thickness
TKBD	tackboard
TO	top of
TP	top of paving
TRANS	transverse
TS	top of slab
TV	television
TW	top of wall
TYP	typical
UNO	unless noted otherwise

VAT	vinyl asbestos tile	W/O	without
VB	vapor barrier	WC	water closet
VCT	Vinyl Composition Tile	WD	wood, wood finish
VERT	vertical	WP	waterproof(ing)
VG	vertical grain	WNS	wainscot
VIF	verify in field	WR	water resistant
VWC	vinyl wall covering	WS	waterstop
		WW	window wall
W	width, wide, water	WWC	wood wall covering
W/	with	WWF	woven wire fabric

B. Words which may be found elsewhere in the Project Manual and Drawings are abbreviated in accordance with the standards set forth in the following table:

&	and
λ	angle
@	at
ι	diameter, round
"	inches
:	is, shall b
'	feet
ζ	perpendicular
/	per
%	percent
#	pound, number
X	by (as in 2 by 4)

END OF SECTION

SECTION 014216

DEFINITIONS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Words which may be found elsewhere in the Contract Documents are defined in accordance with the standards set forth in the following table:

Approve:

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

As Detailed, As Shown:

Where “as detailed”, “as shown” or words of similar importance are used, it shall be understood that reference to the Drawings accompanying the Specifications is made unless otherwise stated.

As Directed, As Required, As Authorized, As Reviewed, As Accepted:

Where “as directed”, “as required”, “as authorized”, “as reviewed”, “as accepted” or words of similar importance are used, it shall be understood that the direction, requirement, permission, authorization, review, or acceptance of the Architect is intended, unless otherwise stated.

As Indicated:

Where “as indicated” is used it shall be understood that reference to Drawings and/or Specifications is made unless otherwise stated.

Directed, Requested, etc.:

Terms such as "directed," "requested," "authorized," "selected," will be understood as "directed by Architect," "requested by Architect," and similar phrases shall not be interpreted to extend Architect's responsibility into Contractor's responsibility for construction supervision.

Furnish:

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

Indicated:

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

Install:

Except as otherwise defined in greater detail, the term "install" is used to describe operations at 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.

Installer:

The term "installer" is defined as the entity (person or firm) engaged by Contractor, or its subcontractor or sub-subcontractor for performance of a particular unit of Work at project site, including installation, erection, application and similar required operations. It is a general requirement that such entities (Installers) be expert in operations they are engaged to perform.

Provide:

Except as otherwise defined in greater detail, term "provide" means furnish and install, complete and ready for intended use, as applicable in each instance.

PART 2 – PRODUCTS (Not Used)

PART 3 – EXECUTION (Not Used)

END OF SECTION

SECTION 014219

REFERENCE STANDARDS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Quality Assurance.

B. Location of References.

C. Schedule of References.

1.2 QUALITY ASSURANCE

A. For products or quality of work specified by association, trade, or federal standards, comply with requirements of the standard, except when more rigid requirements are specified or are required by applicable codes.

B. Conform to reference standard by date of issue current on date of Contract Documents.

C. General Applicability of Standards: Except where Contract Documents include more stringent requirements, applicable standards of the construction industry have the same force and effect as if bound or copied directly into Contract Documents.

D. Such standards are made a part of the Contract Documents by reference.

E. Individual sections indicate which codes and standards the Contractor must keep at the project site, available for reference.

F. Referenced industry standards take precedence over standards which are not referenced but recognized in industry as applicable.

G. Non-referenced standards are not directly applicable to the Work, except as a general requirement of whether the Work complies with standards recognized in the construction industry.

1.3 LOCATION OF REFERENCES

A. Valley Library, Oregon State University.

1.4 SCHEDULE OF REFERENCED ASSOCIATIONS

AIA	American Institute of Architects WWW.AIA.ORG
AISC	American Institute of Steel Construction WWW.AISC.ORG
AISI	American Iron and Steel Institute WWW.STEEL.ORG
ANSI	American National Standards Institute

WWW.ANSI.ORG

APA	American Plywood Association WWW.APAWOOD.ORG
ASHRAE	American Society of Heating, Refrigerating, and Air Conditioning Engineers WWW.ASHRAE.ORG
ASTM	American Society for Testing and Materials WWW.ASTM.ORG
AWPA	American Wood Protection Association WWW.AWPA.COM
AWS	American Welding Society WWW.AWS.ORG
BIA	Masonry Institute of America WWW.MASONRYINSTITUTE.ORG
BOLI	Oregon Bureau of Labor and Industries WWW.BOLI.STATE.OR.US
CCB	Construction Contractors Board WWW.OREGON.GOV.CCB/
CDA	Copper Development Association WWW.COPPER.ORG
CISPI	Cast Iron Soil Pipe Institute WWW.CISPI.ORG
CSI	Construction Specification Institute WWW.CSINET.ORG
DEQ	Department of Environmental Quality (Oregon) WWW.OREGON.GOV/DEQ/
DHI	Door and Hardware Institute WWW.DHI.ORG
DOT	Department of Transportation WWW.DOT.GOV
EPA	U.S. Environmental Protection Agency WWW.EPA.GOV
FM	Factory Mutual System WWW.FMGLOBAL.COM
FS	Federal Specification General Services Administration Specifications and Consumer Information Distribution Section (WFSIS) WWW.GSA.GOV/PORTAL/CONTENT/103856
IBC	International Building Code

	WWW.ICCSAFE.ORG
ICBO	International Conference of Building Officials PUBLICECODES.CITATION.COM/ICOD/IBG/INDEX.HTM
IRS	Internal Revenue Service WWW.IRS.GOV
ISA	Instrumentation Systems and Automation Society WWW.ISA.ORG
NAAMM	National Association of Architectural Metal Manufacturers WWW.NAAMM.ORG
NBFU	National Board of Fire Underwriters WWW.NFPA.ORG
NEC	National Electric Code WWW.NECPLUS.ORG
NEMA	National Electrical Manufacturers' Association WWW.NEMA.ORG
NESC	National Electrical Safety Code WWW.IEEE.ORG
NFPA	National Fire Protection Association WWW.NFPA.ORG
NRCA	National Roofing Contractors' Association WWW.NRCA.NET
OAR	Oregon Administrative Rules ARCWEB.SOS.STATE.OR.US/404.HTML
OESP	State of Oregon Electrical Specialty Code http://www.bcd.oregon.gov/programs/online_codes.html
ORS	Oregon Revised Statutes LANDRU.LEG.STATE.OR.US/ORS/
OSHA	Occupational Safety and Health Administration WWW.OSHA.GOV
OSSC	Oregon Structural Specialty Code http://www.bcd.oregon.gov/programs/online_codes.html
PS	Product Standard STANDARDS.GOV/STANDARDS.CFM
SDI	Steel Door Institute WWW.STEELDOOR.ORG
SMACNA	Sheet Metal and Air Conditioning Contractors' National Association WWW.SMACNA.ORG

SPRI	Single Ply Roofing Institute WWW.SPRI.ORG
SSPC	Steel Structures Painting Council WWW.SSPC.ORG
SWRI	Sealing, Waterproofing and Restoration Institute WWW.SWIRONLINE.ORG
UBC	Uniform Building Code (See ICBO)
UFC	Uniform Fire Code WWW.NFPA.ORG
UL	Underwriters' Laboratories, Inc. WWW.UL.COM
UMC	Uniform Mechanical Code WWW.UBC.COM
UPC	Uniform Plumbing Code WWW.UBC.COM
WHL	Warnock Hersey Laboratories WWW.INTEK.COM/MARKS/WH/
WCLIB	West Coast Lumber Inspection Bureau WWW.WCLIB.ORG
WWPA	Western Wood Products Association WWW.WWPA.ORG

PART 2 – PRODUCTS (Not Used)

PART 3 – EXECUTION (Not Used)

END OF SECTION

SECTION 014500

QUALITY CONTROL

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Codes, regulations and permits.

B. Procedures for quality control.

1.2 OWNER RESPONSIBILITIES

A. Owner will employ and pay for services of an independent testing laboratory to perform inspection, sampling and testing as required by local building authority.

B. Owner's Authorized Representative will provide on-site observation during construction.

1.3 CODES, REGULATIONS AND PERMITS

A. All Work shall conform with the Oregon Structural Specialty Code (OSSC) based on the International Building Code (IBC), as amended by the State of Oregon Building Codes Division and the edition designated by the governing authority.

B. Contractor shall comply with all applicable state and local construction codes.

C. References to codes, Specifications and standards referred to in the Contract Documents shall mean, and are intended to be, the latest edition, amendment or revision of such reference standard in effect as of the date of these Contract Documents.

D. The Owner shall be responsible for all permits and City of Corvallis plan review fees; the Contractor shall be responsible for all licenses and associated fees required for the Project.

E. Contractor shall arrange and attend all required permit inspections and furnish evidence of approved City inspection reports per Section 01 77 00.

1.4 QUALITY OF WORK

A. It is the true and specific intent of these Specifications that quality of Work on all phases of the construction and embracing all the trade sections shall be of high quality performed by workers skilled in their trade and performing their Work only according to the standard of best practice of the trade.

B. All manufactured articles, materials, and equipment shall be applied, installed, connected, erected, used, cleaned and conditioned in accordance with manufacturer's directions unless otherwise specified.

C. If Work is required in a manner to make it impossible to produce first quality Work, or should discrepancies appear among Contract Documents, request interpretation from Architect before proceeding with Work.

D. Failure to secure interpretation may cause rejection by Architect or owner of installation.

1.5 LAYOUT

A. Be responsible for properly laying out the Work and for lines and measurements for the Work.

B. Verify the figures shown on the drawings before laying out the Work and report errors or inaccuracies to the Architect before commencing Work.

C. Strict compliance with maximum slopes is required. Accessible parking spaces and adjacent access aisles with slope exceeding 2% in any direction, as determined by OSU, shall be removed and replaced by the contractor at their expense.

D. Strict compliance with maximum slopes is required. New sidewalks exceeding 1:20 slope or with cross slope exceeding 2%, as determined by OSU, shall be removed and replaced by the contractor at their expense. Ramps exceeding 1:16 slope or with cross slope exceeding 2%, as determined by OSU, shall be removed and replaced by the contractor at their expense.

1.6 SUPERVISION

A. The Contractor shall maintain effective supervision on the project at all times Work is being performed.

B. The superintendent shall be the same person throughout the project and shall attend the preconstruction conference.

1.7 INSPECTIONS AND TESTING

A. Contractor shall notify the Owner at least twenty-four (24) hours in advance of any required progress inspection or final inspection including final punch list inspection.

B. Cooperate with laboratory personnel, provide access to Work and furnish incidental equipment material and labor required for field testing and sample taking.

1.8 EVALUATION OF TESTS AND INSPECTIONS

A. Results of laboratory and/or field control tests and inspections shall be the principal basis upon which satisfactory completion of Work shall be judged.

B. If results of tests and inspections indicate Work is below requirements of Contract Documents, that portion of Work is subject to rejection.

1.9 ADJUSTMENTS

A. Remove and replace Work so rejected at Contractor’s expense including costs of subsequent tests and inspections until Work meets requirements of Contract Documents.

B. The Owner reserves the right to perform any testing as may be required to determine compliance with the Contract Documents.

C. Costs for such testing will be the Owner’s responsibility unless testing indicates noncompliance. Cost for such testing indicating noncompliance shall be borne by the Contractor.

D. Noncomplying Work shall be corrected and testing will be repeated until the Work

complies with the Contract Documents.

E. Contractor will pay costs for retesting noncomplying Work.

PART 2 – PRODUCTS (Not Used)

PART 3 – EXECUTION (Not Used)

END OF SECTION

SECTION 015100

CONSTRUCTION FACILITIES AND TEMPORARY CONTROLS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. This Section specifies requirements for temporary services and facilities, including utilities, construction and support facilities, security and protection.

1.2 REQUIREMENTS OF REGULATORY AGENCIES

A. Regulations: Comply with industry standards and applicable laws and regulations of authorities having jurisdiction.

B. Standards: Comply with NFPA Code 241, "Building Construction and Demolition Operations", ANSI-A10 Series standards for "Safety Requirements for Construction and Demolition".

C. Electrical Service: Comply with NEMA, NEC and UL standards and regulations for temporary electric service; install service in compliance with National Electric Code (NFPA 70).

D. Inspections: Arrange for authorities having jurisdiction to inspect and test each temporary utility before use; obtain required certifications and permits if required.

1.3 PROTECTION

A. Protect sidewalks, asphalt paving, concrete, trees, shrubs, and lawn areas at all times from damage resulting from construction activities.

B. Protect Existing Air Handling Systems:
   1. Contractor shall be responsible for protection of the cleanliness of the existing air handling system at all times. This protection shall include:
      a. During site work or building demolition, prefilters shall be provided and maintained on all building outside air intakes at all times throughout the construction duration.
      b. During any interior work that may create dust in the interior space and adjacent corridor/hallways, air filters shall be provided and maintained on all affected air return and exhaust grilles. Where air flow in or out of the space is not required, all air duct openings shall be temporarily blanked off with plywood or sheet metal.
      c. Prior to starting any work, the Contractor shall record and submit to the Owner’s Authorized Representative, pressure readings across all existing air handler air filter banks before installation of new prefilters.
      d. Upon completion of all Work affecting existing air handling systems, the Contractor shall remove all temporary filters, covers and associated parts and restore the system to its original operating condition unless otherwise stated elsewhere in the Contract Documents

C. Clean, repair, resurface, or restore existing surfaces to their original, or better, condition, or completely replace such surfaces to match existing, where damaged by construction operations.

D. Security is the responsibility of the Contractor.

E. Construction Debris:
   1. Debris shall not be allowed to remain around the buildings during performance of Work, but shall be disposed of as rapidly as it accumulates.

2. On completion of Work, the buildings and grounds shall be left in a condition that is equal to or better than original condition.
3. In case of failure to do so, the Owner may remove rubbish and charge the cost to the Contractor.

F. The Contractor shall manage a safe job environment for both the safety of all the people around the Work site as well as the safety of the Owner's and general public's property.

G. The Contractor shall provide and maintain suitable barricades, shelters, lights, and danger signals during the progress of the Work; they shall meet the requirements of the local building code and OSHA.

1.4 DRAINAGE

A. Verify that all rain drains in the construction areas are in working order and notify the Owner’s Authorized Representative in writing of any rain drains that are plugged, prior to the start of the Work.

B. Start of Work will be considered as acknowledgment that all drains are clear and in good working order.

C. All drains shall be left in a clean and proper working condition.

1.5 CONSTRUCTION PROJECT SAFETY FORM

A. Contractor shall submit to the Owner, prior to signing the Contract, the completed "Construction Project Safety Form", which is provided with instructions at the end of this Section.

1.6 TEMPORARY UTILITIES

A. Temporary Utilities:
1. Prepare a schedule indicating dates for implementation and termination of each temporary utility.
2. At the earliest feasible time, when acceptable to the Owner, change over from use of temporary service to use of the permanent service.

B. Conditions of Use:
1. Keep temporary services and facilities clean and neat in appearance.
2. Operate in a safe and efficient manner.
3. Take necessary fire prevention measures.
4. Do not overload facilities or permit them to interfere with progress.
5. Do not allow hazardous, dangerous or unsanitary conditions, or public nuisances to develop or persist on the site.

C. Electrical Service:
1. Service limited to 20 amp 120V circuits will be paid for by the Owner.
2. Connection to the service shall be the responsibility of the Contractor, with the Owner's approval.
3. Coordinate with the Owner's Authorized Representative.

D. Water Service:
1. Service in reasonable quantities for the Project will be paid for by the Owner.
2. Connection to the service shall be the responsibility of the Contractor, with the Owner's approval.
3. Coordinate with the Owner's Authorized Representative.

1.7 TEMPORARY SUPPORT FACILITIES

A. Temporary Sanitary Facilities:

1. Provide and maintain an adequate number of facilities for the use of all persons employed on the Work during construction.
2. Provide enclosed, weatherproof facilities with heat as required.
3. Use of new or existing Owner's facilities will not be permitted.

B. Temporary Heat and Ventilation:
1. As necessary, provide temporary heat and ventilation required by construction activities, for curing or drying of completed installations or protection of installed construction from adverse effects of low temperatures or high humidity. Select safe equipment that will not have a harmful effect on completed installations or elements being installed. Coordinate ventilation requirements to produce the ambient condition required and minimize consumption of energy.

C. Telephone Equipment: Provide telephone communications at project site.

D. Existing Services:
1. Do not interrupt any existing service.
2. Prior request and approval of the Owner's Representative will enable the Owner to shut down any utility required by the Work.
3. Contractor shall not shut down utilities.

1.8 TEMPORARY BARRIERS AND ENCLOSURES

A. Provide barriers and fencing to prevent unauthorized entry to construction areas and to protect existing facilities and adjacent properties from damage.

B. Provide Commercial grade chain link fence construction.

C. Provide 6 foot high fence around construction site as directed by Owner’s Authorized Representative; equip with vehicular and pedestrian gates with lock.

D. Exterior Closures: Provide temporary secured, weather-tight closures at exterior openings, to permit acceptable working conditions and protection of the Work.

E. Interior Closures:
1. Provide temporary floor to ceiling partitions (not plastic sheeting) and ceilings as required to separate work areas from Owner occupied areas, to prevent penetration of dust and moisture into Owner occupied areas, to reduce construction noise, and to prevent damage to existing materials and equipment.
2. Paint surfaces exposed to view from Owner occupied areas.

1.9 ODORS

A. Work that causes excessive odors shall be performed only after coordination with the Owner’s Authorized Representative. Filtering of air intakes to units may be required to prevent odors and vapors from entering the buildings.

B. Contractor shall provide 7 days advance notice to the Owner’s Authorized Representative in order for advance notice to be forwarded to building occupants. Work stoppage may occur if advance notification has not been coordinated or odors and vapors from the work are found to generate complaints from building occupants.

1.10 FIRE SAFETY

A. Ensure that required exit routes remain unobstructed while building is occupied.

B. Abide by all fire safety requirements for buildings under construction, alteration or demolition as required by Article 87, of the Uniform Fire Code as adopted by the State of Oregon.

C. An emergency telephone shall be provided on site. Cellular telephone equipment is acceptable.

D. Fire Suppression Equipment:
1. Install and maintain temporary fire protection facilities of the types needed to protect against reasonably predictable and controllable fire losses. Comply with NFPA 10 "Standard for Portable Fire Extinguishers", and NFPA 241 "Standard for Safeguarding Construction, Alterations and Demolition Operations".
2. Maintain equipment in working condition with current inspection certificate attached to each.
3. Locate fire extinguishers where convenient and effective for their intended purpose, but not less than one extinguisher on each floor at or near each usable stairwell.
4. Store combustible materials in containers in fire-safe locations.
5. Maintain unobstructed access to fire extinguishers, fire hydrants, temporary fire protection facilities, stairways, and other access routes for fighting fires.
6. Provide continual supervision of welding operations, combustion type temporary heating units, and similar sources of fire ignition.
7. When possible, relocate hot work to a designated hot work area.
8. If the materials or equipment cannot be relocated to a designated hot work area, use the least hazardous form of hot work that will get the job done and prepare the area properly.
9. Manage mobile hot work using the formal hot work permit system. (mentioned in the next bullet point and also a directive in the OSU Hot Work Safety Program)
10. Make sure both fire protection and hot work equipment work properly.
11. Train all personnel involved in hot work operations and activities so that they have the understanding, knowledge, and skills necessary to safely perform their jobs.

1.11 CONSTRUCTION AIDS

A. Scaffolding: comply with applicable OSHA requirements.

B. Material Handling Equipment:
1. Provide necessary cranes, hoists, towers, or other lifting devices.
2. Use only experienced operators.
3. Remove equipment as soon as possible after task is ended.
4. Coordinate placement of such equipment with Owner’s Authorized Representative.
5. Obtain required permits and meet requirement of governing authorities regarding applicable regulations.

C. Materials or debris shall not be allowed to free fall from building.

D. The use of chutes or conveyors must be approved by Owner.

1.12 TEMPORARY CONTROLS

A. Water Control:
1. Maintain excavations free of water.
2. Provide, operate, and maintain necessary pumping equipment.

B. Protection:
1. Protect installed Work and provide special protection where specified in individual specification sections.
2. Prohibit traffic or storage upon waterproofed or roofed surfaces.

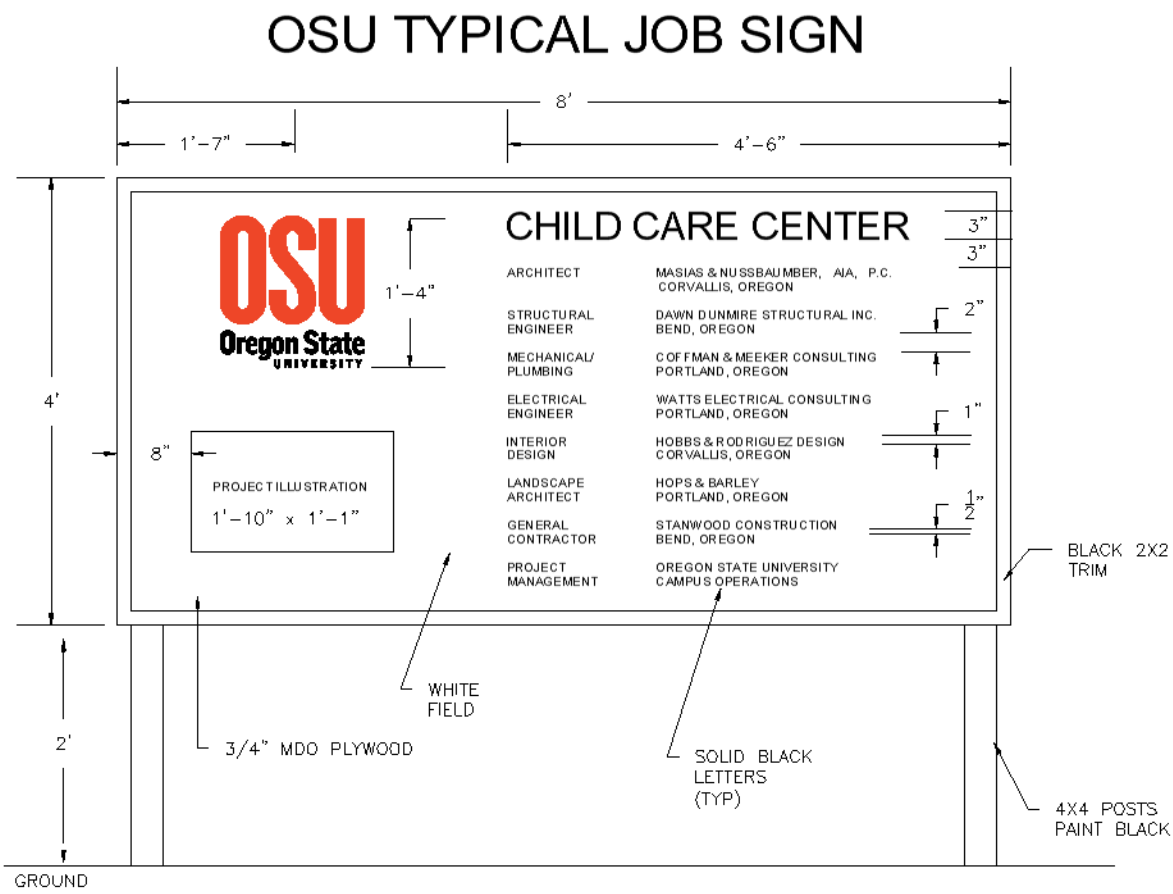
C. Security:
1. Provide security and facilities to protect Work and existing facilities and Owner’s operations from unauthorized entry, vandalism, or theft.
2. Coordinate operations with Owner’s Authorized Representative.

D. Temporary Traffic Control /Pedestrian Accessibility

1. A continuous route for all pedestrians, including persons with disabilities and bicyclists, shall be maintained at all times. When existing pedestrian facilities are disrupted, closed, or relocated in a construction zone, temporary pedestrian facilities shall be provided.
2. Temporary pedestrian facilities should be safe and accessible. There should be no curbs or abrupt changes in grade that could cause tripping or be a barrier to wheelchair use.
3. Signage shall be provided directing people to the temporary accessible route. The signage shall include the International Symbol of Accessibility.
4. Contractors shall not block temporary walkways with vehicles, equipment, construction materials, signs, trash, or other objects that might prohibit pedestrian passage.
5. Construction equipment and equipment operation must be separated from any open walkways. At construction zones, pedestrian fences or other protective barriers shall be provided to prevent access into the construction zone.

1.13 PROJECT SIGNAGE

A. Contractor is permitted to post only one project identification sign based on the following example:



1.14 PREPARATION

A. Consult with Owner to review jobsite areas required for field offices, material storage and stockpiles, equipment storage, access to different locations, etc.

1.15 PERFORMANCE

A. Confine equipment, apparatus, and storage of material to work limits. The Owner will not be responsible for protection of materials and equipment from damage, pilfering, etc.

B. Install temporary facilities in such a manner that the installed work will not be damaged.

C. Do not use facilities of existing building unless authorized in writing by the Owner.

D. Effective September 1, 2012, OSU became a non-smoking campus and smoking is prohibited on all Campus property.

E. Keep facilities well maintained.

F. Relocate temporary facilities as required during job progress.

G. At Substantial Completion, clean and renovate permanent facilities that have been used during the construction period, including but not limited to:
   1. Replace air filters and clean inside of ductwork and housings.
   2. Replace significantly worn parts and parts that have been subject to unusual operating conditions.
   3. Replace lamps that are burned out or noticeably dimmed by substantial hours of use.

PART 2 – PRODUCTS (Not Used)

PART 3 – EXECUTION (Not Used)

END OF SECTION

Oregon State University Construction and Maintenance Safety Requirements
EH&S, 100 Oak Creek Building, Corvallis, OR 97331-7405, (541) 737-2273,
FAX (541) 737-9090

Complete OSU Construction and Maintenance Safety Form - Send completed documents (including Site Safety Plan and all separate answer pages) to Construction Contract Administration along with the signed contract and bonds.

Project Isolation - All construction and remodeling activities regardless of size and/or scope must be fenced, barricaded, or otherwise protected to restrict entrance and to ensure the safety of those in the general area. See isolation requirements.

Site Safety Plan - A site safety plan will be required and will address:

- General Information
- Emergency Information
- Key Organization Personnel
- Hazard Evaluation/Facility Impact
- Emergency Procedures
- Work Zones
- Security Measures
- Fire Protection

A model plan is attached. This form can be used if another plan has not already been prepared. Contact OSU Environmental Health & Safety for more information 737-2505.

Isolation Requirements

General: All construction, maintenance, and remodeling activities, regardless of size or scope, must be fenced, barricaded, or otherwise isolated to restrict entrance and to ensure the safety of those in the general area.

Outdoor Activities: Outdoor projects require the following perimeter isolation:

- A six foot chain-link fence, with controlled access points, extending in all directions around the excavation or building site such that no area of the construction is accessible to pedestrians or unauthorized personnel or vehicles.
- Isolation area will include vehicle loading and unloading areas.
- At the University's option, other barricading plans may be accepted. These may apply to projects such as road resurfacing, parking lot striping, exterior building water proofing, deliveries, etc. Contact EH&S regarding other barricading plans.

Overnight: Any excavation across or adjacent to sidewalks or pathways which must be left open overnight, must be identified with working, blinking construction lights in addition to solid barricades

Indoor Activities: Indoor construction or maintenance projects which will create dust, potentially hazardous fumes or vapors, or offensive odors are subject to the following isolation:

- Areas where existing doors can provide isolation will be labeled "Construction Area--Authorized Personnel Only ".
- All other areas will be isolated by a solid barrier. The minimum barrier allowed is 4 mil poly sheeting sealed to prevent migration of dust.
- Mechanical ventilation may be required.
- A solid wall is required if building envelope is opened to the outside.

Contractor Responsibilities

- The contractor will provide all barricading, isolation, and fencing material. OSU will not provide any materials.
- The contractor will also provide all appropriate warning and detour signs when sidewalks, exits, or roads are closed.
- Contractor will provide all other construction area signs.

OSU Construction and Maintenance Safety Form

Send completed safety documents to Construction Contract Administration with contract and bonds.

Date: _____ Project: _____

Start Date: _____ Completion date: _____

Contractor:_____ Contact: _____

Work # _____ 24 hr #: _____

OSU Project Mgr: _____ Work / 24hr #'s: _____

Dept Contact: _____ OSU EH&S Contact: _____

Preconstruction meeting? **Y N** Date/Time/Location: _____

For the following items, prepare answers on a separate sheet for all items marked "Yes". Precede each answer with the appropriate item number. All boxes need to be checked

Y	N	For This Project	If YES, then:
		1 Will any confined spaces be accessed?	Describe location of entry Specify location of permit Notify EH&S prior to entry See SAF 209
		2 Will hot work be performed (welding, cutting, brazing, etc.)?	Provide min. 5# 2A10BC extinguisher within 10 ft If indoors - provide and describe ventilation See SAF 214
		3 Any products brought to campus?	Provide MSDS on site prior to first use; Make available to OSU on request
		4 Will lead paint be impacted?	Describe plan to limit contamination
		5 Will asbestos-containing-material be impacted?	Coordinate with OSU asbestos manager
		6 Will <u>any</u> materials (construction debris, soil, water, etc) be removed from campus?	Describe in detail identity and disposition of material (how, where)
		7 Any open trenches or holes?	Describe isolation procedures (see Page 1)
		8 Will a crane be used?	Describe crane safety plan (include plan to prevent loads above occupied areas)
		9 Is this project building a new facility, a major remodel?	Provide Site Safety plan Describe isolation procedures (see Page 1)
		10 Is this a minor remodeling project?	Provide, or fill out model Site Safety Plan form (see Page 3) Describe isolation procedures (see Page 1)
		11 Will air contamination be produced (e.g. dust, CO, solvent vapors, VOCs, odors)?	Describe project ventilation and isolation Indicate position of building air intake(s)
		12 Will there be noise > 85 dB?	Describe noise minimization plan
		13 Will this project use a scaffold or an external chute?	Describe isolation, dust control, installation
		14 Will this project involve a working surface >6' above a lower level	Describe fall protection
		15 Will any "blind" saw-cuts or penetrations be made in existing foundations, floors, ceilings and/or walls?	Describe plan for detecting and protecting power lines or other building utility lines.

<u>EH&S Review:</u> _____ Date: _____

Model Site Safety Plan

1. General Information

Contractor name_____
Address_____
City, State, Zip_____
Site Safety Officer_____ Project Dates_____
Project Name

_____

2. Emergency Information

Emergency Response	911	OSU EH&S and OSU Facilities Services must be notified in the event of an emergency
Hazardous Materials Spill		
MSDS on-site location		
OSU EH&S	(541) 737-2273	
Facilities Services	(541) 737-2969	

3. Contractor Key Personnel

	Name	Phone	Emergency Contact
Company Owner			
Project Manager			
Job Supervisor			
Site Safety Officer			
Other Responsible Individual			
24 Hour Notification			

List of employees on site _____

_____

_____

4. Hazard Evaluation/ Facility Impact	
Physical	**Yes / No**
Heavy Equipment	
Noise	
Heat	
Elevation	
Radiation Materials	
Excavations	
Underground Utilities	
Confined Spaces	
Fire Prevention	
Electrical	

5. Emergencies
Services
Evacuation Route
First Aid Location
Hazardous Materials Spill Procedure

6. Work Zones

Material Storage_____
Parking locations_____
Individuals with OSU keys_____
Access issues_____

7. Security measures_____

_____

_____

8. Fire protection _____

SECTION 016000

PRODUCT REQUIREMENTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Summary:
1. Product options.
2. Owner-furnished products.
3. Product delivery, storage and handling.

1.2 PRODUCTS

A. Products:
1. New material, machinery, components, equipment, fixtures, and systems forming the Work, but does not include machinery and equipment used for preparation, fabrication, conveying and erection of the Work.
2. Products may also include existing materials or components specifically identified for reuse.

B. Use interchangeable components of the same manufacture for similar components.

C. Unless otherwise specified, all material and equipment shall be new; free from defects impairing strength, durability, and appearance; of current manufacture.

D. Items specified shall be considered minimum as to quality, function, capacity, and suitability for application intended.

E. Items incorporated into the Work shall conform to applicable specifications and standards designated, and shall be of size, make, type, and quality specified.

F. Design, fabricate, and assemble in accordance with current best engineering, industry, and shop practices.

G. Manufacture like parts of duplicate units to standard size and gauge to make them interchangeable.

H. Two or more items of the same kind shall be identical and made by the same manufacturer.

1.3 PRODUCT OPTIONS

A. Products Specified by Reference Standards or by Description Only: Any product meeting those standards or description.

B. Products Specified by Naming One or More Manufacturers with a Provision for Substitutions: Submit a request for substitution for any manufacturer not named.

C. Products Specified by Naming One or More Manufacturers: Products of manufacturers named and meeting specifications, no options or substitutions allowed.

D. Substitution Procedure: Under Section 01 25 00.

1.4 REUSE OF EXISTING PRODUCTS

A. Except as specifically indicated or specified, materials and equipment removed from existing construction shall not be used in the completed Work.

B. For material and equipment specifically indicated or specified to be reused in the Work:

1. Use care in removal, handling, storage, and reinstallation to assure proper function in the completed Work.
2. Arrange for transportation, storage, and handling of products which require off-site storage, restoration, or renovation.
3. Remove and reinstall mechanical units, vents, guys, antennae, and electrical and grounding wires or conduits.

1.5 OWNER FURNISHED PRODUCTS

A. Designate delivery dates of Owner-furnished items in the construction schedule.

B. Receive, unload, store and handle Owner-furnished items at the site; protect from damage.

1.6 DELIVERY, STORAGE AND HANDLING

A. Transport, handle, store and protect products in accordance with manufacturer's instructions.

B. Arrange deliveries in accordance with construction schedules; coordinate to avoid conflict with Work and site conditions.

C. Deliver and store products in undamaged condition in manufacturer's original containers or packaging with identifying labels intact and legible.

D. Inspect shipments to assure compliance with Contract Documents and reviewed submittals, and that products are undamaged.

E. Prevent soiling or damage to products or packaging.

F. Interior Storage: Maintain required temperature and humidity ranges. Verify that Owner furnished storage meets product manufacturer's requirements.

G. Exterior Storage:
1. Store materials above ground to prevent soiling and/or moisture infiltration.
2. Cover materials with waterproof breathable sheet coverings; provide adequate ventilation.
3. All storage locations to be approved in advance by the Owner.

H. Arrange storage to provide access for inspection.

I. Coordinate with Owner’s Authorized Representative all on-site storage activities.

J. Provide for security of stored products.

PART 2 – PRODUCTS (Not Used)

PART 3 – EXECUTION (Not Used)

END OF SECTION

SECTION 017329

CUTTING AND PATCHING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Requirements and limitations for cutting and patching of Work.

1.2 RELATED SECTIONS

A. Section 01 25 00, Product Substitution Procedures.

B. Section 01 33 23, Shop Drawings, Product Data, Samples

1.3 SUBMITTALS

A. Submit written request in advance of cutting or alteration which affects:
   1. Structural integrity of any element of the Work.
   2. Efficiency, maintenance, or safety of any operational element.
   3. Visual qualities of sight exposed elements.
   4. Work of Owner or separate contractor.

B. Include in request:
   1. Identification of project.
   2. Location and description of affected work.
   3. Necessity for cutting or alteration.
   4. Description of proposed work, and products to be used.
   5. Alternatives to cutting and patching.
   6. Effect on work of Owner or separate contractor.
   7. Written permission of affected separate contractor.
   8. Date and time work will be executed.

PART 2 PRODUCTS

2.1 MATERIALS

A. Primary Products: Those required for original installation.

B. Product Substitution: For any proposed change in materials, submit request for substitution under provisions of Section 01 25 00.

PART 3 EXECUTION

3.1 EXAMINATION

A. Inspect existing conditions prior to commencing Work, including elements subject to damage or movement during cutting and patching.

B. After uncovering existing work, inspect conditions affecting performance of Work.

C. Beginning of cutting or patching means acceptance of existing conditions.

3.2 PREPARATION

A. Provide temporary supports to ensure structural integrity of the Work.

B. Provide devices and methods to protect other portions of the Work from damage.

C. Provide protection from elements for areas which may be exposed by uncovering work.

3.3 CUTTING AND PATCHING

A. Execute cutting, fitting and patching to complete work.

B. Fit products together, to integrate with other work.

C. Remove and replace defective or non-conforming work.

D. Provide openings in the work for penetration of mechanical and electrical work.

3.4 PERFORMANCE

A. Execute work by methods to avoid damage to other Work, and which will provide appropriate surfaces to receive patching and finishing.

B. Cut rigid materials using masonry saw or core drill. Pneumatic tools are not allowed without prior approval from Owner's Authorized Representative.

C. Restore work with new products in accordance with requirements of Contract Documents.

D. At penetrations of fire rated walls, partitions, ceiling or floor construction, completely seal voids with approved fire rated material, to full thickness of the penetrated element.

E. Refinishing:
1. Refinish surfaces to match adjacent finish.
2. For continuous surfaces, refinish to nearest intersection or natural break.
3. For an assembly, refinish entire unit.

END OF SECTION

SECTION 017400

CLEANING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Related requirements specified elsewhere, cleaning for specific products or work: Specification section for that work.

B. Maintain premises and public properties free from accumulations of waste, debris, and rubbish, caused by operations.

C. At completion of Work remove waste materials, rubbish, tools, equipment, machinery and surplus materials, and clean all sight-exposed surfaces; leave project clean and ready for occupancy.

1.2 QUALITY ASSURANCE

A. Standards: Maintain project in accord with applicable safety and insurance standards.

B. Hazard Control:
1. Store volatile wastes in covered metal containers.
2. Provide adequate ventilation during use of volatile or noxious substances.

1.3 MATERIALS

A. Use only cleaning materials recommended by manufacturer of surface to be cleaned.

B. Use cleaning materials only on surfaces recommended by cleaning material manufacturer.

1.4 DURING CONSTRUCTION

A. Wet down dry materials and rubbish to lay dust and prevent blowing dust.

B. At reasonable intervals during progress of Work clean site and public properties, and dispose of waste materials, debris and rubbish.

C. Provide on-site containers for collection of waste materials, debris and rubbish.

D. Remove waste materials, debris and rubbish from site and legally dispose of at public or private dumping areas off Owner's property.

E. Vacuum clean interior building areas when ready to receive finish painting, and continue vacuum cleaning on an as-needed basis until project is ready for Substantial Completion or occupancy.

F. Handle materials in a controlled manner with as few handlings as possible; do not drop or throw materials from heights.

1.5 FINAL CLEANING

A. Employ experienced workers, or professional cleaners, for final cleaning.

B. In preparation for Substantial Completion or occupancy, conduct final inspection of sight-exposed interior and exterior surfaces, and of concealed spaces.

C. Remove grease, dust, dirt, stains, labels, and other foreign materials from exposed interior and exterior finished surfaces.

D. Remove putty, paint, labels, lubricants, etc., from windows, mirrors, and sash, and then polish, taking care not to scratch glass.

E. Vacuum carpeting (shampoo where required), removing debris and excess nap.

F. Repair, patch and touch up marred surfaces to specified finish, to match adjacent surfaces.

G. Replace air filters where units were operated during construction.

H. Maintain cleaning until project, or portion thereof, is occupied by Owner.

PART 2 – PRODUCTS (Not Used)

PART 3 – EXECUTION (Not Used)

END OF SECTION

SECTION 017700

CONTRACT CLOSEOUT

PART 1 - GENERAL

1.1 DESCRIPTION

A. The requirements specified in this section relate to all Contractors individually performing under these Contract Documents:
   1. Project Record Documents.
   2. Final review and payment.

B. Related work specified elsewhere:
   1. OSU General Conditions.
   2. Shop Drawings, Product Data and Samples, Section 01 33 23.

1.2 PROJECT RECORD DOCUMENTS

A. The Project Record Documents shall be organized to include the following information, as applicable:
   1. Table of Contents
   2. Project Team List
   3. Specifications (Including Addenda and Change Orders)
   4. Drawings
   5. Inspection Reports
   6. Signed Warranty(ies)
   7. Maintenance Instructions

B. Draft Project Record Documents shall be submitted for review upon 75% completion of the Work.

C. Project Record Documents shall be submitted electronically to the Owner. Hard copies will not be accepted.

D. The project team list shall include the name, address, and phone number of the Owner, Contractor, Inspector, Subcontractors, and the materials manufacturers.

E. Legibly mark each Specification section to indicate actual as-built condition indicating changes in the Work made by addenda or change order or actual materials used and actual manufacturer(s) used.

F. Maintain current and accurate as-built mark-ups during construction and make available to Owner’s Authorized Representative upon request.

G. Legibly mark the drawings to indicate actual as-built conditions indicating changes in the Work made by addenda or change order or actual conditions which differ from the drawings.

H. Redraw or provide new drawings as required for a complete as-built set of drawings. The Contractor shall maintain current and accurate as-built mark-ups during construction and make available to Owner’s Authorized Representative.

I. Include inspection reports if applicable.

J. Include, in a single section, all copies of the Project’s labor and material warranties clearly marked to identify the Owner's responsibilities under the terms of each warranty and the section of Work that each warranty covers. One set must be clearly marked as containing original documents.

K. In the case of an elevator installation, the Contractor's and manufacturer's warranty shall provide for the Owner's right to respond to emergency/car failure situations for the purpose of extricating individuals trapped in the elevator.

L. Include maintenance instructions complete with technical information and name, address, and phone number of the Contractor(s) and manufacturer(s) of each material and product.

1.3 FINAL REVIEW AND PAYMENT

A. Prior to completion, the Contractor shall inspect the Work and make a Punch-list noting all items that are incomplete and/or incorrect.

B. The Contractor shall notify all Subcontractors in writing of incomplete and/or incorrect items. Notify far enough in advance of the completion date that the Work can be completed on schedule. Said Work shall be immediately corrected.

C. Should conditions prevail which prohibit some elements of the Work from being accomplished, but the work-in-place will perform the primary function (i.e., painting cannot be completed due to high moisture content of masonry walls.) the Contractor shall record the reason with this Punch-list item requesting temporary delay in completion from the Owner in writing.

D. Notify the Owner in writing that all items are completed and ready for final review or else that the Work product is fully usable, but some listed deficiencies remain to be completed. Submit all record documents at this time.

E. The Owner will review all documents. When the documents include a Contractor's request for delay in completion, the Owner will review all Work which is certified as complete to the best knowledge of the Contractor. The Owner will also review the listed incomplete Work and assign a value to such uncompleted work.

F. The Contractor shall make the required corrections to the Work expeditiously. A letter will be addressed to the Contractor informing the Contractor of the project status.

G. When Contract closeout procedures are completed and all Punch-list deficiencies have been corrected, provide Owner with final corrected Project Record Documents based on Owner’s preliminary review. Correct Project Record Documents shall be in electronic format.

H. Final Completion by the Owner will be documented and the Contractor will receive written notice of acceptance of the Work and notification that final payment may be billed and released.

I. All warranties shall commence and become effective beginning on the date of Substantial Completion.

PART 2 – PRODUCTS (Not Used)

PART 3 – EXECUTION (Not Used)

END OF SECTION

SECTION 072100

THERMAL INSULATION

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Board insulation at over roof deck and face of roof curbs.

B. Batt insulation in exterior wall construction.

1.2 RELATED REQUIREMENTS

A. Section 075400 - Thermoplastic Membrane Roofing: Installation requirements for board insulation over low slope roof deck.

1.3 REFERENCE STANDARDS

A. ASTM C518 - Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus; 2021.

B. ASTM C665 - Standard Specification for Mineral-Fiber Blanket Thermal Insulation for Light Frame Construction and Manufactured Housing; 2017.

C. ASTM C1289 - Standard Specification for Faced Rigid Cellular Polyisocyanurate Thermal Insulation Board; 2022.

D. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2022.

1.4 SUBMITTALS

A. See Section 013000 - Administrative Requirements for submittal procedures.

B. Product Data: Provide data on product characteristics, performance criteria, and product limitations.

C. Manufacturer's Installation Instructions: Include information on special environmental conditions required for installation and installation techniques.

1.5 FIELD CONDITIONS

A. Do not install insulation adhesives when temperature or weather conditions are detrimental to successful installation.

PART 2 PRODUCTS

2.1 GENERAL

A. Products to be formaldehyde-free.

2.2 APPLICATIONS

A. Insulation Over Roof Deck: Polyisocyanurate board.

B. Insulation Over Face of Roof Curbs: Polyisocyanurate board continuous with roof insulation.

C. Insulation Within Roof Curb Wall Framing: Mineral fiber batt insulation.

2.3 FOAM BOARD INSULATION MATERIALS

A. Polyisocyanurate (ISO) Board Insulation: Rigid cellular foam, comply with ASTM C1289.
   1. Classifications:
      a. Type II: Faced with either cellulosic facers or glass fiber mat facers on both major surfaces of the core foam.
         1) Class 1 - Faced with glass fiber reinforced cellulosic facers on both major surfaces of core foam.
         2) Compressive Strength: Classes 1-2-3, Grade 1 - 16 psi (110 kPa), minimum.
         3) Thermal Resistance, R-value: At 1-1/2 inch thick; Class 1, Grades 1-2-3 - 8.4 (1.48), minimum, at 75 degrees F.
   2. Board Size: 48 inch by 96 inch.
   3. Board Thickness: 3.0 inch.
   4. Tapered Board: Slope as indicated; minimum thickness_____inch; fabricate of fewest layers possible.
   5. Board Edges: Square.

2.4 MINERAL FIBER BLANKET INSULATION MATERIALS

A. Mineral Wool Blanket Thermal Insulation: Flexible or semi-rigid preformed insulation, complying with ASTM C665.
   1. Flame Spread Index: 25 or less, when tested in accordance with ASTM E84.
   2. Smoke Developed Index: 0 (zero), when tested in accordance with ASTM E84.
   3. Thermal Resistance: R-value of 21, at 5-1/2 inch framed walls.
   4. Thickness: Full Cavity.
   5. Products:
      a. Knauf Insulation; EcoBatt Insulation.
      b. ROCKWOOL; COMFORTBAT, or AFB evo.
      c. Thermafiber, Inc; SAFB FF.

2.5 ACCESSORIES

A. Paint Vapor Retarder: See Section 09 9123 - Int

B. Tape: Reinforced polyethylene film with acrylic pressure sensitive adhesive.
   1. Application: Sealing of interior circular penetrations, such as pipes or cables.
   2. Width: Are required for application.

C. Tape: Bright aluminum self-adhering type, mesh reinforced, 2 inch wide.

D. Insulation Fasteners: Impaling clip of unfinished steel with washer retainer and clips, to be adhered to surface to receive insulation, length to suit insulation thickness and substrate, capable of securely and rigidly fastening insulation in place.

E. Nails or Staples: Steel wire; electroplated or galvanized; type and size to suit application.

F. Adhesive: Type recommended by insulation manufacturer for application.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that substrate, adjacent materials, and insulation materials are dry and that substrates are ready to receive insulation.

B. Verify substrate surfaces are flat, free of honeycomb, fins, irregularities, or materials or substances that may impede adhesive bond.

3.2 BOARD INSTALLATION OVER LOW SLOPE ROOF DECK

A. Board Installation Over Roof Deck, General:
1. See applicable roofing specification section for specific board installation requirements.
2. Fasten insulation to deck in accordance with roofing manufacturer's written instructions and applicable Factory Mutual requirements.
3. Do not apply more insulation than can be covered with roofing on the same day.

3.3 BATT INSTALLATION

A. Install insulation and vapor retarder in accordance with manufacturer's instructions.

B. Install in exterior wall and roof spaces without gaps or voids. Do not compress insulation.

C. Trim insulation neatly to fit spaces. Insulate miscellaneous gaps and voids.

D. Fit insulation tightly in cavities and tightly to exterior side of mechanical and electrical services within the plane of the insulation.

3.4 FIELD QUALITY CONTROL

A. See Section 014000 - Quality Requirements and Delegated Design for additional requirements.

3.5 PROTECTION

A. Do not permit installed insulation to be damaged prior to its concealment.

END OF
SECTION

SECTION 075600

FLUID-APPLIED ROOFING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Fluid-applied roofing materials.

B. Accessories.

1.2 RELATED REQUIREMENTS

A. Section 076200 - Sheet Metal Flashing and Trim: Metal parapet covers, copings, and counter flashings.

1.3 SUBMITTALS

A. See Section 013000 - Administrative Requirements for submittal procedures.

B. Product Data: Provide manufacturer's data for membrane and accessory materials.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials in manufacturer's original containers, dry and undamaged, with seals and labels intact.

B. Store materials in weather protected environment, clear of ground and moisture.

C. Ensure storage and staging of materials does not exceed static and dynamic load-bearing capacities of roof decking.

1.5 FIELD CONDITIONS

A. Maintain ambient temperatures above 40 degrees F for 24 hours before and during application and until cured.

B. Schedule applications so that no partially completed sections of roof are left exposed at end of workday.

PART 2 PRODUCTS

2.1 MATERIALS

A. PMMA: Siplast Parapro Reinforced Roof Membrane System or approved equal.
   1. Dry Film Thickness (DFT): 60 mils minimum, applied in two coats with reinforcing fabric between each coat.
   2. Color: Gray

2.2 ACCESSORIES

A. Flexible Flashing Sheet: Neoprene or other elastic type sheets approved by roofing membrane manufacturer.

B. Surface Primer: As recommended by liquid applied membrane manufacturer.

C. Reinforcing Sheet: Manufacturer's standard.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify existing conditions prior to starting this work.

B. Verify substrate surfaces are free of frozen matter, dampness, loose particles, cracks, pits, projections, penetrations, or foreign matter detrimental to adhesion or application of roofing system.

C. Verify that roof openings, curbs, and items that penetrate surfaces to receive roofing materials are securely and properly installed.

3.2 PREPARATION

A. Clean and prepare surfaces to receive roofing in accordance with manufacturer's instructions and recommendations.

B. Seal cracks and non-moving open joints less than 1/2 inch wide with sealant using methods recommended by roofing and sealant manufacturers; do not seal expansion joints or moving joints of any width.

C. Install cant strips at inside corners, where indicated and where required by roofing manufacturer.

D. Protect adjacent surfaces not designated to receive roofing.

3.3 INSTALLATION

A. Install fluid-applied roofing in accordance with manufacturer's instructions and recommendations, to specified minimum thickness.

B. Apply roofing materials to surfaces that are acceptable to manufacturer.

C. Installations Over Sealant-Filled Joints: Install an extra coating of roofing material over joints at least 6 inches on each side of joint.

D. Penetrations: Unless otherwise indicated on drawings, or recommended by roofing manufacturer, seal flexible flashing sheet around penetrations and to roofing substrate prior to installation of roofing material, embedding flashing sheet in one coat of roofing material.

E. Applying to Vertical Surfaces: Extend fluid-applied roofing material at least 6 inches above horizontal roofing surfaces.

F. Embedded Flexible Flashing Sheet: Apply full thickness of roofing material over exposed flashing sheet.

G. Apply extra thickness of roofing material at corners, intersections, and angles, when recommended by roofing manufacturer.

3.4 PROTECTION

A. Protect installed roofing and flashings from construction operations.

B. Where traffic must proceed over installed roofing materials, protect surfaces using durable materials acceptable to roofing material manufacturer.

END OF SECTION

SECTION 076200

SHEET METAL FLASHING AND TRIM

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Fabricated sheet metal items, including flashings, counterflashings, exterior penetrations, and other items indicated.

B. Sealants for joints within sheet metal fabrications.

C. Other sheet metal items as indicated in Drawings.

1.2 REFERENCE STANDARDS

A. AAMA 2605 - Voluntary Specification, Performance Requirements and Test Procedures for Superior Performing Organic Coatings on Aluminum Extrusions and Panels (with Coil Coating Appendix); 2022.

B. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process; 2022.

C. ASTM A666 - Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar; 2015.

D. ASTM C920 - Standard Specification for Elastomeric Joint Sealants; 2018.

E. ASTM D4586/D4586M - Standard Specification for Asphalt Roof Cement, Asbestos-Free; 2007 (Reapproved 2018).

F. CDA A4050 - Copper in Architecture - Handbook; current edition.

G. SMACNA (ASMM) - Architectural Sheet Metal Manual; 2012.

1.3 SUBMITTALS

A. See Section 013000 - Administrative Requirements for submittal procedures.

B. Shop Drawings: Indicate material profile, jointing pattern, jointing details, fastening methods, flashings, terminations, and installation details.

1.4 QUALITY ASSURANCE

A. Perform work in accordance with SMACNA (ASMM) and CDA A4050 requirements and standard details, except as otherwise indicated.

B. Maintain one copy of each document on site.

C. Fabricator and Installer Qualifications: Company specializing in sheet metal work with five years of documented experience.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Stack material to prevent twisting, bending, and abrasion, and to provide ventilation. Slope metal sheets to ensure drainage.

B. Prevent contact with materials that could cause discoloration or staining.

PART 2 PRODUCTS

2.1 SHEET MATERIALS

A. (GALV) Pre-Finished Galvanized Steel: ASTM A653/A653M, with G90/Z275 zinc coating; minimum 24-gauge, 0.0239-inch thick base metal, shop pre-coated with PVDF coating.
   1. Polyvinylidene Fluoride (PVDF) Coating: Superior performing organic powder coating, AAMA 2605; multiple coat, thermally cured fluoropolymer finish system.

B. (SS) Stainless Steel: ASTM A666, Type 304 alloy, soft temper, 28 gauge, 0.0156 inch thick; smooth No. 4 - Brushed finish.

2.2 FABRICATION

A. Form sections true to shape, accurate in size, square, and free from distortion or defects.

B. Form pieces in longest possible lengths.

C. Hem exposed edges on underside 1/2 inch; miter and seam corners.

D. Form material with flat lock seams, except where otherwise indicated; at moving joints, use sealed lapped, bayonet-type or interlocking hooked seams.

E. Fabricate corners from one piece with minimum 18-inch long legs; seam for rigidity, seal with sealant.

F. Fabricate flashings to allow toe to extend 2 inches over roofing gravel. Return and brake edges.

2.3 ACCESSORIES

A. Fasteners: Stainless steel, with soft neoprene washers.

B. Primer Type: Zinc chromate.

C. Concealed Sealants: Non-curing butyl sealant.

D. Exposed Sealants: ASTM C920; elastomeric sealant, with minimum movement capability as recommended by manufacturer for substrates to be sealed; color to match adjacent material.

E. Asphalt Roof Cement: ASTM D4586/D4586M, Type I, asbestos-free.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify roof openings, curbs, pipes, sleeves, ducts, and vents through roof are solidly set, reglets in place, and nailing strips located.

B. Verify roofing termination and base flashings are in place, sealed, and secure.

3.2 PREPARATION

A. Install starter and edge strips, and cleats before starting installation.

B. Install surface mounted reglets true to lines and levels, and seal top of reglets with sealant.

C. Back paint concealed metal surfaces with protective backing paint to a minimum dry film thickness of 15 mil, 0.015 inch.

3.3 INSTALLATION

A. Secure flashings in place using concealed fasteners, and use exposed fasteners only where permitted.

B. Apply plastic cement compound between metal flashings and felt flashings.

C. Fit flashings tight in place; make corners square, surfaces true and straight in planes, and lines accurate to profiles.

D. Seal metal joints watertight.

END OF SECTION

SECTION 078400

FIRESTOPPING

PART 1 - GENERAL

1.1 WORK INCLUDES

A. Provide firestopping systems with fire-resistance rating indicated by reference to UL designations as listed in its “Fire Resistance Directory,” or to designations of another testing agency acceptable to authorities having jurisdiction.

B. Provide through-penetration firestopping systems with F-ratings indicated, as determined according to ASTM E 814 but not less than fire-resistance rating of construction penetrated.
   1. Provide through-penetration firestopping systems with T-rating as well as F-rating, as determined according to ASTM E 814, where indicated.

1.2 SUBMITTALS

A. Submittals: Product Data and product certificates signed by manufacturer certifying that products furnished comply with requirements.

1.3 DESIGN REQUIREMENTS

A. For exposed firestopping, provide products with flame-spread indexes of less than 25 and smoke-developed indexes of less than 450, as determined according to ASTM E 84.

PART 2 - PRODUCTS

2.1 FIRESTOPPING SYSTEMS

A. Any through-penetration firestop system that is rate classified by UL for the application and with F-rating indicated may be used.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Install firestopping system to comply with requirements listed in testing agency’s directory for indicating fire-resistance rating.

B. Identification: Identify through-penetration firestop systems with permanent labels attached to surfaces adjacent to firestop systems so that labels will be visible to anyone seeking to remove penetrating items of firestop systems. Include the following information on labels:
   1. The words “Warning - Through-Penetration Firestop Systems - Do Not Disturb.”
   2. Classification/listing designation of applicable testing and inspecting agency.
   3. Through-penetration firestop system manufacturer’s name and product name.

END OF SECTION

SECTION 079200

JOINT SEALANTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Nonsag gunnable joint sealants.

B. Joint backings and accessories.

1.2 REFERENCE STANDARDS

A. ASTM C661 - Standard Test Method for Indentation Hardness of Elastomeric-Type Sealants by Means of a Durometer; 2015.

B. ASTM C920 - Standard Specification for Elastomeric Joint Sealants; 2018.

C. ASTM C1193 - Standard Guide for Use of Joint Sealants; 2016.

D. ASTM C1248 - Standard Test Method for Staining of Porous Substrate by Joint Sealants; 2018.

E. ASTM C1311 - Standard Specification for Solvent Release Sealants; 2022.

F. ASTM C1330 - Standard Specification for Cylindrical Sealant Backing for Use with Cold Liquid-Applied Sealants; 2018.

G. ASTM C1521 - Standard Practice for Evaluating Adhesion of Installed Weatherproofing Sealant Joints; 2019 (Reapproved 2020).

H. SWRI (VAL) - SWR Institute Validated Products Directory; Current Edition.

1.3 SUBMITTALS

A. See Section 013000 - Administrative Requirements, for submittal procedures.

B. Product Data for Sealants: Submit manufacturer's technical data sheets for each product to be used, that includes the following.
   1. Physical characteristics, including movement capability, VOC content, hardness, cure time, and color availability.
   2. List of backing materials approved for use with the specific product.
   3. Substrates that product is known to satisfactorily adhere to and with which it is compatible.
   4. Substrates the product should not be used on.
   5. Substrates for which use of primer is required.
   6. Substrates for which laboratory adhesion and/or compatibility testing is required.
   7. Installation instructions, including precautions, limitations, and recommended backing materials and tools.
   8. Sample product warranty.
   9. Certification by manufacturer indicating that product complies with specification requirements.

10. SWRI Validation: Provide currently available sealant product validations as listed by SWRI (VAL) for specified sealants.

C. Product Data for Accessory Products: Submit manufacturer's technical data sheet for each product to be used, including physical characteristics, installation instructions, and recommended tools.

D. Color Cards for Selection: Where sealant color is not specified, submit manufacturer's color cards showing standard colors available for selection.

1.4 QUALITY ASSURANCE

A. Maintain one copy of each referenced document covering installation requirements on site.

B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.

C. Installer Qualifications: Company specializing in performing the work of this section and with at least three years of documented experience.

D. Field Adhesion Tests of Joints: Test for adhesion using most appropriate method in accordance with ASTM C1521, or other applicable method as recommended by manufacturer.

1.5 WARRANTY

A. See Section 017800 - Closeout Submittals, for additional warranty requirements.

B. Correct defective work within a five year period after Date of Substantial Completion.

C. Warranty: Include coverage for installed sealants and accessories that fail to achieve watertight seal , exhibit loss of adhesion or cohesion, or do not cure.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Non-Sag Sealants: Permits application in joints on vertical surfaces without sagging or slumping.
1. Adhesives Technology Corporation.
2. BASF Construction Chemicals-Building Systems.
3. Bostik Inc.
4. Dow Corning Corporation.
5. Pecora Corporation.
6. Tremco Global Sealants.
7. W.R. Meadows, Inc.
8. Substitutions: See Section 016000 - Product Requirements.

2.2 JOINT SEALANT APPLICATIONS

A. Scope:

1. Exterior Joints: Seal open joints, whether or not the joint is indicated on drawings, unless specifically indicated not to be sealed. Exterior joints to be sealed include, but are not limited to, the following items.
    a. Joints between different exposed materials.
    b. Other joints indicated below.
2. Do not seal the following types of joints.
    a. Joints indicated to be treated with manufactured expansion joint cover or some other type of sealing device.
    b. Joints where sealant is specified to be provided by manufacturer of product to be sealed.
    c. Joints where installation of sealant is specified in another section.

B. Exterior Joints: Use non-sag non-staining silicone sealant, Type A, unless otherwise indicated.
1. Lap Joints in Sheet Metal Fabrications: Butyl rubber, non-curing. Type Q.
2. Lap Joints between Manufactured Metal Panels: Butyl rubber, non-curing. Type Q.

2.3 JOINT SEALANTS - GENERAL

A. Sealants and Primers: Provide products with levels of volatile organic compound (VOC) content as indicated in Section 016116.

2.4 NONSAG JOINT SEALANTS

A. Type A - Non-Staining Silicone Sealant: ASTM C920, Grade NS, Uses M and A; not expected to withstand continuous water immersion or traffic.
1. Movement Capability: Plus and minus 50 percent, minimum.
2. Non-Staining To Porous Stone: Non-staining to light-colored natural stone when tested in accordance with ASTM C1248.
3. Dirt Pick-Up: Reduced dirt pick-up compared to other silicone sealants.
4. Hardness Range: 15 to 35, Shore A, when tested in accordance with ASTM C661.
5. Color: To be selected by Architect from manufacturer's standard range.
6. Cure Type: Single-component, neutral moisture curing.
7. Service Temperature Range: Minus 20 to 180 degrees F.

Type Q - Non-Curing Butyl Sealant: Solvent-based; ASTM C1311; single component, non-sag, non-skinning, non-hardening, non-bleeding; vapor-impermeable; intended for fully concealed applications.

2.5 ACCESSORIES

A. Backer Rod: Cylindrical cellular foam rod with surface that sealant will not adhere to, compatible with specific sealant used, and recommended by backing and sealant manufacturers for specific application.
1. Type for interior use at joints not subject to vehicular or pedestrian traffic: ASTM C1330; Type O - Open Cell Polyurethane.
2. Type for Joints Subject to Pedestrian or Vehicular Traffic and at all enclosure elements: ASTM C1330; Type B - Bi-Cellular Polyethylene.
3. Open Cell: 40 to 50 percent larger in diameter than joint width.
4. Closed Cell and Bi-Cellular: 25 to 33 percent larger in diameter than joint width.

B. Backing Tape: Self-adhesive polyethylene tape with surface that sealant will not adhere to and recommended by tape and sealant manufacturers for specific application.

C. Masking Tape: Self-adhesive, nonabsorbent, non-staining, removable without adhesive residue, and compatible with surfaces adjacent to joints and sealants.

D. Joint Cleaner: Non-corrosive and non-staining type, type recommended by sealant manufacturer; compatible with joint forming materials.

E. Primers: Type recommended by sealant manufacturer to suit application; non-staining.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that joints are ready to receive work.

B. Verify that backing materials are compatible with sealants.

C. Verify that backer rods are of the correct size.

3.2 PREPARATION

A. Remove loose materials and foreign matter that could impair adhesion of sealant.

B. Clean joints, and prime as necessary, in accordance with manufacturer's instructions.

C. Perform preparation in accordance with manufacturer's instructions and ASTM C1193.

D. Mask elements and surfaces adjacent to joints from damage and disfigurement due to sealant work; be aware that sealant drips and smears may not be completely removable.

E. Concrete Floor Joints That Will Be Exposed in Completed Work: Test joint filler in inconspicuous area to verify that it does not stain or discolor slab.

3.3 INSTALLATION

A. Perform work in accordance with sealant manufacturer's requirements for preparation of surfaces and material installation instructions.

B. Perform installation in accordance with ASTM C1193.

C. Measure joint dimensions and size joint backers to achieve width-to-depth ratio, neck dimension, and surface bond area as recommended by manufacturer, except where specific dimensions are indicated.

D. Install bond breaker backing tape where backer rod cannot be used.

E. Install sealant free of air pockets, foreign embedded matter, ridges, and sags, and without getting sealant on adjacent surfaces.

F. Do not install sealant when ambient temperature is outside manufacturer's recommended temperature range, or will be outside that range during the entire curing period, unless manufacturer's approval is obtained and instructions are followed.

G. Nonsag Sealants: Tool surface concave, unless otherwise indicated; remove masking tape immediately after tooling sealant surface.

3.4 POST-OCCUPANCY

A. Post-Occupancy Inspection: Perform visual inspection of entire length of project sealant joints at a time that joints have opened to their greatest width; i.e. at low temperature in thermal cycle. Report failures immediately and repair.

END OF
SECTION

SECTION 230500

GENERAL HVAC PROVISIONS

PART 1 - GENERAL

1.1 CONTRACT DOCUMENTS

A. General HVAC provisions apply to all work performed in Division 23.

B. The Contract Documents are complementary. What is required by any one, as affects this Division, shall be as binding as if repeated herein.

C. Separation of this Division from other Contract Documents shall not be construed as segregation of the Work.

D. Location of equipment on Drawings is approximate. Plan exact location with respect to site measurements and work of other trades prior to starting work. If measurements differ slightly, modify work. If measurements differ substantially, notify Architect/Engineer and Owner's Authorized Representative prior to fabrication.

E. Make minor changes in equipment connections and equipment locations as directed or required before rough-in without extra cost.

F. For products specified by listing one or more manufacturers, followed by "Similar to" and one manufacture's model number, the following requirements apply:
   1. Approval of each listed manufacturer is contingent upon that manufacturer having a product which meets the specification, fits in the available space, and is comparable to the listed model.
   2. Electrical requirements, duct requirements, pipe connections, and space requirements indicated on drawings are based on the listed model and may not be suitable for all manufacturers listed. Provide revisions required to accommodate the model actually furnished.

G. For product specified by listing one or more manufacturers, followed by a model number for each manufacturer, the following requirements apply:
   1. Provide one of the listed model numbers or an approved substitution.
   2. Electrical requirements, duct connections, pipe connections, and space requirements indicated on the Drawings are based on one of the listed models and may not be suitable for all models listed. Provide revisions required to accommodate the model actually furnished.

1.2 DEFINITIONS

A. Authority Having Jurisdiction (AHJ): A federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority.

B. Owner's Authorized Representative (OAR): Owner's representative with authority to act on Owner's behalf.

C. Architect/Engineer: The design professional leading the design team and can be either an architect or engineer.

D. The words furnish, install and provide are defined as follows:
   1. Furnish: To supply and deliver to the project ready for installation and in operable condition.
   2. Install: To place in final position, complete, anchored, connected in operable condition.
   3. Provide: To furnish and install complete. Includes the supply of specified services.
   4. When neither furnish, install or provide is stated, provided is implied.

1.3 COORDINATION

A. Check drawings of other trades to avert possible installation conflicts. Should major changes from original drawings be necessary to resolve such conflicts, notify Architect/Engineer and secure written approval and agreement on necessary adjustments before start of work.

B. Coordinate identification systems with other trades. All mechanical systems shall use identical piping, valve, and equipment identification and regulatory signage.

1.4 SUBMITTALS AND SHOP DRAWINGS

A. See Division 01.

B. Action Submittal Content
   1. Action submittal information not expressly required by the specifications will not be reviewed.
   2. Action submittal information shall be provided in sufficient detail to establish conformance with specified requirements. Where submitted literature includes multiple models, features, or options, the specific models, features, or options proposed shall be clearly indicated. Where a brief inspection shows that product data is not complete, the submittal will be rejected without review.
   3. Action submittal data shall be clear, concise, legible, and relevant. Where data is not properly organized and contains significant information that is not relevant, the submittal will be rejected without review.
   4. Action submittal requirements are listed in individual specification sections. The following definitions apply.
      a. Materials List: Provide tabular list of materials including specification reference, specification product name, manufacturer, model/part number, and size and/or quantity where appropriate. Do not include supplemental data, except where specifically requested.
      b. Catalog data: Manufacturer's standard product cut sheet.
      c. Product Data: Detailed data including dimensions, weight, materials of construction, connections, and all other information needed to confirm that the product conforms to all requirements listed in the individual specification section.
      d. Performance Data: Capacity, input, output, flow, etc. as required to confirm that the product meets the performance requirements scheduled in the Specifications or on the Drawings.
      e. Wiring Diagrams: Power and control wiring diagrams.
      f. Shop Drawings: Construction drawings of items manufactured specifically for this project including dimensions, construction details, weights, and additional information to identify the physical features of the system or piece of equipment.
      g. Installation Instructions
      h. Special Requirements Listed: Additional requirements indicated in individual specification sections.

C. Delegated Design
   1. The Contractor shall provide delegated design services where indicated in the Contract Documents and obtain necessary approval from the AHJ. The Contractor shall be

responsible for the design, calculations, submittals, permits, fabrication, transportation and installation of these Delegated Design components. The Contractor is responsible to submit all Delegated Design documents required for approvals by regulatory agencies for each item of delegated design work.

2. Delegated design work shall be performed by a register professional engineer or architect specializing in the associated work and registered in State in which the work is performed where required by the AHJ or as specified herein.
3. Comply with requirements of the AHJ over the Work current at the time of submission. The Contractor is responsible to coordinate and submit all material required by the AHJ so review and process of submittals and permits will not adversely affect the construction schedule. Each Delegated Design item requiring review by the AHJ must be provided by the Contractor and all fees and costs associated therewith shall be the Contractor's responsibility at no additional cost to the Owner.
4. Performance and Design Criteria: Where professional design services or certifications by a design professional are specifically required of Contractor by the Contract Documents, provide products and systems complying with specific performance and design criteria indicated.
    a. If criteria indicated are not sufficient to perform services or certification required, submit a written request for additional information to Engineer.
5. Delegated-Design Services Certification: In addition to shop drawings, product data, and other required submittals, submit digitally signed PDF electronic file, signed and sealed by the responsible design professional, for each product and system specifically assigned to Contractor to be designed or certified by a design professional.
    a. Indicate that products and systems comply with performance and design criteria in the Contract Documents. Include list of codes, loads, and other factors used in performing these services.

1.5 QUALITY ASSURANCE

A. All materials and equipment provided hereunder shall be installed and started in complete conformance with the manufacturer's recommendations.

B. Asbestos products or equipment or materials containing asbestos shall not be used.

C. Certify that each welder has passed the American Welding Society (AWS) qualification tests for the welding processes involved, and that certification is current.

1.6 DESIGN REQUIREMENTS

A. Equipment and systems provided hereunder shall be rated to provide performance specified and scheduled on Drawings at the elevation of the project site.

B. Materials and equipment provided hereunder shall be rated for the service conditions of the system to which they are connected including but not limited to temperature, pressure, and humidity.

1.7 CODES AND STANDARDS

A. Applicable codes and standards shall determine minimum requirements for materials, methods, and labor practices not otherwise stated herein.

B. Work shall comply with the Americans with Disabilities Act (ADA).

1.8 SEQUENCING

A. Testing, adjusting, and balancing of HVAC systems will begin after commissioning construction checks and equipment start-up are complete and Systems Ready to Balance Checklist forms have been executed and submitted.

B. Submit schedule for operator training eight weeks prior to Substantial Completion. Schedule shall include time and duration of each required training session.

C. Submit control verification reports three weeks after Substantial Completion.

D. Submit draft operations and maintenance manuals to Owner’s Authorized Representative 30 days prior to substantial completion.

E. Operator training shall be performed prior to Substantial Completion, or as otherwise approved by the Owner’s Authorized Representative.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store products in a clean and dry place.

B. Comply with manufacturer's written rigging and installation instructions for unloading and moving to final installed location.

C. Handle products carefully to prevent damage, breaking, denting, and scoring. Do not install damaged products.

D. Protect products from weather, dirt, dust, water, construction debris, and physical damage.

E. Retain factory-applied coverings on equipment to protect finishes during construction and remove just prior to operating unit.

F. Cover unit openings before installation to prevent dirt and dust from entering inside of units. If required to remover coverings during unit installation, reapply coverings over openings after unit installation and remove just prior to operating unit.

G. Replace installed products damaged during construction.

1.10 TEMPORARY SERVICES

A. Provide in accordance with Division 01 as required for completion of work.

B. Maintain existing systems operational. Owner will be responsible to operate and maintain existing equipment during the course of the project. However, any damage to existing equipment resulting directly from work under this Contract shall be repaired by the Contractor at no expense to Owner.

C. All mechanical systems currently operating including HVAC equipment and controls, which serve Owner occupied areas, must be maintained operational during construction. It is the responsibility of the Contractor to provide temporary facilities as required to maintain operation. If any system currently in use must be turned off to perform work, permission must be obtained, and owner notified prior to performing any work.

1.11 OPERATIONS AND MAINTENANCE MANUALS

A. Furnish operation and maintenance data for project, as described herein.

B. Manuals, Electronic Files: Submit manuals in the form of a multiple file composite electronic PDF files.
   1. Include a directory of all subcontractors and maintenance contractors with names, addresses, and telephone numbers, indicating the area of responsibility for each.
   2. Electronic Files: Use electronic files prepared by manufacturer where available. Where scanning of paper documents is required, configure scanned file for minimum readable file size.
   3. Provide a composite summary table indicating each item of equipment listed in the operations and maintenance manual and its required maintenance and time period. This summary table shall be the first section in the O&M manual.
   4. Manual Content: Manuals shall contain complete information for each item of mechanical, electrical or other operating equipment. Include as applicable:
      a. Manufacturer's instructions for installation, startup, operation, inspection, and maintenance
      b. Lubrication schedules
      c. Performance capacity
      d. Final approved product submittals for each product included in project.
         1) Mark the model actually provided where the literature covers more than one model. Include all submittal data corrected to "as-built" conditions within the manual.
         2) Parts list
      e. Maintenance schedules
      f. Maintenance instructions shall indicate routine-type work with step-by-step instructions that should be performed to ensure long life and proper operations. Recommended frequency of performance shall also be included.
   5. File Names and Bookmarks: Bookmark individual documents based on file names. Name document files to correspond to system, subsystem, and equipment names used in manual directory and table of contents. Group documents for each system and subsystem into individual composite bookmarked files, then create composite manual, so that resulting bookmarks reflect the system, subsystem, and equipment names in a readily navigated file tree. Configure electronic manual to display bookmark panel on opening file.
   6. Provide electronic configuration files for all packaged equipment control systems furnished with equipment.

C. Manuals, Paper Copy: Submit manuals in the form of hard copy, bound and labeled volumes.
   1. Binders: Heavy-duty, three-ring, vinyl-covered, loose-leaf binders, in thickness necessary to accommodate contents, sized to hold 8-1/2-by-11-inch paper; with clear plastic sleeve on spine to hold label describing contents and with pockets inside covers to hold folded oversize sheets.
   2. Provide a composite summary table indicating each item of equipment listed in the operations and maintenance manual and its required maintenance and time period. This summary table shall be the first section in the O&M manual.
   3. Manual Content: Manuals shall contain complete information for each item of mechanical electrical or other operating equipment. Include as applicable:
      a. Manufacturer's instructions for installation, startup, operation, inspection, and maintenance
      b. Lubrication schedules
      c. Performance capacity
         1) Final approved product submittals for each product included in project.

a) Mark the model actually provided where the literature covers more than one model. Include four copies of all submittal data corrected to "as-built" conditions within the manual.
b) Parts list

d. Maintenance schedules
e. Maintenance instructions shall indicate routine-type work with step-by-step instructions that should be performed to ensure long life and proper operations. Recommended frequency of performance shall also be included.

D. Provide printed copy and electronic configuration files for all packaged equipment control systems furnished with equipment.

1.12 RECORD DRAWINGS

A. Provide record "as-built" drawings. Show all deviations from contract drawings and location of underground lines by accurate dimensions from building lines. Show depth of all stub outs and underground lines. Dimension all concealed piping from column grids or building lines. Alternately, provide electronically using .pdf markup of contract drawings.

PART 2 - PRODUCTS

2.1 PRODUCTS AND MATERIALS

A. All materials employed in permanent construction shall be new, full weight, in first class condition, and suitable for space provided. All similar equipment and materials shall be of one manufacturer.

B. Equipment used as the basis of design is scheduled on Drawings or designated in product specifications. If Contractor chooses to use equipment that is not the basis of design, Contractor is responsible for all re-design and construction costs associated with variations in arrangement, dimension, or capacity. Such work may include, but is not limited to, changes to facility structure or dimensions and revisions to associated mechanical and electrical systems needed to provide equal system performance and maintainability.

2.2 ELECTRICAL EQUIPMENT

A. Electrical Disconnect Switch: Electrical disconnect switches specified for mechanical equipment shall conform to OSHA Lock-out/Tag-out requirements.

B. All electrical equipment shall be listed as approved for its application by the Underwriters Laboratory or other testing agency approved by the State of Oregon Electrical and Elevator Board. Approval indicates agency meets testing standard requirements for electrical safety required by Oregon Revised Statutes 479.510 through 479.855 and Oregon Administrative Rules.

C. Enclosure: Provide the following electrical equipment enclosure types.
1. NEMA 1: Dry, enclosed locations where the ambient temperature will not be outside of the VFD temperature ratings.
2. NEMA 12: Enclosed mechanical spaces equipped with floor drains where dripping or splashing may occur and where the ambient temperature will not be outside of the VFD temperature ratings.
3. NEMA 3R, 4, or 4X with Temperature Control: Outdoors or in unconditioned spaces where ambient temperatures will be outside of the VFD temperature ratings.

4. Enclosure will be provided with a ventilation fan and heater capable of maintaining enclosure temperature within the manufacturer's recommended range. Drive and enclosure shall be a single, UL-listed assembly with single point electrical connections.

2.3 FIRESTOPPING

A. Comply with Division 07.

B. Acceptable Manufacturers: 3M, Hilti, Tremco, Nelson Firestop Products.

C. Provide firestopping for the following:
1. All penetrations through fire resistance rated floors, walls and partitions including openings containing pipes, ducts and other penetrating items.
2. All penetrations through non-fire resistance rated floors where the vertical service riser penetrates three or more floors.

D. Firestop system shall be UL Classified for the application and correspond to those indicated by reference to designation listed by UL Fire Resistance Directory.

E. Material shall be tested in accordance with UL-1479, ASTM E-814 for the specific fire-rated construction conditions confirming to construction assembly type, penetration item type, annular space requirements, and fire-rating involved.

2.4 SPECIAL TOOLS AND LUBRICANTS

A. Furnish and turn over to Owner's Authorized Representative, special tools not readily available commercially, that are required for disassembly or adjustment of equipment and machinery furnished.

B. Grease Guns with Attachments for Applicable Fittings: Provide one for each type of grease required for motor or other equipment.

C. Lubricants: Provide a minimum of one quart of oil, and one pound of grease, of equipment manufacturer's recommended grade and type, in unopened containers and properly identified as to use for each different application.

PART 3 - EXECUTION

3.1 ACCESS TO EQUIPMENT AND ACCESSORIES

A. Install equipment with sufficient access for service. Where not conveniently accessible by other means, provide adequately sized access doors for valves, dampers, motors, belts, and all other mechanical equipment requiring access for removal or maintenance. Type, size and exact location of access doors shall be coordinated with Architect/Engineer prior to work.

B. Provide clearances for maintenance access as indicated on Drawings or as recommended by manufacturer. If access requirements shown on Drawings conflict with manufacturer's recommendations, provide larger clearance of the two.

C. If equipment location shown on Drawings does not allow required access, notify Architect/Engineer prior to start of work.

D. Apply and install all items in accordance with manufacturer's written instructions. Refer conflicts between the manufacturer's instructions and the contract drawings and specifications to Architect/Engineer for resolution prior to starting work.

E. Provide access doors as required for access to mechanical equipment. Doors required for access are not necessarily shown on Drawings. Consult with Architect/Engineer for direction on placement of required doors not shown on Drawings.
   1. Comply with manufacturer's instructions for installation of access doors. Provide all necessary support and supplemental framing for assembly where the access doors are required. Set accurately in position, plumb, level, and flush to adjacent finish surfaces; and secure to support.

F. Where ladder access is required to service elevated components, provide an installation that provides for sufficient access within ladder manufacturer's written instructions for use.

G. Comply with OSHA regulations.

3.2 ARRANGEMENT AND INSTALLATION OF EQUIPMENT AND PIPING

A. Coordinate location of piping, sleeves, inserts, hangers, ductwork and equipment. Locate piping, sleeves, inserts, hangers, ductwork and equipment clear of windows, doors, openings, lights, electrical outlets, and other services and utilities. Follow manufacturer's published recommendations for installation methods not otherwise specified.

B. Equipment and Piping Support: Coordinate structural systems necessary for pipe and equipment support with pipe and equipment locations to permit proper installation.

C. Location of pipe sleeves, trenches and chases shall be accurately coordinated with equipment and piping locations.

D. Minor Piping: Small diameter pipe runs from drips and drains, water cooling, and similar minor services are generally not shown but must be provided. Contractor is responsible to provide all such minor piping where needed to maintain mechanical spaces clean and dry and to allow full equipment function and maintenance.

E. Interconnection of Controls and Instruments: Generally not shown but must be provided. This includes interconnections of sensors, transmitters, transducers, control devices, control and instrumentation panels, instruments, and computer workstations. Comply with NFPA-70.

F. Work in Existing Building: Cut required openings through existing masonry and reinforced concrete using diamond core drills. Use of pneumatic hammer type drills, impact type electric drills, and hand or manual hammer type drills, will be permitted only with approval of the Owner's Authorized Representative. Locate openings that will least affect structural slabs, columns, ribs, or beams. Refer to the Architect/Engineer for determination of proper design for openings through structural sections and obtain layout approval prior to cutting or drilling into structure. After Architect/Engineer approval, carefully cut opening through construction no larger than absolutely necessary for the required installation.

G. Switchgear Drip Protection: Do not install piping above electrical switchgear.

H. Inaccessible Equipment
   1. Where the Owner's Authorized Representative determines that the Contractor has installed equipment not conveniently accessible for operation and maintenance,

equipment shall be removed and reinstalled or remedial action performed as directed at no additional cost to the Owner.

2. The term "conveniently accessible" is defined as capable of being reached without the use of ladders, or without climbing or crawling under or over obstacles such as motors, fans, pumps, belt guards, transformers, high voltage lines, piping, and ductwork.

3.3 RIGGING

A. Design is based on use of available structure without modification except as specifically shown. Existing openings in building structures are planned to accommodate design scheme.

B. Alternative methods of equipment delivery may be offered by Contractor and will be considered by Architect/Engineer under specified restrictions of phasing and maintenance of service as well as structural integrity of the building.

C. Close all openings in the building when not required for rigging operations to maintain proper environment in the facility.

D. Contractor shall provide all facilities required to deliver specified equipment and place on foundations. Attachments to structures for rigging purposes and support of equipment on structures shall be Contractor's full responsibility. Where it is not clear that the building structure has adequate capacity to support rigging, Contractor shall check all clearances, weight limitations and shall offer a rigging plan designed by a Registered Professional Engineer. All modifications to existing building structure, including reinforcement thereof, shall be at Contractor's cost, time and responsibility.

E. Restore building to original condition upon completion of rigging work.

3.4 EXISTING EQUIPMENT REUSED OR RELOCATED

A. All equipment designated as existing or furnished by Owner shall be cleaned and repaired before reinstallation. Any items requiring repair shall be brought to the attention of the construction manager before the item is reinstalled. Damage not brought to the attention of the construction manager shall be deemed the result of reinstallation of the item and shall be repaired without expense to the Owner.

3.5 MECHANICAL SYSTEMS FIRESTOPPING

A. Do not cover firestop installations until they are examined by the Authority Having Jurisdiction, if required.

B. Install firestopping in accordance with manufacturer’s recommendations and conditions of product UL listing.

3.6 LUBRICATION

A. Lubricate all devices requiring lubrication prior to initial operation. Field check all devices for proper lubrication.

B. Equip all devices with required lubrication fittings or devices.

C. All lubrication points shall be accessible without disassembling equipment, except to remove access panels.

3.7 CLEANING SYSTEMS

A. General: After all equipment, pipes and duct systems are installed, system shall be thoroughly cleaned. Remove all stickers and tags from equipment or fixtures. Clean all piping systems prior to installation of insulation or painting.

B. Hydronic Piping: Clean and flush hydronic piping and strainers as required to complete work described in Section 232513 – Water Treatment for Hydronic Systems.

C. Air Distribution Duct System:
1. Remove all debris from system before operation. Under no circumstances shall system be operated without filters. Replace filters used during construction with new filters.
2. Repair or replace any discolorations or damage to system, building finish, or furnishings resulting from Contractor's failure to properly clean system.

3.8 START UP

A. The Mechanical Contractor shall be responsible for proper operation of all systems and shall coordinate startup procedures, calibration and system checkout. System operational problems shall be diagnosed and corrected as required for system operation prior to Substantial Completion inspection.

B. Start equipment in accordance with manufacturer's recommendations and under manufacturer's supervision where required. Ensure that associated filters, strainers, electrical overloads, and other devices intended to protect the equipment are installed and functional prior to startup.

C. Verify that piping has been flushed and cleaned prior to startup.

D. The Mechanical Contractor shall perform TAB system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work. TAB system-readiness checklists will be provided by the TAB Specialist. See Section 230593 - Testing, Adjusting, and Balancing for HVAC.

3.9 DEMONSTRATION

A. General: After installation is complete, demonstrate to Engineer and Owner's Authorized Representative satisfaction as being complete and operational and entirely in conformance with Contract Documents.

B. Preparation: Prior to demonstration, submit check-off list indicating completeness of submittals and certificates of compliance for review to Owner's Authorized Representative. Operate completed system for one week. Verify that control verification is complete and verification report has been approved by Architect/Engineer.

C. Arrange for demonstration with Owner's Authorized Representative, Engineer, required factory technicians, and installer at least one week in advance of demonstration.

3.10 TRAINING

A. Instruct Owner in proper operation and maintenance of equipment and systems. Instruction shall generally include topics listed in manufacturer's operations and maintenance manual. Operator instructions shall cover all aspects of manual, automatic, and safety controls. Contractor shall also instruct the Owner in the general configuration of systems and location of equipment and components.

B. Furnish competent qualified technicians knowledgeable in the building HVAC systems and equipment provided for this project for a minimum of 8 hours on-site to instruct Owner in operation and maintenance of systems and equipment. This figure does not include additional training noted under individual specification sections. Contractor shall keep a log of this instruction including date, times, subjects, and those present and shall present such log when requested by Engineer. Contractor shall coordinate training with Owner's Project Manager and provide a schedule for training minimum two-weeks prior to Substantial Completion. All training shall be complete 30-days after Substantial Completion.

C. Contractor shall furnish training by equipment manufacturers in addition to training described in this section where specifically listed in other sections. Contractor shall schedule training with Owner's Project Manager minimum 48-hours prior to training session. Equipment shall be fully operational prior to scheduling training session. Manufacturer's field start-up, adjustment, and service will not fulfill manufacturer's training requirement.

D. Contractor shall coordinate operator training with the Owner's Authorized Representative as follows:
   1. Training Schedule: Contractor shall develop and submit a training schedule listing all required training including contractor training, manufacturer training, and factory training as specified for approval by the Owner's Authorized Representative.
   2. Training Record and Evaluation Section: Contractor shall maintain a Training Record documenting attendees and duration of each training session. The Contractor shall complete Training Record after each training session. Submit training record when all training is complete.

END OF SECTION

SECTION 230513

COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes general requirements for single-phase and polyphase, general-purpose, squirrel-cage induction and electrically commutated 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°C and at altitude of 3,300 feet 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 INDUCTION MOTORS

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

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

C. Service Factor: 1.15 unless listed otherwise under section where motor is provided.

D. Rotor: Random-wound, squirrel cage.

E. Bearings: Re-greaseable, shielded, antifriction ball bearings suitable for radial and thrust loading.

F. Temperature Rise: Match insulation rating.

G. Insulation: Class F.

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

I. Enclosure Type: Provide open drip proof enclosure, except provide totally enclosed fan cooled enclosure for the applications listed below, or as expressly specified elsewhere, or as indicated on Drawings.
1. Outdoor applications including roof exhaust fans, cooling towers, and similar equipment.
2. Fan motors mounted in an unfiltered air stream.
3. Motors 10 HP and larger.

J. Additional Requirements for Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
1. Inverter Duty as defined in NEMA MG 1 with Class F temperature rise; Class H insulation.
2. 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.
3. Maximum RPM: 3600 rpm minimum, or 150% of as design motor speed, whichever is greater.
4. Speed Ratio:
   a. Constant load applications: 4:1, except 1000:1 where high turndown motor is required.
   b. Variable torque applications: 20:1, except 1000:1 where high turndown motor is required.
5. Bearing Protection Ring: For motors controlled by variable frequency drives, provide maintenance free, conductive microfiber, shaft grounding ring with a minimum of two rows of circumferential microfibers to discharge electrical shaft currents within the motor and/or its bearings. AEGIS SGR or approved equal.

2.4 SINGLE-PHASE ELECTRICALLY COMMUTATED MOTORS

A. General: Electrically commutated, variable-speed, DC, brushless, direct drive type. Motor rotor shall be permanent magnet type with near zero rotor losses.

B. Bearings: Heavy duty, pre-lubricated, antifriction ball bearings.

C. Motor Controller: Single-phase integrated controller/inverter that operates the wound stator and senses rotor position to electronically commutate the stator. Motors designed for synchronous rotation and to overcome reverse rotation.
1. Operating Speed: Controllable from 100% to 20% of full speed.
2. Motor Control: Remote digital input
3. Speed Control: Provide either manual or remote speed control input as specified and as required to perform intended function:
   a. Manual: Potentiometer dial mounted on the motor.
   b. Remote modulating analog input: 4-20mA or 0-10 VDC.
4. Soft-start function to reduce inrush current at start-up
5. Overcurrent Protection
6. Thermal Overload Protection

D. Electrical Input: Single phase, 60 hertz. Voltage as required or as scheduled on drawings.

E. Efficiency: Motor shall be minimum of 70% efficient over entire operating range.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify motor mounts are compatible with motor frame.

3.2 INSTALLATION

A. Motors Used with Variable Frequency Controllers: Arrange location of motor, variable frequency controller and electrical wiring to ensure the distance from motor to inverter does not exceed manufacturer recommended maximum length.

3.3 APPLICATION

A. EC Motor Speed Control
   1. Remote speed control where required for variable volume applications to perform specified control sequences.
   2. Manual speed control for constant volume applications.

END OF SECTION

SECTION 230514

COMMON MOTOR CONTROL REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Variable frequency drive motor controllers.
2. Enclosures.
3. Accessories.

1.2 DEFINITIONS

A. CPT: Control power transformer.

B. MCCB: Molded-case circuit breaker.

C. MCP: Motor circuit protector.

D. DDC: Direct digital control.

E. EMI: Electromagnetic interference.

F. OCPD: Overcurrent protective device.

G. PID: Control action, proportional plus integral plus derivative.

H. RFI: Radio-frequency interference.

I. SCCR: Short-circuit current rating.

J. SCPD: Short-circuit protective device.

K. VFD: Variable-frequency drive motor controller.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of magnetic motor controller.
1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
2. Include control for VFDs
   a. Control and monitoring functions
   b. Hardwired input and output control capabilities.
   c. Network communications capabilities.

B. Shop Drawings: For each type of magnetic controller.
1. Include plans, elevations, sections, and mounting details.
2. Indicate dimensions, weights, required clearances, and location and size of each field connection.
3. Wire Termination Diagrams and Schedules: Include diagrams for power, signal, and control wiring. Identify terminals and wiring designations and color-codes to facilitate installation, operation, and maintenance. Indicate recommended types, wire sizes,

and circuiting arrangements for field-installed wiring, and show circuit protection features. Differentiate between manufacturer-installed and field-installed wiring.
4. Include features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

C. Product Schedule: List the following for each enclosed controller:
1. NRTL listing.
2. Factory-installed accessories.
3. SCCR of integrated unit.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, for magnetic controllers, from manufacturer.
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
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.

B. Listing of network communication point data that shared with BAS.

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For magnetic controllers to include in operation and maintenance manuals.
1. In addition to items specified in Division 01, include the following:
a. Routine maintenance requirements for magnetic controllers and installed components.
b. Manufacturer's written instructions for testing and adjusting circuit breaker and MCP trip settings.
c. Manufacturer's written instructions for setting field-adjustable overload relays.
d. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that switch settings for motor-running overload protection suit actual motors to be protected.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Store controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.

B. If stored in areas subject to weather, cover controllers to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers.

1.8 FIELD CONDITIONS

A. Ambient Environment Ratings: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
   1. Ambient Temperature: Not less than 23 deg F and not exceeding 104 deg F.
   2. Altitude: Not exceeding 6600 feet for electromagnetic and manual devices.
   3. The effect of solar radiation is not significant.

1.9 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace VFDs that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: Three years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

B. Magnetic motor controllers to comply with UL 508 and UL 60947-4-1.

C. VFD controllers to comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 508A.

D. NEMA Compliance: Fabricate motor controllers to comply with ICS 2.

E. Seismic Performance: Motor controllers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
   1. The term "withstand" means "the controller will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
   2. Component Importance Factor: 1.5.

F. Factory Assembled Equipment:
   1. Each motor controller shall be provided with a factory installed isolation switch.

2.2 VARIABLE FREQUENCY DRIVE MOTOR CONTROLLER

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. ABB Low Voltage HVAC Drives

B. Description: Variable-frequency motor controller, consisting of power converter that employs pulse-width-modulated inverter, factory built and tested in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.
   1. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."

2. Listed and labeled for integrated short-circuit current rating by an NRTL acceptable to authorities having jurisdiction.

C. Application: Variable torque.

D. Design and Rating: Match load type, such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.

E. Output Rating: Three phase; 6 to 60 Hz, with voltage proportional to frequency throughout voltage range; maximum voltage equals input voltage.

F. Unit Operating Requirements:
1. Input AC Voltage Tolerance: Plus 10 and minus 10 percent of VFD input voltage rating.
2. Input AC Voltage Unbalance: Not exceeding 5 percent.
3. Input Frequency Tolerance: Plus or minus 3 percent of VFD frequency rating.
4. Minimum Efficiency: 97 percent at 60 Hz, full load.
5. Minimum Displacement Primary-Side Power Factor: 98 percent under any load or speed condition.
6. Minimum Short-Circuit Current (Withstand) Rating: 100 kA.
7. Ambient Temperature Rating: Not less than 10 deg F and not exceeding 104 deg F.
8. Humidity Rating: 5 to 95 percent (noncondensing).
9. Altitude Rating: Not exceeding 3300 feet.
10. Vibration Withstand: Comply with NEMA ICS 61800-2.
11. Overload Capability: 1.1 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.
12. Starting Torque: Minimum 100 percent of rated torque from 3 to 60 Hz.
13. Speed Regulation: Plus or minus 5 percent.
14. Output Carrier Frequency: Selectable; 1.0 to 12 kHz.
15. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.

G. Isolated Control Interface: Allows VFDs to follow remote-control signal over a minimum 40:1 speed range.

H. Internal Adjustability Capabilities:
1. Minimum Speed: 5 to 25 percent of maximum rpm.
2. Maximum Speed: 80 to 100 percent of maximum rpm.
3. Acceleration: 0.1 to 999.9 seconds.
4. Deceleration: 0.1 to 999.9 seconds.
5. Current Limit: 30 to minimum of 150 percent of maximum rating.

I. Self-Protection and Reliability Features:
1. Surge Suppression: Factory installed as an integral part of the VFD, complying with UL 1449 SPD, Type 1 or Type 2.
2. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
3. Under- and overvoltage trips.
4. Inverter overcurrent trips.
5. VFD and Motor-Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFDs and motor thermal characteristics, and for providing VFD overtemperature and motor-overload alarm and trip; settings selectable via the keypad.
6. Critical frequency rejection, with three selectable, adjustable deadbands.
7. Instantaneous line-to-line and line-to-ground overcurrent trips.
8. Loss-of-phase protection.

9. Reverse-phase protection.
10. Short-circuit protection.
11. Motor-overtemperature fault.

J. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.

K. Bidirectional Autospeed Search: Capable of starting VFD into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.

L. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

M. Integral Input Disconnecting Means and OCPD: UL 489, instantaneous-trip circuit breaker with pad-lockable, door-mounted handle mechanism.
1. Disconnect Rating: Not less than 115 percent of VFD input current rating.
2. Disconnect Rating: Not less than 115 percent of NFPA 70 motor full-load current rating or VFD input current rating, whichever is larger.
3. Auxiliary contacts "a" and "b" arranged to activate with circuit-breaker handle.

N. Controls and Indication
1. Status Lights: Door-mounted LED indicators displaying the following conditions:
   a. Power on.
   b. Run.
2. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English-language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.
   a. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.
   b. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.
      1) Control Authority: Supports at least four conditions: Off, local manual control at VFD, local automatic control at VFD, and automatic control through a remote source.
3. Historical Logging Information and Displays:
   a. Real-time clock with current time and date.
   b. Running log of total power versus time.
   c. Total run time.
   d. Fault log, maintaining last four faults with time and date stamp for each.
4. Indicating Devices: Digital display mounted flush in VFD door and connected to display VFD parameters including, but not limited to:
   a. Output frequency (Hz).
   b. Motor speed (rpm).
   c. Motor status (running, stop, fault).
   d. Motor current (amperes).
   e. Motor power (kW)
   f. Motor torque (percent).
   g. Fault or alarming status (code).
   h. PID feedback signal (percent).
   i. DC-link voltage (V dc).
   j. Set point frequency (Hz).
   k. Motor output voltage (V ac).
5. Control Signal Interfaces:

a. Electric Input Signal Interface:
   1) A minimum of two programmable analog inputs.
   2) A minimum of six multifunction programmable digital inputs.
b. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the DDC system for HVAC or other control systems.
c. Output Signal Interface: A minimum of two programmable analog output signal(s), which can be configured for any of the following:
   1) Output frequency (Hz).
   2) Output current (load).
   3) DC-link voltage (V dc).
   4) Motor torque (percent).
   5) Motor speed (rpm).
   6) Set point frequency (Hz).
d. Remote Indication Interface: A minimum of three programmable dry-circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
   1) Motor running.
   2) Set point speed reached.
   3) Fault and warning indication (overtemperature or overcurrent).
   4) PID high- or low-speed limits reached.

6. PID Control Interface: Provides closed loop setpoint, differential feedback control in response to dual feedback signals. Allows for closed loop control of fans and pumps for pressure, flow, or temperature regulation.
   a. Number of Loops: Two.
7. Interface with DDC System for HVAC: Factory-installed hardware and software shall interface with DDC system for HVAC to monitor, control, display, and record data for use in processing reports. VFD settings shall be retained within VFD's nonvolatile memory. Third party gateways and multiplexers is not acceptable.
   a. Communication Interface: Communication shall interface with DDC system for HVAC to remotely control and monitor VFD from a DDC system for HVAC operator workstation. Control features and monitoring points displayed locally at VFD panel shall be available through the DDC system for HVAC. All protocols shall be “certified” by the governing authority (i.e., BTL Listing for BACnet). Use of non-certified protocols is not allowed.
      1) The VFD shall have an EIA-485 port and support the following communication protocols:
         a) Modbus
         b) BACnet: The BACnet connection shall be an Ethernet and comply with ASHRAE 135, IP interface. The connection shall be tested by the BACnet Testing Labs (BTL) and be BTL Listed. The BACnet interface shall conform to the BACnet standard device type of an Applications Specific Controller (B-ASC). The interface shall support all BIBBs defined by the BACnet standard profile for a B-ASC.

O. Line Conditioning and Filtering
1. Input Line Conditioning: Based on the manufacturer's harmonic analysis study and report, provide input filtering, as required, to limit total demand (harmonic current) distortion and total harmonic voltage demand at the defined point of common coupling to meet IEEE 519 recommendations.
2. EMI/RFI Filtering: CE marked; certify compliance with IEC 61800-3 for Category C2.

2.3 ENCLOSURES

A. Comply with NEMA 250, type designations, complying with environmental conditions at installed location.

B. The construction of the enclosures shall comply with NEMA ICS 6.

C. Outdoor Enclosures: Provide heaters, cooling fan, and/or sun shield with temperature control system as required to maintain interior enclose temperature with manufacturer rated operating conditions for all internal components.

2.4 ACCESSORIES

A. General Requirements for Control Circuit and Pilot Devices: NEMA ICS 5; factory installed in controller enclosure cover unless otherwise indicated.

B. Motor protection relays shall be with solid-state sensing circuit and isolated output contacts for hardwired connections.
1. Phase-failure.
2. Phase-reversal, with bicolor LED to indicate normal and fault conditions. Automatic reset when phase reversal is corrected.
3. Under/overvoltage, operate when the circuit voltage reaches a preset value, and drop out when the operating voltage drops to a level below the preset value. Include adjustable time-delay setting.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and space conditions for compliance with requirements for motor controllers, their relationship with the motors, and other conditions affecting performance of the Work.

3.2 INSTALLATION

A. Comply with NECA 1.

B. Wall-Mounted Controllers: Install magnetic controllers on walls with tops at uniform height indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks.

C. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

D. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

E. Setting of Overload Relays: Select and set overloads on the basis of full-load current rating as shown on motor nameplate. Adjust setting value for special motors as required by NFPA 70 for motors that are high-torque, high-efficiency, and so on.

F. Hand-Off-Auto Switch: Safety interlocks for life-safety or emergency shutdown to protect equipment or systems shall be wired so that safety interlocks are active in both Hand and Auto position.

3.3 APPLICATION

A. Provide motor controllers as scheduled on drawings and as otherwise specified.

B. Provide Single Phase Motor Control Relays for single phase motors less than ½ horsepower.

3.4 FIELD QUALITY CONTROL

A. Start-up and Testing of Motor Controllers other than VFDs
   1. Contractor to test and inspect components, assemblies, and equipment installations, including connections.
   2. Tests and Inspections:
      a. Comply with the provisions of NFPA 70B, "Testing and Test Methods" Chapter.
      b. Visual and Mechanical Inspection:
         1) Compare equipment nameplate data with drawings and specifications.
         2) Inspect physical and mechanical condition.
         3) Inspect anchorage, alignment, and grounding.
         4) Verify the unit is clean.
         5) Inspect contactors:
            a) Verify mechanical operation.
            b) Verify contact gap, wipe, alignment, and pressure are according to manufacturer's published data.
         6) Verify overload element rating is correct for its application.
         7) Inspect bolted electrical connections for high resistance.
         8) Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
      c. Electrical Tests:
         1) Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Insulation-resistance values shall be according to manufacturer's published data or NETA ATS Table 100.1.
         2) Test motor protection devices according to manufacturer's published data.
         3) Test circuit breakers as follows:
            a) Operate the circuit breaker to ensure smooth operation.
            b) For adjustable circuit breakers, adjust protective device settings according to the coordination study. Comply with coordination study recommendations.
         4) Perform operational tests by initiating control devices.

B. Start-up and Testing of VFDs
   1. Perform tests and inspections with the assistance of a factory-authorized service representative.
   2. Acceptance Testing Preparation:
      a. Test insulation resistance for each VFD element, bus, component, connecting supply, feeder, and control circuit.
      b. Test continuity of each circuit.
   3. Tests and Inspections:
      a. Inspect VFD, wiring, components, connections, and equipment installation.
      b. Test insulation resistance for each VFD element, component, connecting motor supply, feeder, and control circuits.
      c. Test continuity of each circuit.
      d. Test each motor for proper phase rotation.
      e. Perform tests according to the Inspection and Test Procedures for Adjustable Speed Drives stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
      f. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
      g. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

C. Motor controller will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.5 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain switchgear.

END OF SECTION

SECTION 230517

SLEEVES, SLEEVE SEALS, AND ESCUTCHEONS FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes sleeves, sleeve seals, escutcheons, and related materials.

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.

2.2 GROUT

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

B. Characteristics: Non-shrink; recommended for interior and exterior applications.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.3 ESCUTCHEONS

A. One-Piece, Cast-Brass Type: With polished, chrome-plated or rough-brass finish and setscrew fastener.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.

C. Split-Casting Brass Type: With polished, chrome-plated or rough-brass finish and with concealed hinge and setscrew.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
   1. Sleeves are not required for core-drilled holes.

B. 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 above finished floor level.
   2. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.

C. 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 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.

D. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. See Section 230500 – General HVAC Provisions.

3.2 SLEEVE SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:
   1. Exterior Concrete Walls above Grade:
      a. Galvanized-steel wall sleeves.
   2. Concrete Slabs above Grade and Interior Partitions:
      a. Galvanized-steel-pipe sleeves.

3.3 ESCUTCHEONS

A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.

B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

C. Use one-piece, deep-pattern escutcheons for new piping where fittings would protrude from the wall and be exposed if standard escutcheons were used.

D. Escutcheons for New Piping:
   1. Finished Areas: One-piece, cast-brass type with polished, chrome-plated finish.
   2. Unfinished Areas: One-piece, cast-brass type, rough brass finish.

E. Escutcheons for Existing Piping:
   1. Finished Areas: Split-casting brass type with polished, chrome-plated finish.
   2. Unfinished Areas: Split-casting brass type with rough brass finish.

F. Install floor plates for piping penetrations of equipment-room floors.

G. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
   1. New Piping: One-piece, floor-plate type.
   2. Existing Piping: Split-casting, floor-plate type.

END OF SECTION

SECTION 230519

METERS AND GAGES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Thermometers, mounting brackets, and thermowells
2. Pressure gages and gage attachments
3. Test plugs
4. Hydronic sight flow indicators
5. Hydronic flow meters
6. Air pressure indicators

1.2 ACTION SUBMITTALS

A. Provide submittals for products listed in the Product Table below in accordance with Section 23 05 00 – General HVAC Provisions. Submittal requirements indicated by column number designation as follows:
1. Materials List
2. Catalog Data
3. Product Data
4. Performance Data
5. Wiring Diagrams
6. Shop Drawings
7. Installation Instructions
8. Special Requirement listed herein.

PRODUCT TABLE	1	2	3	4	5	6	7	8
Thermometers, Thermowells, and Accessories		X						
Pressure Gauges and Gauge Attachments		X						
Test Plugs		X						
Air Pressure Indicators		X						

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For meters and gages to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 THERMOMETERS, THERMOWELLS, AND ACCESSORIES

A. Bimetallic-Actuated Thermometers
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Ashcroft Inc.
   b. Marsh Bellofram
   c. Palmer Wahl Instrumentation Group
   d. Trerice, H. O. Co.

e. Weiss Instruments, Inc.
2. Standard: ASME B40.200.
3. Case: Liquid-filled and sealed type(s); stainless steel with 5-inch nominal diameter.
4. Dial: Non-reflective aluminum with permanently etched scale markings and scales in degrees F.
5. Connector Type(s): Union joint, adjustable angle, rigid back, or rigid bottom selected for ease of reading. Unified-inch screw threads.
6. Connector Size: 1/2 inch, with ASME B1.1 screw threads.
7. Stem: 0.25 or 0.375 inch in diameter; stainless steel.
8. Window: Double strength glass or plastic.
9. Ring: Stainless steel.
10. Element: Bimetal coil.
11. Pointer: Dark-colored metal.
12. Scale: Scale: Select the proper scale range so that the operating temperature of the material being measured will be approximately in the middle of the scale. 100°F range, or as required to span entire normal operating range whichever is greater.
13. Accuracy: Plus or minus 1 percent of scale range.

B. Filled-System Thermometers
1. Direct-Mounted, Metal-Case, Vapor-Actuated Thermometers:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Ashcroft Inc.
b. Marsh Bellofram
c. Palmer Wahl Instrumentation Group
d. Trerice, H. O. Co.
3. Standard: ASME B40.200.
4. Case: Sealed type, stainless steel; 4-1/2-inch nominal diameter.
5. Element: Bourdon tube or other type of pressure element.
6. Movement: Mechanical, dampening type, with link to pressure element and connection to pointer.
7. Dial: Non-reflective aluminum with permanently etched scale markings graduated in degrees F.
8. Pointer: Dark-colored metal.
9. Window: Double strength glass or plastic.
10. Ring: Stainless steel.
11. Connector Type(s): Union joint, adjustable, 180 degrees in vertical plane, 360 degrees in horizontal plane with locking device. Alternately rigid, back or rigid bottom. ASME B1.1 screw threads. Select connector for ease of reading.
12. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.
a. Design for Air-Duct Installation: With ventilated shroud.
b. Design for Thermowell Installation: Bare stem.
13. Scale: Black printing on white. 40°F to 160°F range, 2-degree increments.
14. Accuracy: Plus or minus 1 percent of scale range.

C. 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 and PVC Piping: CNR or CUNI.
4. Material for Use with Steel Piping: CRES.
5. Type: Stepped shank unless straight or tapered shank is indicated.
6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, ASME B1.20.1 pipe threads.
7. Internal Threads: 1/2, 3/4, and 1 inch, 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.
12. Heat-Transfer Medium: Mixture of graphite and glycerin.

2.2 PRESSURE GAGES AND GAGE ATTACHMENTS

A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Ashcroft Inc.
   b. Marsh Bellofram
   c. Palmer Wahl Instrumentation Group
   d. Trerice, H. O. Co.
   e. Weiss Instruments, Inc.
2. Standard: ASME B40.100.
3. Case: Liquid-filled type; cast aluminum or drawn steel; 4-1/2-inch nominal diameter.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with NPS 1/4, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is required.
6. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Dial: Non-reflective aluminum with permanently etched scale markings graduated in psi.
8. Pointer: Dark-colored metal.
9. Window: Double strength glass or plastic.
10. Ring: Metal, Friction fit.
11. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.
12. Scale: Black printing on white. 270-degree arc, 0 to 60 range, 1 psi increments. 0 to 100 psi range, 1 psi increments, or as required for system pressure encountered. Range selected so that operating pressure approximately half of full range or maximum scale value exceeds maximum pressure, whichever scale range is greater.

B. Gage Attachments
1. Snubbers: ASME B40.100, brass; with NPS 1/4, ASME B1.20.1 pipe threads and piston or porous-metal-type surge-dampening device. Include extension for use on insulated piping.
2. Siphons: Loop-shaped section of brass pipe with NPS 1/4 pipe threads.
3. Valves: Brass ball, with NPS 1/4, ASME B1.20.1 pipe threads.

2.3 TEST PLUGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Sisco Manufacturing Company, Inc.
2. Trerice, H. O. Co.
3. Watts, a Watts Water Technologies company
4. Weiss Instruments, Inc.

B. Description: Test-station fitting made for insertion into piping tee fitting.

C. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.

D. Thread Size: NPS 1/4, ASME B1.20.1 pipe thread.

E. Minimum Pressure and Temperature Rating: 500 psig at 200°F.

F. Core Inserts: Chlorosulfonated polyethylene synthetic acceptable for air, gas, oil, and water. EPDM self-sealing rubber acceptable for air and water only.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install all equipment in accordance with manufacturer's recommendations.

B. Thermometers
1. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.
2. Install duct-thermometer mounting brackets in walls of ducts. Attach to duct with screws.

C. Thermowells
1. Install thermowells with socket extending to center of pipe and in vertical position in piping tees.
2. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.
3. Install thermowells with extension on insulated piping.
4. Fill thermowells with heat-transfer medium.

D. Pressure Gauges
1. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.
2. Install valve and snubber in piping for each pressure gage for fluids (except steam).
3. Sight Install valve and syphon fitting in piping for each pressure gage for steam.

E. Test Plugs
1. Install test plugs in piping tees.
2. Location:
   a. Provide test plugs where shown on Drawings.
   b. Provide test plug immediately adjacent to each control system component that senses temperature or pressure. For differential pressure transmitters, provide test plug adjacent to both high pressure and low-pressure sensing ports.
3. Arrangement:
   a. Install so temperature probe and pressure gauge probe can easily be inserted and removed with no obstruction.

3.2 CONNECTIONS

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

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.

END OF SECTION

SECTION 230523

VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Valves for HVAC service.

1.2 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene copolymer rubber.

C. RS: Rising stem.

1.3 ACTION SUBMITTALS

A. Catalog Data: For each type of valve.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:
1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, grooves, and weld ends.
3. Set angle and globe valves closed to prevent rattling.

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

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

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Source Limitations for Valves: Obtain each type of valve from single manufacturer.

B. ASME Compliance:
1. ASME B1.20.1 for threads for threaded-end valves.
2. ASME B16.1 for flanges on iron valves.
3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
4. ASME B31.1 for power piping valves.
5. ASME B31.9 for building services piping valves.

C. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.

D. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.

E. Valve Pressure and Temperature Ratings: Not less than indicated and as required for maximum system pressures and temperatures. If valves with specified SWP classes or CWP ratings are unavailable, the same types of valves with higher SWP classes or CWP ratings may be substituted.

F. Valve Sizes: Same as upstream piping unless otherwise indicated.

G. Valves in Insulated Piping:
1. Include 2-inch stem extensions.
2. Ball Valves:
   a. Extended operating handle of nonthermal-conductive material, and protective sleeves that allow operation of valves without breaking the vapor seals or disturbing insulation.
   b. Memory stops shall be fully adjustable after insulation is applied.

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

2.2 GATE VALVES

A. NPS 2 and Smaller.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Apollo Valves.
   b. Crane; Crane Energy Flow Solutions.
   c. Hammond Valve.
   d. Jenkins Valves; Crane Energy Flow Solutions.
   e. Milwaukee Valve Company.
   f. NIBCO INC.
   g. Stockham; Crane Energy Flow Solutions.
2. Class 125, Bronze Gate Valve:
   a. Standard: MSS SP-80, Type 1. Rising stem or non-rising stem as indicated.
   b. CWP Rating: 200 psig.
   c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
   d. Ends: Threaded.
   e. Stem: Bronze.
   f. Disc: Solid wedge; bronze.
   g. Packing: Asbestos free.
   h. Handwheel: Malleable iron or bronze.

B. PS 2-1/2and Larger:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Apollo Valves.
   b. Crane; Crane Energy Flow Solutions.
   c. Hammond Valve.
   d. Jenkins Valves; Crane Energy Flow Solutions.
   e. Milwaukee Valve Company.
   f. NIBCO INC.
   g. Stockham; Crane Energy Flow Solutions.
2. Class 125, Iron Gate Valve:
   a. Standard: MSS SP-70, Type I. Rising stem or non-rising stem as indicated.
   b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
   c. NPS 14 to NPS 24, CWP Rating: 150 psig.
   d. Body Material: ASTM A 126, gray iron with bolted bonnet.
   e. Ends: Flanged.
   f. Trim: Bronze.

g. Disc: Solid wedge.
h. Packing and Gasket: Asbestos free.

2.3 BALL VALVES

A. NPS 2 and Smaller:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Apollo Valves.
b. Hammond Valve.
c. Jenkins Valves; Crane Energy Flow Solutions.
d. Milwaukee Valve Company.
e. NIBCO INC.
f. Stockham; Crane Energy Flow Solutions.
g. Watts; a Watts Water Technologies company.
2. Bronze Ball Valves with Stainless-Steel Trim:
a. Standard: MSS SP-110.
b. SWP Rating: 150 psig.
c. CWP Rating: 600 psig.
d. Body Design: Two-piece.
e. Body Material: Bronze.
f. Ends: Threaded.
g. Seats: PTFE.
h. Stem: Stainless-steel.
i. Ball: Stainless-steel.
j. Port: Full.

2.4 BUTTERFLY VALVES

A. NPS 2-1/2and Larger, Lug Type:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Apollo Valves.
b. Hammond Valve.
c. Jenkins Valves; Crane Energy Flow Solutions.
d. Milwaukee Valve Company.
e. NIBCO INC.
f. Stockham; Crane Energy Flow Solutions.
2. 200 CWP Lug Type Butterfly Valve:
a. Standard: MSS SP-67, Type I.
b. CWP Rating: 200 psig.
c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
d. Body Material: ASTM A 126, cast-iron or ASTM A 536, ductile iron.
e. Seat: EPDM.
f. Stem: One- or two-piece stainless-steel.
g. Disc: Bronze, or stainless-steel.

B. Valve Actuator Types:
1. Handlever: For valves NPS 6 and smaller.
2. Actuator Extension: Suitable for insulation thickness required, but not less than 2-inches.
3. Adjustable Travel Stops: Open and closed position mechanical travel stops that limit valve movement to specific degrees of rotation, field adjustable, stop screws, externally adjustable for gear actuators.

4. Chainwheel: Device for attachment to gear, stem, or other actuator of size and with chain for mounting height, according to "ChainWheels."

2.5 CHECK VALVES

A. NPS 2-1/2and Larger, Pump Discharge:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Hammond Valve.
   b. Metraflex Company (The).
   c. Milwaukee Valve Company.
   d. Mueller Steam Specialty.
   e. NIBCO INC.
   f. Spence Engineering Company, Inc.
2. All Service:
   a. Class 125, Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat:
      1) Standard: MSS SP-125.
      2) Why is this 200 psi and not 125. 200 seams excessive
      3) NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
      4) NPS 14 to NPS 24, CWP Rating: 150 psig.
      5) Body Material: ASTM A 126, gray iron.
      6) Style: Compact wafer.
      7) Seat: Bronze.

PART 3 - EXECUTION

3.1 EXAMINATION

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

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

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

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

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

3.2 VALVE INSTALLATION

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

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

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

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

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

1. Swing Check Valves: In horizontal position with hinge pin level.
2. Center-Guided Check Valves: In horizontal or vertical position, between flanges.
3. Install check valves a minimum of five pipe diameters away from changes of direction, pumps, or equipment that can generate turbulent flow in piping.

3.3 ADJUSTING

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

3.4 GENERAL VALVE APPLICATIONS

A. Drain Valves:
1. Where drain valves are required, include hose end connection and cap with EDPM gasket.
2. Provide drain down valves at the low point in each zone, area of service, or floor level.
3. Provide drain down valves to drain equipment.

B. Gauge Stop Valves:
1. Size to match gauge connection.

C. Provide valves for isolation of services as shown on Drawings and at the following locations:
1. Where piping penetrates the building envelope.
2. Where piping enters the building from a tunnel.
3. At branch connections from piping risers at each floor.
4. Major branches and branches to remote equipment or fixtures for all supply and return systems.
5. As required to individually isolate all equipment and maintainable devices including automatic air vents and hydronic control valves.
6. Where piping penetrates mechanical room walls. Locate valve inside mechanical room.
7. Branch connections for utility systems including piping in utility tunnels.

D. Provide valves where recommended by equipment manufacturer’s installation instructions.

3.5 VALVE SCHEDULE

A. If valve type shown on drawings is different than type indicated below, notify Engineer prior to ordering to verify type.

B. General, Chilled Water,, Service
1. General Shutoff Service
   a. NPS 2 and smaller: Ball Valves with Stainless Steel Trim
   b. NPS 2-1/2 and Larger: 200 CWP Lug Type Butterfly Valve,
2. Check Valve Service:
   a. NPS 2 and Smaller: Class 125, Bronze Swing Check Valve.
   b. NPS 2-1/2 and Larger, Standard Service: Class 250, Iron Swing Check Valve.
   c. NPS 2-1/2 and Larger, Pump Discharge: Class 125, Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat.

END OF SECTION

SECTION 230529

HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this section.

B. Specification 230548: Vibration and Seismic Controls for HVAC.

C. Specification 233113: Metal Ductwork.

1.2 SUMMARY

A. Design and installation of hangers and supports for HVAC piping and equipment provided in Division 23.

1.3 DEFINITIONS

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

B. ASME: American Society of Mechanical Engineers

C. MFMA: Metal Framing Manufacturers Association

D. ASCE: American Society of Civil Engineers

E. ASTM: American Society for Testing and Materials

1.4 PERFORMANCE REQUIREMENTS

A. 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. Supports for multiple pipes, including pipe stands, shall be capable of supporting combined weight of supported systems, system contents, and test water.
   2. Equipment supports shall be capable of supporting combined operating weight of supported equipment and connected systems and components.

1.5 ACTION SUBMITTALS

A. Provide submittals for products listed in the Product Table below in accordance with Section 230500 – General HVAC Provisions Submittal requirements indicated by column number designation as follows:
   1. Materials List
   2. Catalog Data
   3. Detailed Data
   4. Performance Data
   5. Wiring Diagrams
   6. Shop Drawings
   7. Installation Instructions

8. Special Requirement listed herein.
9.

PRODUCT TABLE	1	2	3	4	5	6	7	8
Pipe Hangers and Supports		X						
Thermal Hanger Shield Inserts		X						

B. Shop Drawings:
1. Plans showing type and location of supports and assemblies. Provide full or half size copies of piping plans from the Contract Documents or coordination drawings, showing location and type of each support component to be installed. Drawings shall consist of mechanically reproduced copies of the Contract Documents, or new drawings custom drafted specifically for the Work of this Project. Each drawing shall be printed on a single sheet.
2. Detail fabrication and assemblies for support assemblies including metal framing systems, equipment supports, trapeze hangers, pipe support stands to comply with performance requirements and design criteria. Assemblies may be pre-engineered or custom designed for the application.
3. Detail anchorages and attachments to structure. Where walls, floors, slabs or supplementary steel work are used for support, details of acceptable attachment methods must be included and approved before the condition is accepted for installation. Drawings must include spacing and static loads at all attachment and support points.

C. Delegated-Design Submittal:
1. Provide a delegated submittal package comprised of drawings, details, and calculations signed and sealed by an engineer specializing in the associated work and registered in Oregon. Submittals shall include device dimensions, placement, and attachment and anchorage requirements.

1.6 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 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: Pre-galvanized or hot dipped.
3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
4. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

B. Copper-Coated 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 copper-coated 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 INSULATION INSERTS

A. General: Insulation insert for use with MSS Type 40 protection shield

B. Insulation-Insert Material for Cold Piping:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Foamglas
2. ASTM C 552, Type II cellular glass with 100-psig minimum compressive strength and vapor barrier.
3. ASTM C1126 Type III phenolic foam with factory laminated ASJ.
   a. 1-1/2” to 2-1/2” pipe size: 32 psi at load point.
   b. 3” to 6” pipe size: 85 psi at load point.
   c. 8” to 12” pipe size: 135 psi at load point

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 beyond sheet metal shield for piping operating below ambient air temperature.

2.4 FASTENER SYSTEMS

A. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated 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 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, non-shrink and nonmetallic grout; suitable for interior and exterior applications.
1. Properties: Non-staining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi, 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-89Install 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-89Arrange 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. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.

D. Fastener System Installation:
   1. 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. Install hangers and supports to allow controlled thermal 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.

G. Install lateral bracing with pipe hangers and supports to prevent swaying Coordinate with Section 230548 – Vibration and Seismic Controls for interrelated work.

H. Install building attachments within concrete slabs or to structural steel where possible. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 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.

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

J. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes.

K. Insulated Piping:
   1. Piping Operating less than 180 degrees:
      a. All Piping 1-1/2-inches and Larger: Provide Insulation Insert with MSS Type 40 protection shield.
      b. All Piping 1-1/4-inches and smaller: Provide MSS Type 40 protection shield.
   2. Shield Dimensions for Pipe: Not less than the following:
      a. NPS (Nominal Pipe Size) 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
   3. Insulation Inserts: 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 and equipment supports.

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

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

3.5 HANGER SPACING

A.

HYDRONIC PIPING SPACING TABLE	Maximum Horizontal Span	Maximum Vertical Spacing
Carbon Steel Stainless-		
1-1/4 inch and smaller	7 feet	15
1-1/2 inch to 2-1/2 inch	10 feet	15
3 inch and larger	12 feet	15
Copper Tubing		
¾ inch and smaller	5 feet	10
1 inch to 2 inch	7 feet	10
2-1/2 inch and larger	10 feet	10

3.6 ROD SIZES

A. Select rod diameter to not exceed the maximum safe load listed in Table 2 of MSS SP-58-2009.

3.7 HANGER AND SUPPORT TYPE SCHEDULE

A. Single Pipe, Hung and Insulated
1. Operating Temperature Less Than 140 Degrees: Steel Clevis, MSS Type 1
2. Operating Temperature 140 Degrees and Above.
   a. NPS ½ to NPS2: Steel Clevis, MSS Type 1.
   b. NPS 3 and Larger: Adjustable Roller Hanger: Type 43.

B. Multiple Pipe Trapeze or Pipe Rack: Trapeze Hanger, MSS Type 59.
1. Insulated Piping: Adjustable Roller, MSS Type 43.

C. Single Pipe Floor Support: Adjustable Pipe Support Saddle: MSS Type 38.

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

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

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

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

H. To eliminate the need for seismic restraint, for piping installation where the distance from the top of the pipe to the structure is 12 inches or less for the entire run, select hanger-rod and building attachments to allow pipe movement without stress on hangers and attachments.

I. Hanger-Rod Attachments: Unless otherwise indicated, provide the following types:
1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450°F piping installations.
3. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
4. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450°F piping installations.

J. Building Attachments: Unless otherwise indicated, provide 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. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod use one of the following for indicated loads:
    a. Light (MSS Type 31): 750 lb.
    b. Medium (MSS Type 32): 1500 lb.
    c. Heavy (MSS Type 33): 3000 lb.
13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

K. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications.

L. Comply with MFMA-103 for metal framing system selections and applications.

M. Use mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION

SECTION 230548

VIBRATION AND SEISMIC CONTROLS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Related Requirements: Seismic restraint of roof mounted equipment that will not be equipped with vibration isolation, See Section 230500 – General HVAC Provisions related to roof curbs, bases, and rails.

1.2 DEFINITIONS

A. OSHPD: Office of Statewide Health Planning & Development (for the State of California).

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.
1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device and seismic-restraint component required.
   a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.
   b. Annotate to indicate application of each product submitted and compliance with requirements.
3. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

B. Shop Drawings:
1. Detail fabrication and assembly of equipment bases. Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

C. Delegated-Design Submittal:
1. Provide a delegated submittal package comprised of drawings, details, and calculations signed and sealed by an engineer specializing in the associated work and registered in Oregon. Submittals shall indicate full compliance with the device specification in Part 2. Any deviation shall be specifically noted and subject to engineer approval. Submittals shall include device dimensions, placement, and attachment and anchorage requirements.
2. All restraining devices shall have a pre-approval number from California OSHPD or some other organization acceptable to the Authority Having Jurisdiction. Where pre-approved devices are not available, provide submittals based on independent testing or calculations stamped by a registered professional engineer with at least five years of seismic design experience and licensed in the state of Oregon.
3. Ductwork and Piping Restraint:
   a. Provide full or half size copies of ductwork and piping plans from the Contract Documents or coordination drawings, showing location and type of each vibration isolation component and seismic restraint to be installed. Drawings shall consist of mechanically reproduced copies of the Contract Documents, or new drawings

custom drafted specifically for the Work of this Project. Each drawing shall be printed on a single sheet.

b. Provide piping and ductwork restraint assembly construction and installation details. Assemblies may be pre-engineered or custom designed for the application.

c. Where walls, floors, slabs or supplementary steel work are used for seismic restraint locations, details of acceptable attachment methods for ducts and pipe must be included and approved before the condition is accepted for installation. Restraint manufacturers' submittals must include spacing, static loads and seismic loads at all attachment and support points.

4. Equipment Restraint
   a. Select vibration isolators and accessories as scheduled and as required to meet seismic restraint requirements.
   b. Provide equipment seismic restraint assembly construction and installation details. Assemblies may be pre-engineered or custom designed for the application. Include method of attachment to supporting structure.
   c. Provide specific details of seismic restraints and anchors; include number, size and locations for each piece of equipment.
   d. For equipment mounted outdoors, include wind load in determining the necessary attachment and restraint requirements.
5. Calculations: Provide design calculations to verify that seismic and wind load restraint will comply with the current Oregon Structural Specialty Code for the site and the building type listed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Provide seismic and wind load design in accordance with the current Oregon State Structural Specialty Code and ASCE/SEI 7.

B. Refer to structural notes for project specific seismic requirements.

C. Risk Category: II

D. Component Importance Factor (Ip)
   1. As required by Code

2.2 ELASTOMERIC ISOLATION PADS

A. Elastomeric Isolation Pads: (EP-1)
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Kinetics Noise Control, Inc.
      b. Mason Industries, Inc.
      c. Vibro-Acoustics
   2. Basis of Design: Mason Type Super WM Pads.
   3. Fabrication: Neoprene waffle pad. 3/4-inch thick. 40 durometer. ¼-inch thick steel load distribution plate
   4. Size: Factory or field cut to match requirements of supported equipment.
   5. Accessories: Bolt isolator washer bushings where equipment is bolted to structure. Similar to Mason Type HG

2.3 RESTRAINED ELASTOMERIC ISOLATION MOUNTS

A. Double Deflection Restrained Elastomeric Isolation Mounts: (EM-1)
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Kinetics Noise Control, Inc.
      b. Mason Industries, Inc.
      c. Vibro-Acoustics
   2. Basis of Design: Mason Industries Type BR.
   3. General: Neoprene mountings with a minimum static deflection of 0.2-inches and all directional seismic capability. Constructed with ductile iron casting containing two separated and opposing molded neoprene elements.

2.4 FREE STANDING SPRING MOUNTS

A. Laterally Stable, Open-Spring Mount: (SM-1).
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Kinetics Noise Control, Inc.
      b. Mason Industries, Inc.
      c. Vibro-Acoustics
   2. Basis of Design: Mason Industries Type SLF
   3. General: Free-standing spring isolators. Laterally stable without housing. Complete with molded neoprene cup or ¼-inch neoprene acoustical friction pad between the baseplate and the support.
   4. Provided with leveling bolts rigidly bolted to the equipment.
   5. Spring diameters not less than 80% of the spring height at rated load.
   6. Minimum additional travel to solid equal to 50% of the rated defection.

B. Freestanding, Seismically Restrained, Open-Spring Isolators: (SM-2)
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Kinetics Noise Control, Inc.
      b. Mason Industries, Inc.
      c. Vibro-Acoustics
   2. Basis of Design: Mason Industries Type SSLFH
   3. Free standing laterally supported with neoprene cup or ¼ inch neoprene acoustical friction pads between spring and support. Leveling bolts.
   4. Spring diameter no less than 80 percent of the compressed height of the spring at rated load.
   5. Spring to have an additional minimum travel to solid equal to 50 percent of the rated deflection.
   6. Ductile iron or steel housing to resist motion due to earthquake loads in all directions. Minimum 0.5 G rating.
   7. Minimum clearance of ¼-inch to be maintained between the restraining bolts and a molded neoprene bushing so as not to interfere with spring action
   8. The housing shall be out of contact during normal operating.
   9. Deflection as scheduled.

C. Freestanding, Seismically and Vertically Restrained, Open-Spring Isolators: (SM-3)
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Kinetics Noise Control, Inc.
      b. Mason Industries, Inc.
      c. Vibro-Acoustics
   2. Basis of Design: Mason Industries Type SLR or SLRS

3. Free standing springs, laterally stable and complete with a molded neoprene cup or 1/4" neoprene acoustical friction pad between the spring and the mounting baseplate.
4. Spring diameter no less than 80 percent of the compressed height of the spring at rated load.
5. Spring to have an additional minimum travel to solid equal to 50 percent of the rated deflection.
6. Mount housing shall include vertical limit stops to prevent spring extension when weight is removed.
7. All restraining bolts shall have large rubber grommets to provide cushioning in the vertical and horizontal directions.
8. A minimum clearance of ¼-inch shall be maintained around restraining bolts so as not to interfere with the spring action.
9. Mountings shall have an Anchorage Preapproval Number from OSHPD in the State of California certifying the maximum certified horizontal and vertical load ratings.

2.5 RESTRAINT CHANNEL BRACINGS

A. Description: Restraint Channel With Cushion Clamp: (RC-1)

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. B-line, an Eaton business.
2. Hilti, Inc.
3. Mason Industries, Inc.
4. Vibro-Acoustics

C. Basis of Design: Mason Industries SSBS/SHB

D. Description: MFMA-4, shop- or field-fabricated bracing assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end. Provide other matching components. Corrosion-resistant coating; rated in tension, compression, and torsion forces.

E. Accessories:
1. Neoprene clamp cushion. Similar to Unistrut, Cush-A-Clamp

2.6 RESTRAINT CABLES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Kinetics Noise Control, Inc.
2. Mason Industries, Inc.
3. Vibro-Acoustics

B. Basis of Design: Mason Industries SCB/H

C. Restraint Cables: ASTM A 603 galvanized-steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; with a minimum of two clamping bolts for cable engagement.

2.7 MECHANICAL ANCHOR BOLTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. B-line, an Eaton business

2. Hilti, Inc.
3. Kinetics Noise Control, Inc.
4. Mason Industries
5. Vibro-Acoustics

B. Basis of Design: Mason Industries SASE, SAST

C. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.8 ADHESIVE ANCHOR BOLTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Hilti, Inc.
2. Kinetics Noise Control, Inc.
3. Mason Industries
4. Vibro-Acoustics

B. Basis of Design: Mason Industries SRA

C. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing PVC or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.9 SEISMIC-RESTRAINT ACCESSORIES

A. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections or reinforcing steel angle clamped to hanger rod.

B. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings and restraint cables.

C. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings and matched to type and size of anchor bolts and studs.

D. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings and matched to type and size of attachment devices used.

E. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

PART 3 - EXECUTION

3.1 GENERAL

A. Coordinate locations and sizes of structural supports with locations of vibration isolators and seismic/wind restraints (e.g., roof curbs, etc.).

B. Isolated and restrained equipment, duct and piping located on roofs must be attached to the structure. Intermediate supports between the restraint and structure that are not

attached to the structure must be approved the project structural engineer or by the restraint manufacturer.

C. Block and shim all bases level so that all ductwork, piping and electrical connections can be made to a rigid system at the proper operating level before isolators are adjusted. Ensure that there are no rigid connections or incidental physical contacts between isolated equipment and the building structure or nearby systems.

D. Ensure housekeeping pads have adequate space to mount equipment and isolator housings and shall also be large enough to ensure adequate edge distance for isolator anchors to prevent breakout.

E. Select and locate vibration isolation equipment to give uniform loading and deflection, according to weight distribution of equipment.

3.2 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic- and wind-control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine rough-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

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

3.3 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application.

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

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

3.4 VIBRATION CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Install all equipment in accordance with manufacturer’s recommendations and as shown on seismic design documents.

B. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.

C. Elastomeric Isolation Pads: Provide for entire weight bearing surface of equipment base, or as recommended by equipment manufacturer.

D. Equipment Restraints:
1. Install seismic snubbers on HVAC equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.

2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
3. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.

E. Ductwork Restraints:
1. Space lateral supports a maximum of 40 feet on center and longitudinal supports a maximum of 80 feet on center.
2. Brace a change of direction longer than 12 feet.
3. Provide spring hangers supports for the first three supports from any equipment that produces vibration.

F. Piping Restraints:
1. Comply with requirements in MSS SP-127.
2. Space lateral supports a maximum of 40 feet on center and longitudinal supports a maximum of 80 feet on center.
3. Brace a change of direction longer than 12 feet.
4. Provide spring hangers or spring floor supports for the first three supports from any equipment that produces vibration.
5. Provide spring hangers or spring floor supports for the first three supports from any vertical riser 1-1/2 inch and larger and greater than 20 feet in elevation.

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

H. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.

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

J. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

K. 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.

L. 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 engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid pre-stressed 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. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque, using a torque wrench.

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

3.5 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Equipment Piping Connection:
   1. Provide flexible pipe connectors at all equipment connections to allow seismic motion of piping relative to equipment. Refer to Section 232116 – Hydronic Specialties.
   2. Provide equipment connectors for all motor driven equipment and components connected to such equipment.
   3. Provide equipment connectors for non-motor drive equipment as detailed and as otherwise specified.
   4. Flexible connectors as listed in Section 232116 – Hydronic Specialties must be selected to allow seismic movement without exceeding acceptable nozzle loads on equipment connections. Acceptable nozzle loads provided by manufacturer.
   5. Install flexible pipe connectors and hoses on the equipment side of shutoff valves.

B. Building Seismic Joints:
   1. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Section 232116 – Hydronic Specialties for piping flexible connections.

3.6 FIELD QUALITY CONTROL

A. After installation of seismic and vibration control devices is complete and verified as fully functional, Contractor shall notify Engineer and seismic restraint designer that equipment is ready for inspection.

B. Seismic restraint system Engineer shall inspect the installation to verify that seismic restraints are installed and adjusted in conformance with approved shop drawings and no additional restraints are necessary based on field conditions. Alternately, the restraint system Engineer may designate a qualified representative to provide the inspection. The representative may not be an employee of the installing Contractor or Subcontractor.

C. Prepare inspection reports.

3.7 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.

3.8 HVAC VIBRATION CONTROL AND SEISMIC RESTRAINT DEVICE SCHEDULE

A.

VIBRATION ISOLATION AND SEISMIC RESTRAINT SCHEDULE			
EQUIPMENT	SPECIFICATION	SLAB ON GRADE	ABOVE GRADE (<20 ft Span)
		TYPE/STATIC DEFLECTION	TYPE/STATIC DEFLECTION
Pumps, base-mounted 150 hp	Snubbers Flexible connectors	SM-1 / 0.75”	SM-1 / 0.75”
Computer Room Units		SM-1 / 0.75”	SM-1 / 0.75”
Condensing Units		EP-1 / 0.25”	SM-3 / 0.75”
Rooftop Air Conditioning Units	None if internally isolated	EM-1 / 0.25”	SM-2 / 0.75”

END OF SECTION

SECTION 230553

IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Equipment labels.
2. Pipe labels.
3. Duct labels.
4. Valve tags.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

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

C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

D. Valve numbering scheme.

E. Valve Schedules: For each piping system to include in maintenance manuals.

PART 2 - PRODUCTS

2.1 GENERAL

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Brady Corporation.
2. Marking Services, Inc.
3. Seton Identification Products.

2.2 EQUIPMENT LABELS

A. Metal Labels for Equipment:
1. Material and Thickness: 0.025-inch aluminum. Predrilled or stamped holes for attachment hardware.
2. Letter Color: Black.
3. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
4. Minimum Letter Size: 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-quarters the size of principal lettering.
5. Fasteners: Stainless-steel rivets or self-tapping screws.
6. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:
   1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8-inch-thick, and having predrilled holes for attachment hardware.
   2. Engraved to show white lettering on black background except for labels attached to ceiling grid or located within finished spaces shall have black lettering on white background.
   3. Maximum Temperature: Able to withstand temperatures up to 160°F.
   4. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
   5. Minimum Letter Size: 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-quarters the size of principal lettering. Lettering on labels attached to ceiling grid largest size practical.
   6. Fasteners: Stainless-steel rivets or self-tapping screws.
   7. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

C. Label Content: Include equipment's Drawing designation or unique equipment number.

D. Equipment Label Schedule: For each item of equipment to be labeled, prepare equipment label schedule on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.3 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction according to ASME A13.1.

B. Pre-tensioned Pipe Labels: Pre-coiled, semi-rigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include an arrow indicating flow direction.
   1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
   2. Lettering Size: Size letters according to ASME A13.1 for piping.

2.4 DUCT LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8-inch-thick, and having predrilled holes for attachment hardware.

B. Letter Color: Yellow.

C. Background Color: Black.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

F. Minimum Letter Size: 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-quarters the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings; also include an arrow indicating flow direction.
   1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions or as separate unit on each duct label to indicate flow direction.

2.5 VALVE TAGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Brady Corporation.
   2. Marking Services Inc.
   3. Seton Identification Products.

B. Description: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.
   1. Tag Material: Polished brass, 0.025-inch aluminum and having predrilled or stamped holes for attachment hardware.
   2. Minimum Tag Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4-inch.
   3. Fasteners: Brass wire-link chain or S-hook.

C. Valve Schedules: For each piping system, on 8-1/2-by-11-inch 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-tag schedule shall be included in operation and maintenance data.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 GENERAL INSTALLATION REQUIREMENTS

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 locations of access panels and doors.

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

D. Ceiling Grids and Access Openings: Label ceiling grid and wall/ceiling access doors and to indicate key access points for equipment, valves, control devices and other components requiring quick access or routine maintenance. Provide a clear adhesive label and bold black lettering with component identification information, except were Owner has establish identification standard label in accordance with Owner's standards. Place label on ceiling metal grid and not on removable tiles.

3.3 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.4 PIPE LABEL INSTALLATION

A. Pipe Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
   1. Near each valve and control device.
   2. Near each flange.
   3. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
   4. Near penetrations and on both sides of walls, floors, ceilings, and inaccessible enclosures.
   5. At access doors, manholes, and similar access points that permit view of concealed piping.
   6. Near major equipment items and other points of origination and termination.
   7. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.

B. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.

C. Pipe Label Color Schedule: Letter and background color in accordance with ANSI A13.1.

3.5 DUCT LABEL INSTALLATION

A. Install self-adhesive duct labels with permanent adhesive on air ducts in the following color codes:
   1. Blue: For cold-air supply ducts.

B. Green: For exhaust-, outside-, relief-, return-, and mixed-air ducts.Locate labels near points where ducts enter into and exit from concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.

3.6 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves, valves within factory-fabricated equipment units, faucets, convenience and lawn-watering hose connections, and isolation valves for 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 with captions as indicated in the following subparagraphs:

1. Valve-Tag Information: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch valve tag numbers.
    a. Valve-Tag Information: Stamped or engraved with 1/4-inch letters and 1/2-inch valve tag numbers as listed below:
    b. Valve tag number.
    c. System abbreviation.
    d. Area served.
    e. Normal position.

END OF SECTION

SECTION 230593

TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Balancing air systems and equipment.
2. Balancing hydronic piping systems and equipment.
3. Testing, adjusting, and balancing existing systems and equipment.
4. Control system measurement and verification.

1.2 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. BAS: Building automation systems.

C. NEBB: National Environmental Balancing Bureau.

D. TAB Specialist: An independent entity meeting qualification to perform TAB work.

E. TAB Project Supervisor: Certified individual employed by balancing contractor having administrative and technical responsibility for work performed under this Section.

F. TAB: Testing, adjusting, and balancing.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: Within 15 days of Contractor's Notice to Proceed, submit documentation that the TAB specialist and this Project's TAB team members meet the qualifications specified in Part 1 "Quality Assurance" and Part 3 “TAB Specialist.”

B. Pre-construction TAB Reports:
1. Existing Conditions TAB Report: Within 30 days of Contractor's Notice to Proceed, submit the as specified in Part 3 “Procedures for Testing, Adjusting, and Balancing Existing Systems.”
2. Contract Documents Examination Report: Within 60 days of Contractor's Notice to Proceed, submit the Contract Documents review report as specified in Part 3 “Examination.”

C. Strategies and Procedures Plan: Within 60 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.

D. System Readiness Checklists: Within 60 days of Contractor's Notice to Proceed, submit system readiness checklists as specified in "Preparation" Article.

E. Instrument Calibration Report: Within 60 days of Contractor's Notice to Proceed. Report to include the following:
1. Instrument type and make.
2. Serial number.
3. Application.

4. Dates of use.
5. Dates of calibration.

F. Progress Reports: Submit the as specified in Part 3 “Progress Reporting.”

G. TAB reports.
1. Draft TAB Report
2. Certified Final TAB report.
3. Sound Test Report
4. Vibration Test Report
5. Verification of TAB Report

1.4 QUALITY ASSURANCE

A. All work under this Section shall be performed under the direction of the Certified TAB Supervisor.

B. TAB Specialists Qualifications: Certified by AABC or NEBB.
1. TAB Supervisor: Employee of the TAB specialist and certified by AABC or NEBB.
2. TAB Technician: Employee of the TAB specialist working under the supervision of the TAB Supervisor.

C. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."

1.5 FIELD CONDITIONS

A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

B. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 TAB SPECIALISTS

A. Subject to compliance with requirements, engage one of the following:
1. Air Balancing Specialties.
2. Air Introduction and Regulation, Inc.
3. Neudorfer Engineering, Inc.
4. Southern Oregon Engineering Services, Inc.

3.2 EXAMINATION

A. Contract Document Examination:
1. 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.

2. Confirm that balancing devices and provisions are included to facilitate TAB work. Provide listing of any devices and provisions required that are on included in the Contact Documents.
3. Contract Documents Examination Report: Based on examination of the Contract Documents, 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. Construction Examination:
1. Examine the approved submittals for HVAC systems and equipment.
2. Examine installed systems for 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 applicable for intended purpose and are accessible.
3. 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.
4. Examine ceiling plenums, underfloor air plenums, and vertical shaft plenums used for supply, return, or relief air to verify that they are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed airtight as required.
5. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.
6. Examine test reports specified in individual system and equipment Sections.
7. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.
8. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible, and their controls are connected and functioning.
9. Examine strainers. Verify that startup screens have been replaced by permanent screens with indicated perforations.
10. Examine control valves for proper installation and orientation for their intended function of throttling, diverting, or mixing fluid flows. Verify the pipe connections are in accordance with manufacturers recommendations.
11. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
12. Examine system pumps to ensure absence of entrained air in the suction piping.
13. 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.

3.3 PREPARATION

A. Strategies and Procedures Plan: Prepare a TAB plan that includes the following:
1. Equipment and systems to be tested.
2. Strategies and step-by-step procedures for balancing the systems.
3. Instrumentation to be used.
4. Sample forms with specific identification for all equipment.

B. Prepare system-readiness checks of HVAC systems and equipment to be executed by the Mechanical Contractor to verify system readiness for TAB work. Include, at a minimum, the following:
1. Airside:
a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.

b. Duct systems are complete with terminals installed.
c. Volume, smoke, and fire dampers are open and functional.
d. Clean filters are installed.
e. Fans are operating, free of vibration, and rotating in correct direction.
f. Variable-frequency controllers' startup is complete, and safeties are verified.
g. Automatic temperature-control systems are operational.
h. Ceilings are installed.
i. Windows and doors are installed.
j. Suitable access to balancing devices and equipment is provided.

2. Hydronics:
   a. Verify leakage and pressure tests on water distribution systems have been satisfactorily completed.
   b. Piping is complete with terminals installed.
   c. Water treatment is complete.
   d. Systems are flushed, filled, and air purged.
   e. Strainers are pulled and cleaned.
   f. Control valves are functioning per the sequence of operation.
   g. Shutoff and balance valves have been verified to be 100 percent open.
   h. Pumps are started and proper rotation is verified.
   i. Pump gage connections are installed directly at pump inlet and outlet flanges or in discharge and suction pipe prior to valves or strainers.
   j. Variable-frequency controllers' startup is complete, and safeties are verified.
   k. Suitable access to balancing devices and equipment is provided.

3.4 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" or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and in this Section.
   1. Comply with requirements in ASHRAE 62.1, "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, install test ports and duct access doors as required in Section 233300 – Air Duct Accessories. Otherwise, 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, and 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) units.

3.5 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Cross-check 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. Verify that motor starters are equipped with properly sized thermal protection.

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

H. Check for airflow blockages.

I. Check condensate drains for proper connections and functioning.

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

K. Verify that air duct system is sealed as specified in Section 233113 – Metal Ductwork.

L. Fan Pressure Measurements:
1. Measure static pressure directly at the fan outlet or through the flexible connection.
2. Measure static pressure directly at the fan inlet or through the flexible connection.
3. Measure static pressure across each component that makes up and air-handling system.

M. Air Inlets and Outlets:
1. Supply Diffusers: Set airflow patterns of adjustable outlets for proper distribution without drafts.

N. Control Parameters and Setpoints:
1. Minimum Ventilation Rates: Measure and adjust outside-air, return-air, and relief-air dampers for proper position to achieve minimum outdoor-air conditions. Determine setpoint values for specific control sequences controlling damper operation.
2. Record verification measurement. calibration parameters, and setpoints in Final TAB Report.

3.6 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports for pumps and coils. Obtain approved submittals and manufacturer-recommended testing procedures. Crosscheck the summation of required coil and heat exchanger flow rates with pump design flow rate.

B. In addition to requirements in "Preparation" Article, prepare hydronic systems for testing and balancing as follows:
1. Check highest vent for adequate pressure.
2. Check flow-control valves for proper position.
3. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
4. Verify that motor starters are equipped with properly sized thermal protection.
5. Check that air has been purged from the system.

C. Flow Adjustments:
1. Perform temperature tests after flows have been balanced.
2. Position 3-way control valves to bypass the coil and adjust the bypass valve to maintain design flow.

3. For pressure independent flow devices, measure differential pressure and verify that it is within manufacturer's specified range.
4. Adjust memory stops on balancing devices.

D. Pump Pressure Measurements:
1. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
2. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
3. Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.

E. Record verification measurement. calibration parameters, and setpoints in Final TAB Report.

3.7 ROCEDURES 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 for major (more than 20 gpm) equipment coils, excluding unitary equipment such as reheat coils, unit heaters, and fan-coil units.
4. Dry-bulb temperature of entering and leaving air.
5. Wet-bulb temperature of entering and leaving air for cooling coils.
6. Airflow.

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.
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 refrigerant coil:
1. Dry-bulb temperature of entering and leaving air.
2. Wet-bulb temperature of entering and leaving air.
3. Airflow.

3.8 PROCEDURES FOR MOTORS

A. Motor Measurement and Verification:
1. Motors 1/2 HP and Larger: Test at final balanced conditions and record the following data:
a. Manufacturer's name, model number, and serial number.
b. Motor horsepower rating.
c. Motor rpm.
d. Phase and hertz.
e. Nameplate and measured voltage, each phase.
f. Nameplate and measured amperage, each phase.
g. Starter size and thermal-protection-element rating.
h. Service factor and frame size.
2. Motors Driven by Variable-Frequency Controllers: Test manual bypass of controller to prove proper operation.

B. Motor Speed Adjustments:
   1. Obtain approval from Engineer for adjustment of fan motor speeds higher than the motor synchronous speed. indicated speed for induction motors
   2. Obtain approval from Engineer prior to making fan-speed adjustments that result in motor operation above the motor RLA. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required motor amperage.

3.9 CONTROLS VERIFICATION

A. In conjunction with system balancing, perform the following:
   1. Verify location and installation of sensors to ensure that they sense only intended temperature, humidity, or pressure.
   2. Verify that the system static pressure sensor is located in the duct or piping system as specified or as shown on drawings.
   3. Verify the operation of valve and damper actuators. Verify that controlled devices travel freely and are in position indicated by controller: open, closed, or modulating.

B. Reporting: Include a summary of verifications performed, remaining deficiencies, and variations from indicated conditions in Final Report.

3.10 TOLERANCES

A. Set HVAC system's airflow rates and water flow rates within the following tolerances:
   1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus 10 percent or minus 5 percent.
   2. Air Outlets and Inlets: Plus or minus 10 percent.
   3. Cooling-Water Flow Rate: Plus or minus 10 percent.

B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.11 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.
   3. Certify validity and accuracy of field data.

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. Test reports shall be fully executed reports forms confirming to standard NEBB or AABC documentation standards.
   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 specialist.

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. Settings for supply-air, static-pressure controller.
    g. 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 flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Balancing stations.
6. Position of balancing devices.

E. Instrument Calibration Reports:
1. Report Data:
    a. Instrument type and make.
    b. Serial number.
    c. Application.
    d. Dates of use.
    e. Dates of calibration.

3.12 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. Prepare Seasonal Test Report of measurements and adjustments.

END OF SECTION

SECTION 230713

DUCT INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulation of HVAC ductwork.

1.2 ACTION SUBMITTALS

A. Provide submittals in accordance with Section 230500 – General HVAC Provisions as follows:
   1. Provide catalog data for all products. Indicate thermal conductivity, water vapor permeance, and jackets (both factory and field applied) if any.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Insulation materials and accessories shall be installed in a professional manner by skilled and experienced workers who specialize in commercial insulation work.

B. 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.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.6 COORDINATION

A. Coordinate clearance requirements with duct Installer for duct insulation application. Before preparing ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

1.7 SCHEDULING

A. If duct leak testing is required, schedule insulation application after systems are tested and, where required. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Products shall not contain asbestos, lead, mercury, or mercury compounds.

B. 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.

C. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

D. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

E. Insulation jacket material shall be paintable where painting of the insulation jacket is specified.

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 III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. CertainTeed Corporation
      b. Johns Manville, a Berkshire Hathaway company
      c. Knauf Insulation

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. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. CertainTeed Corporation
      b. Johns Manville, a Berkshire Hathaway company
      c. Knauf Insulation

2.2 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.

C. FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

D. PVC Jacket Adhesive: Compatible with PVC jacket.

2.3 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below ambient services.
1. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
2. Service Temperature Range: Minus 20 to plus 180°F.
3. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
4. Color: White.

C. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below ambient services.
1. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 30-mil dry film thickness.
2. Service Temperature Range: Minus 50 to plus 220°F.
3. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
4. Color: White.

2.4 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:
1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250°F.
4. Color: Aluminum.

B. PSP and PVC Jacket Flashing Sealants:
1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250°F.
4. Color: White.

2.5 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. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with Kraft paper backing; complying with ASTM C 1136, Type II.
2. PSP Jacket: White poly-top with a permeance of 0.2 perms when tested according to ASTM E 96/E 96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.6 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. Self-Adhesive Outdoor Jacket:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. PolyGuard, Alumaguard.
2. Description: 60-mil- thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a cross-laminated polyethylene film covered with stucco-embossed aluminum-foil facing.

2.7 TAPES

A. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
   1. Width: 3 inches.
   2. Thickness: 6.5 mils.
   3. Adhesion: 90 ounces force/inch in width.
   4. Elongation: 2 percent.
   5. Tensile Strength: 40 lbf/inch in width.
   6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

B. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
   1. Width: 2 inches.
   2. Thickness: 6 mils.
   3. Adhesion: 64 ounces force/inch in width.
   4. Elongation: 500 percent.
   5. Tensile Strength: 18 lbf/inch in width.

C. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
   1. Width: 2 inches.
   2. Thickness: 3.7 mils.
   3. Adhesion: 100 ounces force/inch in width.
   4. Elongation: 5 percent.
   5. Tensile Strength: 34 lbf/inch in width.

2.8 SECUREMENTS

A. Insulation Pins and Hangers:
   1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
   2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
   3. 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. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
      b. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
      c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
   4. Self-Sticking-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. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
      b. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
      c. Adhesive-backed base with a peel-off protective cover.
   5. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick, galvanized-steel or aluminum sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

a. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

6. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
1. Verify that systems to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.

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

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.3 GENERAL 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- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge.
   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 beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.4 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 below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Interior Wall and Partition Penetrations (Not Fire Rated): Install insulation continuously through walls and partitions.

C. 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.

3.5 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, and manufacturer’s recommended 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 support pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
    a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
    b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches 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 over-compress 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 from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch 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°F at 18-foot 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.
5. 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.
6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches 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 manufacturer’s recommended 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 support pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
    a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
    b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches 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 over-compress 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 from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch 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°F at 18-foot 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.
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- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Owner reserves the right to perform tests and inspections.

B. Tests will include removing field-applied jacket and insulation in layers in reverse order of their installation for each duct system schedule as directed by the Owner.

C. If sample inspection reveals noncompliance with requirements, all similar insulation applications will be considered defective Work and will be replaced at no expense to the Owner.

3.7 DUCT INSULATION SCHEDULE

A. Insulate all plenums and ductwork as scheduled with the following exceptions.
   1. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
   2. Factory-insulated flexible ducts.
   3. Factory-insulated plenums and casings.
   4. Flexible connectors.
   5. Vibration-control devices.
   6. Factory-insulated access panels and doors.

B. Insulate ductwork located indoors in conditioned spaces:
   1. Supply Air.
      a. Insulate ductwork where the air supply temperature is:
         1) More than 10°F below that space cooling temperature setpoint or below 60°F.
         2) More than 15°F above the space heating temperature setpoint.
      b. Exposed rectangular ductwork:
         1) Mineral-Fiber Blanket: 2 inches thick and 0.75-lb/cu. ft. nominal density, PSP jacket.
      c. Concealed ductwork:

1) Mineral-Fiber Blanket: 2 inches thick and 0.75-lb/cu. ft. nominal density, FSK jacket.

d. Mechanical rooms, more than 8 feet above finished floor:
   1) Mineral-Fiber Blanket: 2 inches thick and 0.75-lb/cu. ft. nominal density, FSK jacket.
   2) Mineral-Fiber board, 1-1/2 inches thick and 3-lb/cu. ft. nominal density.

e. Mechanical rooms, less than 8 feet above finished floor:
   1) Mineral-Fiber board, 1-1/2 inches thick and 3-lb/cu. ft. nominal density.

C. Insulate supply and return ductwork located indoors in unconditioned spaces, or inside a wall between a conditioned and unconditioned space.

1. Supply and Return Air:
   a. Mineral-Fiber Blanket: 3 inches (50 mm) thick and 0.75-lb/cu. ft. nominal density, FSK jacket.

D. Insulate supply and return ductwork located outdoors:

1. Supply Air and Return Air
   a. Rectangular ductwork:
      1) Mineral-Fiber board, 2 inches thick and 3-lb/cu. ft. nominal density.

3.8 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. Ducts: Self-Adhesive Outdoor Jacket:

END OF SECTION

SECTION 230716

HVAC EQUIPMENT INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulation of HVAC equipment

1.2 ACTION SUBMITTALS

A. Provide submittals in accordance with Section 230500 – General HVAC Provisions as follows:
   1. Provide catalog data for all products. Indicate thermal conductivity and water vapor permeance.

1.3 QUALITY ASSURANCE

A. Insulation materials and accessories shall be installed in a professional manner by skilled and experienced workers who specialize in commercial insulation work.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products listed and labeled in accordance with UL 723 or 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.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.5 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 – Hangers and Supports for HVAC Piping and Equipment.

B. Coordinate clearance requirements with equipment Installer for equipment insulation application.

1.6 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Breeching Insulation Schedule" and "Equipment Insulation Schedule" articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Pre-manufactured Removable Insulation Systems
1. General: Removable and Re-useable insulation covers, custom engineered and manufactured for the specific application. Similar to Fit Tight Covers.
2. Construction
   a. Jacket and Liner: Silicon Impregnated Fiberglass Fabric
   b. Insulation: 1-inch Type E Glass Mat
   c. Fastening: 1-inch straps and stainless-steel D-rings.
   d. Thread: Kevlar/stainless steel thread.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
1. Verify that systems and equipment to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.

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

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment 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. Keep insulation materials dry during application and finishing.

E. Install insulation with least number of joints practical.

F. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

G. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

H. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.4 FIELD QUALITY CONTROL

A. Testing: The Owner reserves the right to perform tests and inspections of selected insulation sites at Owner’s cost for testing and repair.

B. Tests will include removing field-applied jacket and insulation in layers in reverse order of their installation for each piping system scheduled. If testing reveals defective work, all similar insulation sites will be considered defective, and Contractor will be responsible for cost of inspection and repair for all such sites.

3.5 EQUIPMENT INSULATION SCHEDULE

A. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.

B. Pump Housing:
1. Pre-manufactured Removable Insulation Systems

END OF SECTION

SECTION 230719

HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulating of above grade HVAC piping.

1.2 ACTION SUBMITTALS

A. Provide submittals for products listed in the Product Table below in accordance with Section 23 05 00 – General HVAC Provisions.
   1. Catalog Data.
   2. For each type of product listed, provide thermal conductivity and water-vapor permeance.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Insulation materials and accessories shall be installed in a professional manner by skilled and experienced workers who specialize in commercial insulation work.

B. Surface-Burning Characteristics: Products shall have flame spread and smoke developed ratings based on test procedures in accordance with NFPA-255 and UL 723. Rating shall be indicated on the product or on the shipping containers.
   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.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.6 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 23 05 29 – Hangers and Supports for HVAC Piping and Equipment.

B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. Coordinate installation and testing of heat tracing.

1.7 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Products shall not contain asbestos, lead, mercury, or mercury compounds.

B. 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.

C. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

D. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

E. Insulation jacket material shall be paintable where painting of the insulation jacket is specified.

F. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials. Listed and labeled per UL723 at 25/50, in plenum spaces.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Aeroflex USA, Inc.
      b. Armacell LLC.

G. Pre-manufactured Removable Insulation Systems
   1. General: Removable and Re-useable insulation covers, custom engineered and manufactured for the specific application. Similar to Fit Tight Covers.
   2. Construction
      a. Jacket and Liner: Silicon Impregnated Fiberglass Fabric
      b. Insulation: 1-inch Type E Glass Mat
      c. Fastening: 1-inch straps and stainless-steel D-rings.
      d. Thread: Kevlar/stainless steel thread.

2.2 ADHESIVES

A. Materials compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Flexible Elastomeric: Comply with MIL-A-24179A, Type II, Class I.

C. ASJ Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

D. PVC Jacket Adhesive: Compatible with PVC jacket.

2.3 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services.
1. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
2. Service Temperature Range: Minus 20 to plus 180°F.
3. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
4. Color: White.

2.4 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-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.

2.5 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. 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. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Johns Manville, a Berkshire Hathaway company
b. P.I.C. Plastics, Inc.
c. Proto Corporation
2. Adhesive: As recommended by jacket material manufacturer.
3. Color: White.
4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

C. Metal Jacket:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Childers Brand; H. B. Fuller Construction Products.
b. ITW Insulation Systems; Illinois Tool Works, Inc.
2. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.
a. Sheet and roll stock ready for shop or field sizing or factory cut and rolled to size.
b. Finish and thickness are indicated in field-applied jacket schedules.
c. Moisture Barrier for Indoor Applications: 3-mil- thick, heat-bonded polyethylene and Kraft paper.
d. Moisture Barrier for Outdoor Applications: 2.5-mil- thick polysurlyn.
e. Factory-Fabricated Fitting Covers:
1) Same material, finish, and thickness as jacket.
2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
3) Tee covers.
4) Flange and union covers.

5) End caps.
6) Beveled collars.
7) Valve covers.
8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2.6 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
1. Width: 3 inches.
2. Thickness: 11.5 mils.
3. Adhesion: 90 ounces force/inch in width.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch in width.
6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
1. Width: 2 inches.
2. Thickness: 6 mils.
3. Adhesion: 64 ounces force/inch in width.
4. Elongation: 500 percent.
5. Tensile Strength: 18 lbf/inch in width.

C. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
1. Width: 2 inches.
2. Thickness: 3.7 mils.
3. Adhesion: 100 ounces force/inch in width.
4. Elongation: 5 percent.
5. Tensile Strength: 34 lbf/inch in width.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
1. Verify that systems to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:
1. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

C. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.

B. 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.

C. Install insulation with longitudinal seams at top and bottom of horizontal runs.

D. Install multiple layers of insulation with longitudinal and end seams staggered.

E. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

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.
   4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

J. Where piping connections, accessories, or control components are attached to piping with an operating temperature less than 60ºF, insulate piping and projections where condensation may occur.
   1. Piping that has constant or intermittent flow: Insulate to match connected piping.
   2. Piping that does not have fluid flow including connections, nipple, wells or other accessories that penetrate insulation and are constructed from materials other than stainless steel, copper, brass, or plastic shall be insulation up to connected devices including pressure relief valves, field mounted control devices, pressure sensing tubing.

K. Apply insulation and jacket manufacturer approved adhesives, mastics, and sealants at recommended coverage rate and wet and dry film thicknesses.

L. Install insulation with factory-applied jackets as follows:
   1. Draw jacket tight and smooth.

2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install 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. 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 pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

P. For above-ambient services, do not install insulation to the following:
1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Manholes.
5. Handholes.
6. Cleanouts.

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

B. Seal penetrations with flashing sealant.

C. 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.

D. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.

E. Seal jacket to roof flashing with flashing sealant.

F. 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.
4. Seal jacket to wall flashing with flashing sealant.

G. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

H. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
1. Comply with requirements in Section 23 05 00 – General HVAC Provisions for firestopping and fire-resistive joint sealers.

3.5 Insulation Installation at Floor Penetrations:

3.6 Pipe: Install insulation continuously through floor penetrations.

3.7 Seal penetrations through fire-rated assemblies. Comply with requirements in Section 23 05 00 – General HVAC Provisions.

3.8 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:
1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover for removable basket flange. For below-ambient services, provide a design that maintains vapor barrier.
6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic

for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.

8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.9 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Installation shall follow the manufacturer's installation instructions or ASTM C 1710.

C. Insulation Installation on Pipe Flanges:

1. Install preformed valve covers manufactured of same material as pipe insulation when available.
2. Install pipe insulation to outer diameter of pipe flange.
3. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
4. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
5. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

E. Insulation Installation on Valves and Pipe Specialties:
1. Install preformed valve covers manufactured of same material as pipe insulation when available.
2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.10 FIELD-APPLIED JACKET INSTALLATION

A. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications. 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.

B. Where metal jackets are indicated, install 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.

3.11 FINISHES

A. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Flexible Elastomeric Thermal Insulation, Exterior Unjacketed: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

C. Do not field paint aluminum or stainless-steel jackets.

3.12 FIELD QUALITY CONTROL

A. Testing: The Owner reserves the right to perform tests and inspections of selected insulation sites.

B. Tests will include removing field-applied jacket and insulation in layers in reverse order of their installation for each piping system scheduled. If testing reveals defective work, all similar insulation sites will be considered defective, and Contractor will be responsible for cost of inspection and repair.

3.13 PIPING INSULATION THICKNESS

A. General
1. For piping smaller than 1-1/2 inches and located in partitions within conditioned spaces, reduction of thickness by 1-inch permitted to a thickness not less than 1-inch.

B. Insulation installed overheat trace for freeze protection: 1-inch thickness

C. Serviceable components, connections, and couplings.
1. Install Pre-manufactured Removable Insulation Systems at the following:
a. Valves, manual and automatic.
b. Flanges and unions requiring access to allow equipment service.
c. Mechanical couplings requiring access to allow equipment service.

D. Flexible Elastomeric Insulation
1.

FLEXIBLE ELASTOMERIC					
FLUID NORMAL OPERATING TEMPERATURE (°F)	NOMINAL PIPE OR TUBE SIZE (inches)				
	<1	1 to < 1.5	1.5 to < 4	4 to < 8	>= 8
141-200	1.5	1.5	2	2	2
105-140	1	1	1.5	1.5	1.5
40-60	0.5	0.5	1	1	1

3.14 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

B. For all systems with an operating temperature that may be below ambient conditions, a vapor barrier must be maintained.

C. For piping smaller than 1-1/2 inches and located in partitions within conditioned spaces, reduction of thickness by 1-inch is permitted to a thickness not less than 1-inch.

D. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
1. Drainage piping located in crawl spaces.
2. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.15 INDOOR PIPING INSULATION SCHEDULE

A. Chilled Water: Normal operating temperature range 42°F to 62°F:
1. Flexible Elastomeric

B. Condensate: Normal operating temperature range 42°F to 62°F:
1. Flexible Elastomeric

C. Refrigerant Suction and Hot-Gas Piping, Operating temperature 125°F:
1. Flexible Elastomeric

3.16 OUTDOOR PIPING INSULATION

A. Refrigerant Suction and Hot-Gas Piping, Operating temperature 125°F:
1. Flexible Elastomeric

3.17 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Subject to Damage: Piping located in mechanical rooms within 6-feet of floor level, across passageways, or otherwise exposed to physical damage as determined by the Owners Authorized Representative:
1. PVC: 30 mils thick.
2. Aluminum, Corrugated: 0.024 inch thick.

3.18 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Provide jacketing for all outdoor insulated piping.

B. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

C. If more than one material is listed, selection from materials listed is Contractor's option.

D. Piping, Exposed:
1. Aluminum, Stucco Embossed: 0.020 inch (0.51 mm) thick.

END OF SECTION

SECTION 230923

BUILDING AUTOMATION SYSTEMS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Work hereunder includes a complete and operational, fully tested, distributed logic, building automation system (BAS) for control of systems and equipment specified in Divisions 22 and 23. Associated work includes but is not limited to:
   1. A network of stand-alone, microprocessor-based building controllers, advanced application controllers, and application specific controllers.
   2. A dynamic color graphics, pc-based workstation, with printers.
   3. Communication, control wiring, power circuits, power supplies, and power wiring as required.
   4. Building operation and energy management software and related programming including complete licensing agreement for complete use and access of software required for installation, configuration, programming, and operation.
   5. Field Mounted Devices as specified in Section 23 09 25 – BAS Field Mounted Devices for HVAC.
   6. Control sequences as specified in Section 23 09 29 – BAS Sequence of Operations for HVAC.
   7. Other materials and devices not shown as part of other work but necessary to provide mechanical and electrical system control and monitoring sequences specified.

1.2 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

A. Control Contractor to coordinate with other trades to ensure delivery and correct installation of products furnished but not installed under this section. Coordination to include a review of schedule, manufacturer's installation requirements, and equipment locations. Such products include but are not limited to the following:
   1. Dampers
   2. Control Valves
   3. Actuators
   4. Terminal Unit Controllers

1.3 PRODUCTS INSTALLED BUT NOT FURNISHED UNDER THIS SECTION

A. Control Contractor to coordinate with other trades to ensure correct installation and control of products installed but not furnished under this section. Such products include but are not limited to the following:
   1. Thermostats furnished with packaged equipment

1.4 RELATED SECTIONS

A. Section 23 09 25 – BAS Field Mounted Devices for HVAC

B. Section 23 09 29 – BAS Sequence of Operations for HVAC

1.5 SUBMITTALS

A. Provide submittals for products listed in the Product Table below in accordance with Section 23 05 00 – General HVAC Provisions. Submittal requirements indicated by column number designation as follows:
1. Materials List
2. Catalog Data
3. Product Data
4. Performance Data
5. Wiring Diagrams
6. Shop Drawings
7. Installation Instructions
8. Special Requirements listed herein.
9.

PRODUCT TABLE	1	2	3	4	5	6	7	8
All Products This Section								X

B. Special Requirements:
1. Provide all control submittals including Sections 23 09 23 – Building Automation Systems for HVAC, 23 09 25 – BAS Field Mounted Devices for HVAC, and 23 09 29 – BAS Sequence of Operations for HVAC as a single package.
2. Submittals prior to starting work:
   a. Submit in accordance with Division 01 and Section 23 05 00 – General HVAC Provisions within 6 weeks of project award.
   b. All required schematics and plans prepared on AutoCAD release 12 or higher.
   c. When manufacturers' product information applies to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Each submitted piece of literature and drawings shall clearly reference the pertinent specification or drawing.
   d. Building Automation System Hardware:
      1) Provide a complete bill of materials of building automation control system hardware indicating quantity, manufacturer, model number, and technical data. Technical data shall include performance curves, product specifications sheets, and installation/maintenance instructions.
      2) Network Communication Diagrams: Provide schematic diagram showing all BAS panels, communications cabling, and termination points. Identify power requirements and power source for each BAS panel. Identify equipment each BAS panel is controlling. Show termination numbers.
      3) Provide plans indicating locations of all BAS hardware.
      4) Provide panel interior and exterior layout details for prefabricated control panels. Details shall include equipment layout and routing of wiring.
      5) Provide two copies of programming manuals for each BAS controller furnished.
      6) Provide a listing and description of all available training programs. Indicate a cost for each location that the training program is available.
   e. Controlled Systems:
      1) Provide an instrumentation list for each controlled system including all controlled system elements in table format. Tables to show element name, type of device, manufacturer, model number, and product data sheet number.
      2) Provide a schematic diagram of each controlled system. Include control points labeled with appropriate point names. Graphically show the location of all control elements.
      3) Provide a schematic wiring diagram for each controlled system. Label all elements. Label all terminals.
      4) Provide a mounting, wiring, and routing plan-view drawing. Layout to account for HVAC, electrical, and other system design and layout requirements.

5) Provide a complete written sequence of operations for each system or subsystem under all modes of operation. Where Contractor proposes any variation to the sequence of operation described hereunder, the Contractor shall specifically highlight the change and describe the reason for the revision.
6) Provide a complete written sequence of operations for each system or subsystem under all modes of operation. Where Contractor proposes any variation to the sequence of operation described hereunder, the Contractor shall specifically highlight the change and describe the reason for the revision.
7) Provide a points list for each system controller including both input and output (I/O) points. Note point designations, point function, controlled device associated with the I/O point, location of the I/O device, and point alarm requirements.

3. Submittals During Construction
   a. Database information: Four weeks prior to system start-up, provide two copies of complete database information for Engineer's record. Database information will not be reviewed for conformance with Contract Documents. Database information shall include system configuration parameters, point definitions, alarm and trending parameters, control parameters, and control software programs. Specifically document all control functions that cannot be performed by applications specific controllers using pre-programmed control routines or which must be performed by supervisory control from a general-purpose controller.
   b. Graphics: Provide three copies of all proposed graphics screens for review prior to installation. Allow 2 weeks for review.
   c. Contractor Verification: Provide Contractor checkout and testing documentation.
4. Closeout Submittals
   a. Submit in accordance with Division 01. Submit 21 days prior to final completion for approval.
   b. Record documents shall include the following:
      1) Project record drawings. Project record drawings will be as-built versions of the shop drawings. Include one set of magnetic media including CAD drawings in .DWG format.
      2) Provide copy of testing and commissioning reports. Include trend logs used for verification.
      3) Material to be included in Project Operation and Maintenance Manuals
         a) Names, addresses and 24-hour telephone numbers of installing Contractors and the service representatives for each.
         b) Operator's manual with procedures for operating the control systems including logging on/off, alarm handling, producing point reports, trending data, overriding computer control, and changing set points and other variables.
         c) A listing and documentation of all custom software created using the programming language including set points, tuning parameters, and object database.
         d) A list of recommended spare parts with part numbers and suppliers.
         e) Recommended preventive maintenance procedures for all system components including a schedule of tasks, time between tasks, and task descriptions.
      4) Supplemental Record Information
         a) Two sets of programming manuals with a description of the programming language (including syntax), statement descriptions (including algorithms and calculations used), point database creation and modification, and use of the program editor.
         b) Two sets of engineering, installation, and maintenance manuals explaining how to design and install new points, panels, and other hardware; preventive maintenance procedures; how to debug hardware problems; and how to replace or repair hardware.

c) One set of magnetic/optical media containing backup files of the software and database.
d) One set of magnetic/optical media containing files of all color graphic screens created for the project.
e) One set of complete original issue documentation for third-party software including installation and maintenance instructions.
f) One set of complete original issue diskettes for all operating systems, programming language, operator workstation software, and graphics software.
g) One set of licenses, guarantees, and warranty documents for all system equipment.

1.6 DESIGN REQUIREMENTS

A. BACnet Compliance
1. The BAS shall exchange data between workstations or workstations and building level controllers over the Management Level Network and First-tier BAS Controller Level Network using BACnet Protocol in the form of BACnet objects.
2. The BAS shall perform network functions using the following BACnet services:
   a. Alarm and Event
   b. Scheduling
   c. Trending
   d. Network Management

B. Performance Standards:
1. Graphic Display: System shall display a graphic with 20 dynamic points and all current data within 10 seconds.
2. Graphic Refresh: System shall update a graphic with 20 dynamic points and all current data at no greater than 8 second intervals.
3. Object Command: The maximum time between an operator command of a binary object and the reaction of the commanded device shall be 2 seconds. The maximum time between an operator command of an analog object and the start of object adjustment shall be 2 seconds.
4. Object Scan: All changes of state and change of analog values will be transmitted on system communications networks such that any data used or displayed at a controller will have been current within the previous 6 seconds.
5. Alarm Response Time: The maximum time from an object going into alarm-to-alarm annunciation at the workstation shall not exceed 45 seconds.
6. Program Execution Frequency: Custom and standard applications shall be capable of running as often as once every 5 seconds. Contractor shall select execution times consistent with the process under control.
7. Performance: Programmable controllers shall be able to execute BAS PID control loops at a selectable frequency of a least once per second. The controller shall scan and update the process value and output generated at the same frequency.
8. Multiple Alarm Annunciations: All workstations on the network must receive alarms within 5 seconds of each other.
9. Reporting Accuracy: The system shall report all values with an end-to-end accuracy no less than listed in Table 1.
10. Stability of Control: Control loops shall maintain measured variable at setpoint within tolerances listed in Table 2.

TABLE 1 - REPORTING ACCURACY	
Measured Variable	Reported Accuracy
Space Temperature	±1°F
Ducted Air	±1°F
Water Temperature	±1°F
Delta-T	±0.25°F
Water Flow	±5% of full scale
Note 1: 10%-100% of scale	
Note 2: For both absolute and differential pressure	
Note 3: Not including utility-supplied meters	

11.

TABLE 2 - CONTROL STABILITY AND ACCURACY		
Controlled Variable	Control Accuracy	Range of Medium
Air Pressure	±0.01 in. w.g.	0-6 in. w.g.
Airflow	±10% of full scale	-0.1 to 0.1 in. w.g.
Space Temperature	±2.0°F	
Duct Temperature	±3.0°F	

1.7 QUALITY ASSURANCE

A. All products required to conform to BACnet Standards must be BACnet Testing Laboratory (BTL) listed.

B. All products used in this application, except for those specifically indicated for reuse, shall be new and under current manufacture and shall be the most recent version offered by the manufacturer for the application. Spare parts shall be available from the manufacturer for at least five years after final completion.

C. Control Contractor to have in-house, factory-trained and factory-authorized installers and programmers.

1.8 CODES AND STANDARDS

A. Work, materials, and equipment shall comply with all local, state, and federal codes and ordinances.

B. Each DDCP shall be listed under UL916 (Energy Management Systems), UL864-UDTZ (Signal Systems Unit) and shall be tested to comply with sub-part J of Part 15 FCC rules for Class A computing equipment.

1.9 UPDATES

A. Provide at no extra cost all software and firmware updates that become available from the manufacturer during the warranty period.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Building Automation System shall be an extension of the existing JCI system.

2.2 WORKSTATION GRAPHICS

A. System Graphics: Provide graphics to match existing systems graphics.

2.3 SYSTEM CONTROLLERS

A. Application Specific Controllers: Independent, stand-alone microprocessor-based controller to control local equipment or systems where the associated sequence of operation can be met using pre-programmed control routines. Controllers should have the following general characteristics:
   1. Sufficient memory in each controller to control the target system.
   2. Non-volatile memory to maintain the BIOS and programming information in the event of a power failure.
   3. Controller hardware suitable for the anticipated ambient conditions.

B. Provide diagnostic LEDs for power, communication, and processor. All wiring connections made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.

C. All controllers shall operate at 90% to 110% of nominal voltage and perform an orderly shutdown below 80% nominal voltage. Operation protected against electrical noise at 5 to 120 Hz and from keyed radios up to 5 W at 3 feet.

2.4 INPUT/OUTPUT INTERFACE

A. Hardwire inputs and outputs may connect to the system through a first-tier, advanced application, or application specific controller.

B. All input and output points protected so that shorting of the point to itself, to another point, or to ground will cause no damage to the controller. All input and output points protected from connected voltage up to 24V of any duration.

C. Binary Inputs: Binary controller inputs shall provide a wetting current of at least 12 mA and shall be protected against the effects of contact bounce and noise. Binary inputs shall sense “dry contact” closure without external power application required.

D. Pulse Accumulation Inputs: In addition to standard binary input characteristics, pulse accumulation inputs shall accept up to 10 pulses per second.

E. Analog Inputs: Analog inputs shall allow the monitoring of low voltage (0 to 10VDC), current (4 to 20 mA), or resistance signals (thermistor or RTD). Analog inputs compatible with commonly available sensing devices.

F. Binary Outputs: Binary outputs to provide on/off control or a pulsed low-voltage signal for pulse-width modulation. Provide three-position (on/off/auto) switch for each output along with indicator light. Output selectable for normally open or normally closed operation.

G. Analog Outputs: Analog outputs to provide a modulating 0 to 10V or 4 to 20 mA signal for control of an end device. Provide two-position (auto/manual) switch, status lights, and manually adjustable potentiometer for each output. Analog output drift less than 0.4% of range per year.

H. Tri-state Outputs: Provide tri-state outputs (two coordinated binary outputs) for control of three-point floating type electronic actuators without feedback. Use of three-point actuators

limited to terminal unit and unit ventilator control applications. Control algorithms shall send the actuator to one end of its stroke every 24 hours for verification of operator tracking.

2.5 POWER SUPPLIES AND LINE FILTERING

A. Provide UL listed control transformers. Provide class 2 current-limiting type or furnish over-current protection in both primary and secondary circuits in accordance with NEC requirements. Limit connected loads to 80% of rated capacity.

B. Provide transient voltage and surge suppression for all workstations and controllers either internally or as an external component. Surge suppression shall have the following minimum performance criteria:
1. Dielectric strength of 1000 volts minimum.
2. Response time of 10 nanoseconds.
3. Transverse mode noise attenuation of 65 dB or greater.
4. Common mode noise attenuation of 150 dB or better at 40 Hz to 100 Hz.

2.6 WIRING AND RACEWAYS

A. Provide wiring, plenum cable, and raceways in accordance with Division 26.

B. All insulated wire to have copper conductor. UL labeled for 90 degree C service.

PART 3 - EXECUTION

3.1 COORDINATION

A. Testing and Balancing
1. Provide to the Testing and Balancing Contractor a set of all tools and temporary licenses necessary to interface to the control system for testing and balancing purposes. Tools to be returned at the completion of test and balancing work.
2. Provide training in the use of the tools.
3. Provide a qualified technician to assist in the testing and balancing process where required.

B. Life Safety
1. Hardwire interlock smoke dampers or fire smoke damper to air handler motor starters where dampers are capable of closing off more than 50% of the total fan supply air or return air ductwork area. Stop fans if smoke dampers close.

C. Coordinate with controls specified in other sections or divisions. Other sections or divisions include controls and control devices to be part of or interfaced with the control system specified in this section. Integration and coordination with these controls shall be as follows:
1. All communications media and equipment required to interface with equipment specified in other sections provided hereunder unless specifically stated otherwise.
2. Each supplier of a control product is responsible for the configuration, programming, start-up, and testing of that product to meet the sequence of operation stated in Section 23 09 29 – BAS Sequence of Operations for HVAC.
3. Coordinate and resolve any compatibility issues arising between control products provided hereunder and those provided under other sections or divisions.

3.2 WORKMANSHIP

A. Install all equipment in accordance with manufacturers' recommendations.

B. Install equipment, piping, and wiring/raceway parallel to building lines wherever possible.

C. Provide sufficient slack and flexible connections in wiring to allow for vibration of piping and equipment.

D. Install all equipment in readily accessible locations as defined by Chapter 1, Article 100, Part A of the National Electric Code.

3.3 GENERAL WIRING

A. All control and interlock wiring shall comply with national and electrical codes and Division 26. Where requirements of this section differ from those in Division 26, the requirements of this section shall take precedence.

B. Provide circuits for controls power as required. Coordinate with Division 26 for provision of power.

C. All line voltage wiring shall be UL listed in approved raceway according to NEC and Division 26 requirements.

D. All low-voltage wiring shall meet NEC Class or Class 2 requirements. Low voltage power circuits shall be sub-fused when required.

E. Where NEC Class 1 and Class 2 wires are in concealed and accessible locations, including ceiling plenum return air plenums, approved cable not in raceway may be used provided cables are UL listed for the intended application.

F. All wiring in mechanical, electrical, or service rooms and wiring located where it may be subject to damage shall be installed in raceway.

G. Do not install Class 2 wiring in raceways containing Class 1 wiring. Boxes and panels containing high-voltage wiring may not be used for low-voltage wiring except for the purpose of interfacing the two.

H. Where Class 2 wiring is installed exposed, wiring is to be routed parallel or perpendicular to building lines and neatly tied at a maximum of 10-foot intervals.

I. Where plenum cables are used without raceway, support or anchor cable from building structure. Do not anchor or support cable from ductwork, electrical raceways, piping, or suspended ceiling systems.

J. Provide all wire-to-device connections at terminal block or terminal strip. Provide all wire-to-wire connections at terminal block.

K. Neatly bundle wiring located within enclosures to permit access to devices and terminals.

L. Maximum allowable voltage for control wiring shall be 120V. If only higher voltages are available, Contractor shall provide a step-down transformer.

M. All wiring shall be installed as continuous lengths with no splices permitted between termination points.

N. Install plenum wiring in sleeves where it passes through walls and floors. Provide firestop foam where necessary to maintain fire rating.

O. Provide size of raceway and size and type of wire as required by NEC and as required to meet manufacturers' recommendations for connected equipment.

P. Include one pull string in each raceway 1-inch or larger.

Q. Use color coded conductors throughout.

R. Locate control and status relays in designated enclosures only. Such enclosures include packaged equipment control cabinets unless such cabinets also contain Class 1 starters.

S. Conceal all raceways except within mechanical, electrical, or service rooms. Maintain minimum raceway clearance of 6-inches from high temperature equipment such as steam piping or boiler flues.

T. Secure raceways with raceway clamps fastened to the structure and spaced in accordance with code requirements. Raceways and pull boxes may not be hung on flexible duct strap or tie rods. Raceways may not be supported from ductwork, electrical raceways, piping, or suspended ceiling systems.

U. Install insulated bushings on all raceway ends and openings to enclosures. Seal top end of all raceways.

V. Maintain updated wiring diagrams (as built) at site with terminations identified.

W. Flexible metal raceways and liquid-tight, flexible metal raceways shall not exceed 3-feet in length and shall be supported at both ends. Flexible metal raceway less than ½-inch electrical trade size shall not be used. In areas exposed to moisture, including but not limited to chiller and boiler rooms, liquid-tight, flexible metal raceways shall be used.

3.4 COMMUNICATION WIRING

A. Install in accordance with 3.03 above.

B. Follow manufacturers' recommendations for all communications cabling including but not limited to maximum pulling, tension, and bend radius.

C. Do not install communications cabling in a raceway or enclosure containing Class 1 or other Class 2 wiring.

D. Verify the integrity of the entire network immediately following cable installation using test measures appropriate for each cable.

E. Provide a lightning arrestor between cables and grounds where cable enters or exits a building. Install arrestor in accordance with manufacturers' recommendations.

F. All communications wiring shall be un-spliced length when that length is commercially available.

G. All communications wiring shall be labeled to indicate origination and destination.

H. Ground coaxial cable in accordance with NEC regulations article on "Communications Circuits, Cable and Protector Grounding."

3.5 IDENTIFICATION OF HARDWARE AND WIRING

A. Label all wiring and cabling, including wiring and cabling terminating within factory-fabricated panels, within 2 inches of termination with the BAS address or termination number.

B. Permanently label or code each point of field terminal strips to show the instrument or item served.

C. Identify control panels with minimum ½-inch letters on laminated plastic nameplate.

D. Identify all other control components with permanent labels. All plug-in components shall be labeled so that removal of component does not remove label.

E. Identify room sensors relating to terminal box or valves with nameplate located within sensor cover.

F. Arrange components so that UL or CSA labels are visible after equipment is installed.

G. Identifiers shall match record documents.

H. Provide laminated network communication diagrams, point-to-point wiring diagrams, and process control diagrams in each control panel for control components contained therein.

3.6 BAS CONTROLLER INSTALLATION

A. Provide a separate BAS controller for each air handling unit or other discrete system. A BAS controller may control more than one system provided that all points associated with the system are assigned to the same BAS controller. Points used for control loop reset, such as outside air temperature or space temperature, are exempt from this requirement.

B. Provide sufficient internal memory for the specified sequences of operation and trend logging. Provide a minimum of 25% available memory free for future use.

3.7 PROGRAMMING

A. Provide programming for the system as required to perform the sequence of operation. See Section 23 09 29 – BAS Sequence of Operations for HVAC. Provide all other programming necessary for proper operation of the system but not specified including but not limited to time delays, control deadbands, equipment interlocks, equipment sequencing, alarm notification, and control sequences recommended by equipment manufacturers.

B. All control setpoints and loop tuning parameters accessible for review and adjustment at workstation graphics or through workstation menus without requiring modification of program code.

C. For systems using text-based programming, imbed comments in the programming code to clearly describe each section of the program.

D. Contractor to provide time scheduling functions as specified in the Sequence of Operations. Independent schedules shall be provided for each system, unless otherwise specified.

E. Contractor to provide alarming functions as specified in the Sequence of Operations. Contractor shall also configure alarming functions as directed by Owner including setting alarm limits and differentials, states, type of notification, and alarm messages.

F. Contractor shall configure trending functions as directed by Owner including trend data collection and report format.

G. Point Naming: Match existing point naming system.

3.8 GRAPHICS

A. Provide graphics for all controlled systems and floor plans of the building. As a minimum, systems requiring graphics to include each chilled water system, , air handler, and condensers. Point information on the graphic displays shall dynamically update. On each graphic, show input and output points for the system. Also, show relevant calculated points such as setpoints. Input, output, and software point values shall be changeable from graphic screen. Provide link to a text file containing the automatic control sequence of operations.

B. Meet with Owners Authorized Representative prior to beginning development of graphic displays to discuss Owner's preferences.

C. Show terminal unit information on a "graphic" summary table. Provide dynamic information on each point shown.

3.9 CONTROL SYSTEM CHECKOUT AND TESTING

A. Contractor shall completely test and verify specified control system performance. Compile test results and include with written certification.

B. Contractor shall furnish all labor and test apparatus required to calibrate and prepare for service all instruments, controls, and accessory equipment furnished hereunder.

C. Contractor shall perform the following testing and verification
1. Verify that all control and communications wiring is properly connected and free of all shorts and ground faults. Verify that terminations are tight.
2. Enable control systems and verify instrument calibration and end-to-end reporting accuracy of all input devices individually. Perform calibration in accordance with manufacturers' recommendations. Repair or replace all temperature sensors requiring a calibration offset greater than +/- 1oF.
3. Verify control stability and end-to-end reporting requirements are met.
4. Verify that all binary output devices (relays, solenoid valves, two-position actuators and control valves, magnetic starters, etc.) operate properly and that normal positions are correct.
5. Verify that all analog output devices (I/Ps, actuators, etc.) are functional, start/stop and span are correct, and direction and normal position are correct.
6. Verify that system operation complies with the sequence of operations. Simulate and observe all modes of operation by overriding and varying inputs and schedules. Tune all BAS control loops and optimum start/stop routines.
7. Alarms and Interlocks:
    a. Check each alarm separately by including an appropriate signal at a value that will trip the alarm.
    b. Trip interlocks using field contacts to check the logic and ensure that the fail-safe condition for all actuators is in the proper direction.

c. Test interlock actions by simulating alarm conditions to check the initiating value of the variable and the interlock action.

D. Contractor shall maintain the following documentation:
1. Calibration log including date, time, control system readout, means of verification, verification measurement, and required calibration offset for each analog input.
2. BAS Loop Response: Supply trend data output in graphical form showing the step response of each BAS loop. The test shall show the loop's response to a change in set- point requiring a change in actuator position of at least 25% of full range. Provide sampling rate from 10 seconds to 1 minute depending on loop speed. Trend data shall show for each sample the setpoint, actuator position, and controlled variable values. Contractor shall retune any loop that indicates unreasonably under-damped or over-damped control.
3. Demand Limiting: Supply trend data showing the action of any demand limiting functions. Document operation at maximum one-minute intervals for at least 30 minutes.
4. Operational Logs: Provide operational trend logs for each system indicating setpoints, operating points, valve positions, mode, and equipment status. Logs shall cover three 48-hour periods and have a sample frequency of not more than 5 minutes. Logs provided in both printed and disk formats.

E. After system operation is completely verified, provide written certification to Owner that systems have been fully tested and are operating according to specifications and ready for functional testing. Provide copies of documentation signed by person performing tests. Documentation to include:
1. Calibration logs
2. BAS Loop Response Trends
3. Demand Limiting Trends
4. Operational Logs

3.10 DEMONSTRATION AND ACCEPTANCE

A. Demonstrate operation of control system to Owner and Engineer including:
1. Menu functions
2. Point overrides
3. Control loop response after point modification
4. Alarm response time

3.11 TRAINING

A. Provide a minimum of 24 hours training to Owner's personnel in use and maintenance of BAS building management and control hardware and software. Training shall be provided in two (2) sessions of 8 hours each and two (2) sessions of 4 hours each as follows:
1. The first session shall provide system overview and training on log on procedures, data access and display, alarm and status descriptions, log requests, execution of commands, and other general system operation procedures.
2. The second session shall include instruction on system maintenance procedures. Procedures reviewed will include day-to-day system maintenance requirements, calibration techniques and diagnosis of system failures. Diagnosis procedures shall include instructions to follow in the event of failure of each control sub-system or device.
3. Two remaining sessions shall include instruction on site-specific programs, graphics, and user interfaces.

B. Manufacturers Training: Provide 24-hour manufacturer training course for 3 Owner's Representatives. Training shall be provided on a variety of topic as selected by the Owner. Training shall be performed at manufacturer's designated locations.

END OF SECTION

SECTION 230925

BAS FIELD-MOUNTED DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Temperature instruments
2. Electrical Instruments.

B. Related Requirements:
1. Section 23 09 10 – Building Automation Systems
2. Section 23 09 90 – Building Automation System Sequence of Operations

1.2 DEFINITIONS

A. BAS: Building Automation System

B. Cv: Design valve coefficient.

C. HART: Highway Addressable Remote Transducer Protocol

D. NBR: Nitrile butadiene rubber.

E. PTFE: Polytetrafluoroethylene.

F. RTD: Resistance temperature detector.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product, including the following:
1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation operation and maintenance instructions, including factors affecting performance.

B. Shop Drawings:
1. Include plans, elevations, sections, and mounting details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Include number-coded identification system for unique identification of wiring, cable, and tubing ends.

1.4 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each product requiring a certificate.

B. Product Test Reports: For each product, for tests performed by manufacturer and witnessed by a qualified testing agency.

C. BAS Configuration Data: Provide configuration data necessary for programming conversion of analogy output signals to accurately indicate measured values. Calibration data shall be specific to the measurement device installed.

D. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data:
1. BAS Configuration Data: Copy of analog input configuration data using for programming BAS.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials and parts that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. 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.

B. ASME Compliance: Fabricate and label products to comply with ASME Boiler and Pressure Vessel Code where required by authorities having jurisdiction.

C. Ground Fault: Products shall not fail due to ground fault condition when suitably grounded.

D. Environmental Conditions:
1. Instruments shall operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.
2. Instruments, actuators and accessories shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Instruments and actuators not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Instrument's installed location shall dictate following NEMA 250 enclosure requirements:
   a. Indoors, Heated with Filtered Ventilation: Type 1.

2.2 TEMPERATURE SENSORS, TRANSMITTERS, AND SWITCHES

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

a. Building Automation Products, Inc. (BAPI)
b. Greystone Energy Inc.
c. Schneider Electric.
d. Vaisala
e. Veris Industries
f. Approved BAS System Manufacturer

2. Sensor
   a. 10,000 ohms at 25 deg C and a temperature coefficient of 23.5 ohms/ohm/deg C.
   b. Two-wire, PTFE-insulated, 22-gage stranded copper leads.
   c. Performance Characteristics:
      1) Probe Range: Minus 40 to 220 deg F
      2) Interchangeable Accuracy: At 77 deg F within 0.5 deg F.
      3) Repeatability: Within 0.5 deg F.
      4) Drift: Within 0.5 deg F over 10 years.
      5) Self-Heating: Negligible.
3. Space Air Temperature Sensors:
   a. Temperature Range: Minus 50 to 120 deg F
   b. Sensor assembly shall include a temperature sensing element mounted under a bright white, non-yellowing, plastic.
   c. Provide a mounting plate that is compatible with the surface shape that it is mounted to and electrical box used.
   d. Concealed wiring connection.
4. Accessories
   a. Gasket for attachment to duct or equipment to seal penetration airtight.

B. Liquid Temperature Transmitters, Commercial Grade
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Building Automation Products, Inc. (BAPI)
   b. Greystone Energy Inc.
   c. Schneider Electric.
   d. Vaisala
   e. Veris Industries
   f. Approved BAS System Manufacturer
2. House electronics in NEMA 250, Type 4 or Type 4X enclosure.
3. Functional Characteristics:
   a. Input: 100-ohm platinum RTD temperature coefficient of 0.00385 ohm/ohm/deg C, two- or three-wire sensors.
   b. Default Span (Adjustable):
      1) Chilled Water: Zero to 100 deg F.
   c. Output: 4- to 20-mA dc, linear with temperature; RFI insensitive; minimum drive load of 600 ohms at 24-V dc.
   d. Zero and span field adjustments, plus or minus 5 percent of span. Minimum span of 50 deg F.
   e. Match sensor with temperature transmitter and factory calibrate together. Each matched sensor and transmitter set shall include factory calibration data traceable to NIST.
4. Performance Characteristics:
   a. Calibration Accuracy: Within 0.1 percent of the span.
   b. Stability: Within 0.2 percent of the span for at least 6 months.
   c. Combined Accuracy: Within 0.5 percent.

2.3 ELECTRICAL SWITCHES, RELAYS, SENSORS AND TRANSMITTERS

A. Switches and Relays
1. Push Buttons, Position Selector Switches, Manual Operating Switches.

a. General: UL listed, industrial grade.

B. Electrical Current Switches
1. Current Status Switches, Fixed Trip
a. Acceptable Manufacturer: Hawkeye or approved equal.
b. General: Fixed trip point current switch.
c. Split core sensor, induced powered from monitored load and isolated to 600 VAC rms. Sensor shall indicate status from .25 A to 200 A.
d. Normally open current sensor output. 0.1A at 30 VAC/DC
e. Similar to Hawkeye Model H800

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation. Verify that the proposed mounting locations comply with manufacturers recommendations and requirements indicated and approved submittals.

C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation. Verify that the proposed mounting locations comply with manufacturers recommendations and requirements indicated and approved submittals.

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

3.2 APPLICATION

A. Temperature Instruments
1. Air Temperature Sensors and Transmitters:
a. Duct: Air Thermistor Sensor.
b. Space: Air Thermistor Sensor.
2. Liquid Temperature Sensors and Transmitters:
a. Cold Water Systems (below 60oF): Liquid Temperature Transmitter, Commercial Grade.

B. Electrical Instruments
1. Motor Operating Status:
a. Motors ½ hp and larger, variable speed: Electrical Current Transmitters, except where motor status can be obtained from VFD or ECM motor control.

3.3 INSTALLATION

A. General
1. Install products level, plumb, parallel, and perpendicular with building construction.
2. Properly support instruments, tubing, piping, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment.
3. Provide ceiling, floor, roof, wall openings, and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.
4. Fastening Hardware:

a. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
b. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.

5. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.
6. Mounting Height:
   a. Mount instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.
   b. Mount switches and transmitters, located in mechanical equipment rooms and other similar space not subject to code, state, and federal accessibility requirements at 60 inches above the adjacent floor, grade, or service catwalk or platform.
7. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class.

B. Temperature Instruments
1. Mounting Location:
   a. Roughing In:
      1) Outline instrument mounting locations before setting instruments and routing cable, wiring, tubing, and conduit to final location.
      2) Provide independent inspection to confirm that proposed mounting locations comply with requirements indicated and approved submittals.
         a) Indicate dimensioned locations with mounting height for all surface-mounted products on Shop Drawings.
         b) Do not begin installation without submittal approval of mounting location.
      3) Complete installation rough-in only after confirmation by independent inspection is complete and approval of location is documented for review by Owner’s Authorized Representative.
   b. Install switches and transmitters for air and liquid temperature associated with individual air-handling units and associated connected ductwork and piping near air-handling units co-located in air-handling unit system control panel to provide service personnel a single and convenient location for inspection and service.
   c. Install temperature switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings or approved by the Owner’s Authorized Representative.
   d. Mount switches and transmitters on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer's mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.
2. Special Mounting Requirements:
   a. Temperature instruments having performance impacted by temperature of mounting substrate shall be isolated with an insulating barrier located between instrument and substrate to eliminate effect. Where instruments requiring insulation are located in finished space, conceal insulating barrier in a cover matching the instrument cover.
3. Space Temperature Sensor Installation:
   a. Conceal assembly in an electrical box of sufficient size to house sensor and transmitter, if provided.
   b. Install electrical box with a faceplate to match sensor cover if sensor cover does not completely cover electrical box.

c. In finished areas, recess electrical box within wall.
d. In unfinished areas, electrical box may be surface mounted if electrical light switches are surface mounted. Use a cast-aluminum electric box for surface-mounted installations.
e. Align electrical box with other electrical devices such as visual alarms and light switches located in the vicinity to provide a neat and well-thought-out arrangement. Where possible, align in both horizontal and vertical axis.

4. If required to have a transmitter, mount transmitter remote from sensor in an accessible and serviceable location indoors.
5. Liquid Temperature Sensor Installation:
   a. Assembly shall include sensor, thermowell.
   b. For pipe NPS 4 and larger, install sensor and thermowell length to extend into pipe between 50 to 75 percent of pipe cross section.
   c. This is an excessive requirements and needs reviewed.
   d. For pipe smaller than NPS 4:
      1) Install reducers to increase pipe size to NPS 4 at point of thermowell installation.
      2) For pipe sizes NPS 2-1/2 and NPS 3, thermowell and sensor may be installed at pipe elbow or tee to achieve manufacturer-recommended immersion depth in lieu of increasing pipe size.
      3) Minimum insertion depth shall be 2-1/2 inches.
   e. Install matching thermowell.
   f. Fill thermowell with heat-transfer fluid before inserting sensor.
   g. Tip of spring-loaded sensors shall contact inside of thermowell.
   h. For insulated piping, install thermowells with extension neck to extend beyond face of insulation.
   i. Install thermowell in top dead center of horizontal pipe positioned in an accessible location to allow for inspection and replacement. If top dead center location is not possible due to field constraints, install thermowell at location along top half of pipe.
   j. For applications with transmitters, mount transmitter remote from sensor in an accessible and serviceable location from floor, service platform, or catwalk.

C. Electrical Switches, Relays, Sensors, and Transmitters
1. Occupancy Sensors: Coordinate occupancy sensor auxiliary relays to provide control functions required with Division 26. Provide auxiliary relays where required. Coordinate electrical rating and provide auxiliary devices as required to provide required control function.

3.4 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 26 28 16 – Enclosed Switches and Circuit Breakers.

C. Furnish and install power wiring. Comply with requirements in 26 05 19 - Low-Voltage Electrical Power Conductors and Cables.

D. Furnish and install raceways. Comply with requirements in 26 05 33 - Raceways and Boxes for Electrical Systems.

3.5 IDENTIFICATION

A. Identify control components and piping. Comply with 23 05 53 - Identification for VAC Piping and Equipment.

B. Identify system electrical components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 26 05 53 - Identification for Electrical Systems.

3.6 CLEANING

A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.

3.7 ADJUSTMENT, CALIBRATION, AND TESTING

A. Description:
1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
2. Equipment and procedures used for calibration shall meet instrument manufacturer's written instructions.
3. Provide diagnostic and test equipment for calibration and adjustment.
4. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.
5. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
6. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.
7. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements and to supplement requirements indicated.

END OF SECTION

SECTION 230929

BAS SEQUENCE OF OPERATIONS FOR HVAC

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Description of Control Sequences.

1.2 WORK INCLUDES

A. The control system will consist of all necessary devices and software to provide the sequences of operation described herein.

B. Provide custom engineered BAS operating software to perform control sequences specified. Sequence of operations describes major control functions but does not limit Contractor's responsibility to provide a fully operational automatic control system. Contractor shall provide additional control functions not specifically described herein including time delays, control deadbands, equipment interlocks, equipment sequencing, alarm notification, control functions recommended by equipment manufacturers, or as otherwise required.

1.3 SUBMITTALS

A. Provide submittals for products listed in the Product Table below in accordance with Section 23 05 00 – General HVAC Provisions. Submittal requirements indicated by column number designation as follows:
1. Materials List
2. Catalog Data
3. Product Data
4. Performance Data
5. Wiring Diagrams
6. Shop Drawings
7. Installation Instructions
8. Special Requirements listed herein.

PRODUCT TABLE	1	2	3	4	5	6	7	8
All Products This Section								X

B. Special Requirements: Provide a complete written sequence of operations for each system or subsystem under all modes of operation. Where Contractor proposes any variation to the sequence of operation described hereunder, the Contractor shall specifically highlight the change and describe the reason for the revision.

1.4 DESIGN REQUIREMENTS

A. All safety control circuits interlocked with motor starters or VFDs shall be hardwired and shall function in all operating modes (Automatic, Hand, and Manual Bypass).

B. Control setpoints and parameters listed in control sequences are initial values. Adjust setpoints and control parameters as directed by Engineer to achieved desired environment conditions, optimum system performance, and as recommended by TAB contractor.

C. Control setpoints shall be adjustable from the Operator Workstation without modification of control programming or use of proprietary software. All setpoints which are necessary for normal operation and optimization of system performance as required by Owner shall be adjustable, and shall include, but not be limited to: time schedules; temperature, pressure, humidity, and CO_2 setpoints; time delay settings; safety sequence setpoints; and alarming parameters.

D. Where BAS network communications are provided to networkable control systems or equipment, Contractor shall configure accessible points for control, monitoring, and alarm as required to provide specified sequences and as directed by the Owner's Authorized Representative for trending and monitoring.

E. All cascade control sequences and closed control loops shall have proportional-integral action and derivative capability, except where approved otherwise.

F. Provide BAS alarm functions and configuration as detailed in plans and specifications, and as directed by Owner's Authorized Representative. Alarm functions may include:
1. Visual display on workstation graphic.
2. Audible alarm at workstation computer.
3. Listing in workstation alarm log.
4. "Pop-up" alarm notification at workstation computer.
5. Dial-out alarm to Owner's security staff or alarm monitoring service.

PART 2 - PRODUCTS

2.1 COMMON CONTROL SEQUENCES

A. Building Occupancy Schedules
1. General: The following time schedules will be established for control of HVAC systems:
   a. Data Center Occupancy: Time schedule for normal occupied and unoccupied periods for data center spaces.
   b. Office Occupancy: Time schedule for normal occupied and unoccupied periods for office and circulation spaces.
2. Optimum Start/Stop: Where indicated, provide optimum start routine to calculate system warm-up/cool down duration subject to outside air temperature and space temperatures so that all spaces are at occupied temperature at the occupied start time. Optimum start routines shall use a sophisticated algorithm that monitors historical system performance to accurately predict start-up duration and shall be capable to achieving occupied space temperature in all spaces within 2°F, unless the start-up duration exceeds the maximum start-up duration setpoint. Maximum start-up duration shall be adjustable and initially set to 2 hours.

B. Equipment Lead/Lag
1. General: Systems with two pumps that serve a given load. Units may be fully redundant and only one is intended to operate at any time, or both units may be required to operated.
2. Lead/Lag Designation:
   a. Lead and lag designations shall be determined automatically; however, the operator shall have capability to manually changing the lead unit designation.
   b. Lead and lag designations shall be alternated weekly.
3. Equipment Operation:
   a. Start lead unit when system is enabled.
   b. Start lag unit if lead unit operating status indicates that lead unit has failed, or lag unit operating command is on.

c. Stop lag unit if lead unit operating status is restored and lag unit operating command is off.
d. Lag unit shall operate for a minimum of 5 minutes after start-up, unless otherwise indicated.
e. For pumping applications, lead pump shall remain in operation for two minutes after the system is disabled.
f. Refer to individual system control sequences for system enable/disable and lag unit start/stop commands.

2.2 COMPUTER ROOM AIR CONDITIONING UNITS (CCU-1, CCU-2, CCU-3, CCU-4)

A. General: Variable volume computer room cooling units with direct expansion cooling coils and chilled water cooling coils. Units are controlled by internal packaged equipment controllers. BAS system interfaces with units and monitors equipment operation and room conditions.

B. Provide graphic display screen for each of the computer cooling units indicating all points listed on the drawings.

C. Unit controller operates unit humidifiers to maintain a minimum return air relative humidity of 35% rh.

D. Provide current transformer monitoring of CCUs and indicate status on system graphic.

E. The chilled water coil will be the primary source for cooling. If the outside air temperature exceeds 85°F, then the unit shall switch to DX cooling.

F. DDC Supervisor inputs to indicate chilled water cooling or DX cooling.

G. Safety Control:
1. High Temperature: Initiate a critical BAS workstation alarm if the room temperature exceeds 95°F. Maintain alarm until acknowledged by operator.
2. Humidity Sensor Alarm: If sensor indicates humidity level lower than 35% RH or greater than 65% RH then activate a Humidity Alarm.
3. Fan Failure: If a fan motor is commanded “on” and the motor status after a one minute delay indicates that the motor is off, activate status alarm. Maintain alarm until acknowledged by building operator.
4. Chilled Water Alarm: Activate alarm if chilled water cooling is active and the room exceeds the temperature setpoint by 5°F for more than 30 minutes.

H. Input/Output Points List
1. Provide all control points required to perform the automatic control sequence described above and reconnect all existing scheduled BAS points. All points scheduled on the drawing shall be shown on the graphics.

2.3 CHILLED WATER SYSTEM

A. General: Variable flow chilled water system operating in conjunction with campus distribution system.
1. Primary System: Chilled water provided from the campus district cooling plant will be circulated to cooling coils at approximately 44ºF.
2. CWP-2 will operate in a lead/lag arrangement with existing CWP-1.

B. System Operation
1. System is intended to operate continuously.

2. Provide manual primary chilled water system enable/disable switch at Operator Workstation.

C. Primary Pump Operation (CWP-2**)**
1. System Enabled:
   a. Refer to Common Control Sequences, Equipment Lead/Lag.
   b. Start Lead pump when system is enabled.
   c. Stop pumps if the following conditions occur:
      1) Pump operating speed is at minimum speed for 15 minutes. Configure VFD minimum speed to 6 hz.
      2) Measured chilled water differential pressure is 3 psig above setpoint.
   d. Restart lead pump if measured chilled water differential pressure is below setpoint for 5 minutes.
2. System Disabled: Pump off.

D. Primary Pump Speed Control
1. Modulate pump speed to maintain a pressure difference between supply and return piping to maintain differential pressure setpoint.
2. Differential Pressure Setpoint
   a. Primary System: Reset chilled water differential pressure setpoint subject to the chilled water control valve having the most open position. Increase chilled water differential pressure setpoint by 0.5 psi every 5 minutes when the maximum valve position exceeds 90% full open. Decrease chilled water differential pressure setpoint by 0.25 psi every 5 minutes when the maximum valve position is less than 85% full open. Initial setpoints range shall be a maximum of 20 psi and a minimum of 4 psi.
3. Minimum pump flow will be maintained by existing 3-way control valves.

E. Safety Control, Monitoring, and Alarming
1. Pump Status: If a motor is commanded “on” and the motor status after a 20 second delay indicates that the motor is off, activate status alarm. Maintain alarm until acknowledged by building operator.

F. BAS Points List
1. Provide all control points required to perform the automatic control sequence described herein, which as a minimum shall include all points listed in BAS Points List scheduled on drawings.
   a. Point Communication: All points listed are to be hardwired to BAS controllers, except where point is identified as being communicated over a BAS network.
      1) PTP = Hardwired point-to-point
      2) C = BAS network communication
   b. Point Source: All points shall be connected to field-mounted control devices, except where the point is identified as being obtained from an equipment controller identified. See Drawing Legend or equipment schedules for designation of equipment control panel abbreviations.

2.4 HEAT PUMP (HP-1)

A. General: Constant volume heat pump unit. Unit is controlled by internal packaged equipment controller. BAS system interfaces with unit and monitors equipment operation and room conditions.

B. Provide graphic display screen for rooftop heat pump.

C. System Operation
1. System is intended to continuously operate.

D. Temperature Control Mode:
1. Mode Control: Enabled.
2. Damper Control: Open outside air and exhaust fan dampers. Modulate outside air and return air dampers from minimum ventilation position to maintain required temperature setpoint.
3. Fan Operation: Supply and exhaust fans on.

E. Input/Output Points List
1. Provide all control points required to perform the automatic control sequence described above and reconnect all existing scheduled BAS points. All points scheduled on the drawing shall be shown on the graphics.

2.5 HEAT PUMP (HP-2)

A. General: Constant volume heat pump unit. Unit is controlled by internal packaged equipment controller. BAS system interfaces with unit and monitors equipment operation and room conditions.

B. Provide graphic display screen for rooftop heat pump.

C. System Operation
1. System is intended to operate during office occupied hours and as needed for night setback or purge.

D. Night Low Limit Mode:
1. Mode Control: Enable during unoccupied period if any space temperature is below 58ºF. Disable when all space temperatures are above 62ºF.
2. Damper Control: Close outside air and exhaust air damper. Open return air damper.
3. Fan Operation: Supply fans on. Powered exhaust fan off.

E. Warm-up Mode:
1. Mode Control: Enable between fan start time and occupancy time in accordance with Time Control.
2. Damper Control: Close outside air and exhaust air damper.
3. Fan Operation: Supply fans on. Powered exhaust fan off.

F. Cool-down Mode:
1. Mode Control: Enable between fan start time and occupancy time in accordance with Time Control.
2. Damper Control: Open outside air and exhaust air dampers. Close return air damper. Modulate outside air damper to maintain discharge setpoint.
3. Fan Operation: Supply fans and powered exhaust fan on.

G. Occupied Temperature Control Mode:
1. Mode Control: Enable during occupied period.
2. Damper Control: Open outside air and exhaust fan dampers. Modulate outside air and return air dampers from minimum ventilation position to maintain required temperature setpoint.
3. Fan Operation: Supply and exhaust fans on.

H. Input/Output Points List
1. Provide all control points required to perform the automatic control sequence described above and reconnect all existing scheduled BAS points. All points scheduled on the drawing shall be shown on the graphics.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install complete control system including all components, devices, and accessories required to perform desired sequence of operation.

B. Contractor may re-use existing devices as long as it maintains functionality. Reused devices shall be verified for functionality. Contractor shall provide a report of all devices and note any devise needing to be replaced.

END OF SECTION

SECTION 232113

ABOVE GROUND HYDRONIC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes pipe, fittings, and joining methods for HVAC systems.

1.2 PERFORMANCE REQUIREMENTS

A. All hydronic piping, equipment, fittings, and accessories shall be capable of withstanding the following maximum pressure and temperature. Exceptions would include specific items of equipment where a lower operating pressure is specified.
   1. Chilled-Water Piping:
      a. Maximum operating pressure: 125 psig.
      b. Maximum operating temperature: 200°F.
   2. Makeup-Water Piping:
      a. Maximum operating pressure: 125 psig.
      b. Maximum operating temperature: 100°F.
   3. Condensate-Drain Piping:
      a. Maximum operating pressure: 50 psig.
      b. Maximum operating temperature: 7°F.
   4. Air-Vent Piping:
      a. Same as connected service pressure
      b. Same as connected service temperature.

1.3 ACTION SUBMITTALS

A. Provide materials list for pipe and fittings.

B. Provide catalog data for dielectric fittings.

1.4 QUALITY ASSURANCE

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

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

C. 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 ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.

B. Drawn-Temper Copper Tubing: ASTM B 88, Type M.

C. DWV Copper Tubing: ASTM B 306, Type DWV.

D. Wrought-Copper Fittings: ASME B16.22.

E. Wrought-Copper Unions: ASME B16.22.

2.2 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; type, grade, and wall thickness as indicated in Part 3 "Piping Applications" Article.

B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in Part 3 "Piping Applications"

C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in Part 3 "Piping Applications"

D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in Part 3 "Piping Applications"

E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in Part 3 "Piping Applications" Article.

F. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

G. 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.

H. Grooved Mechanical-Joint Fittings and Couplings:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Grinnell Mechanical Products
      b. Victaulic Company
   2. Joint Fittings: ASTM A 536, Grade 65-45-12 ductile iron; ASTM A 47/A 47M, Grade 32510 malleable iron; ASTM A 53/A 53M, Type F, E, or S, Grade B fabricated steel; or ASTM A 106, Grade B steel fittings with grooves or shoulders constructed to accept grooved-end couplings; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
   3. 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, rigid and flexible.

I. Steel Pipe Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.

2.3 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inchmaximum thickness unless thickness or specific material is indicated.
a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.

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

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

D. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.

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

F. Gasket Material: Thickness, material, and type suitable for fluid to be handled and working temperatures and pressures.

2.4 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Watts, a Watts Water Technologies company
b. Wilkins
2. Description:
a. Standard: ASSE 1079.
b. Pressure Rating: 125 psig minimum at 180°F, 150 psig.
c. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Watts, a Watts Water Technologies company
b. Wilkins
2. Description:
a. Standard: ASSE 1079.
b. Factory-fabricated, bolted, companion-flange assembly.
c. Pressure Rating: 125 psig minimum at 180°F, 150 psig.
d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Insulating Kits:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
   a. Advance Products & Systems, Inc.
2. Description:
   a. Nonconducting materials for field assembly of companion flanges.
   b. Pressure Rating: 150 psig.
   c. Gasket: Neoprene or phenolic.
   d. Bolt Sleeves: Phenolic or polyethylene.
   e. Washers: Phenolic with steel backing washers.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Chilled-water piping, NPS 2and smaller, shall be either of the following:
1. Type L drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
2. Schedule 40 steel pipe; Class 150, malleable-iron fittings; cast-iron flanges and flange fittings; and threaded joints.

B. Chilled-water piping, NPS 2-1/2and larger, shall be either of the following:
1. Type L drawn-temper copper tubing, wrought-copper fittings, and joints.
2. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
3. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.

C. Makeup-water piping shall be the following:
1. Type L drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

D. Condensate-Drain Piping:
1. 1-1/4 and larger: Type DWV drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
2. 1” and smaller: Type M drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

E. Air-Vent Piping:
1. Inlet: Same as service where installed.
2. Outlet: Type K annealed-temper copper tubing with soldered or flared joints.

F. Refrigerant Relief Piping: Schedule 40 steel pipe; Class 150, malleable-iron fittings; cast-iron flanges and flange fittings; and threaded joints.

G. Connectors, Flexible Mechanical Couplings as specified in 23 21 16 - Hydronic Piping Specialties: Flexible grooved, mechanical joint coupling and fittings.

H. Control and Instrumentation Piping:
1. 3/8-inch stainless steel tubing, unless otherwise indicated on drawings.

I. Where piping connections, accessories, or control components are attached to piping with an operating temperature less than 60^{o}F, penetrate the insulation vapor barrier, and do not have continuous or intermittent fluid flow.
1. Provide piping and components that are non-corrosive such as stainless steel or bronze.
2. Insulate and provide vapor barrier to prevent condensation. Refer to 23 07 19 - HVAC Piping Insulation

3.2 VALVE APPLICATIONS

A. Install shutoff-duty valves at each branch connection to supply mains at supply connection to each piece of equipment, and where shown on drawings.

B. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; and pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

C. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

D. Install control valves according with manufacturer's instructions. Verify control valve port arrangement provides the intended function. Notify Engineer of any potential conflict between valve arrangement shown on plans and control valve installation requirements prior installing valves. Any control valves installed with incorrect connections will be re-piped to provide correct function at no expense to the Owner.
   1. Three-way control valve arrangement shown on plans is based on typically valve configuration. Verify three-way control valve connections prior to installing valves.

3.3 PIPING INSTALLATIONS

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved by Engineer.

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

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

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

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

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

I. Install piping to allow application of insulation.

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

K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

L. Install drains, consisting of a tee fitting, NPS ¾ball valve, and short NPS ¾threaded nipple with cap, at low points in piping system mains and elsewhere as required for complete system drainage.

M. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

O. Install branch connections to mains using tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.

P. Install unions in piping, NPS 2and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

Q. Install flanges in piping, NPS 2-1/2and larger, at final connections of equipment and elsewhere as indicated.

R. Install strainers on inlet side of each control valve, pressure-reducing valve, solenoid valve, in-line pump, and elsewhere as indicated. Install NPS ¾nipple and ball valve in blowdown connection of strainers NPS 2and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.

S. Flexible Mechanical Coupling Connectors: Refer to 23 21 16 - Hydronic Piping Specialties for installation requirements.

T. Flush and fill systems with fluid. Coordinate and assist with installation of chemical treatment equipment and testing.

U. Provide temporary facilities required for cleaning and treatment of piping connected to existing hydronic systems:
   1. Provide temporary recirculation bypass assembly including:
      a. Shutoff valves to isolates new work from existing system.
      b. Temporary recirculation pipe connections with shutoff valves and caps.
      c. Bypass piping with isolation valve to enable circulation in new section of piping.
      d. Drain valves as required.

3.4 CONNECTION BETWEEN DISSIMILAR METALS

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 2 and Smaller: Use dielectric unions.

C. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges.

3.5 HANGERS AND SUPPORTS

A. Comply with requirements in Section 23 05 29 – Hangers and Supports for HVAC Piping and Equipment for hanger, support, and anchor devices.

B. Support vertical runs at roof and at each floor.

3.6 PIPE JOINT CONSTRUCTION

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

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

C. 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.

D. 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.

E. 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.

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

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

H. 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, except use flexible couplings where indicated to accommodate movement and for vibrations control.

3.7 TERMINAL EQUIPMENT CONNECTIONS

A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.

B. Install control valves in accessible locations close to connected equipment.

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 hydronic piping systems with clean water; then remove and clean or replace strainer screens. Repeat process until systems are clean and no debris is found in fluid or strainer screens.
   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 air. Use drains installed at low points for complete draining of test liquid.
   3. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working 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 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
   4. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
   5. Prepare written report of testing.

END OF SECTION

SECTION 232116

HYDRONIC PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes special-duty valves and specialties for hydronic piping applications.

1.2 ACTION SUBMITTALS

A. Provide submittals for products listed in the Product Table below in accordance with Section 23 05 00 – General HVAC Provisions. Submittal requirements indicated by column number designation as follows:
1. Materials List
2. Catalog Data
3. Product Data
4. Performance Data
5. Wiring Diagrams
6. Shop Drawings
7. Installation Instructions
8. Special Requirement listed herein.

PRODUCT TABLE	1	2	3	4	5	6	7	8
Balancing Devices	X		X	X			X	X
Air Control Devices		X						
Strainers		X						
Connectors			X					X
Roof Hydrant		X						

B. Special Requirements
1. Hydronic Specialty Valves: Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
2. Balancing Devices: Provide instrument schedule listing each balancing device furnished along with model number, line size, design flow, permanent pressure drop, and measurement differential pressure at design flow.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air-control devices, hydronic specialties, and special-duty valves to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
1. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

PART 2 - PRODUCTS

2.1 BALANCING DEVICES

A. Flow Measuring Station:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Armstrong Pumps, Inc.
   b. Tour & Andersson; available through Victaulic Company.
   c. Macon Balancing.
   d. Wheatley.
2. Body:
   a. 2-inch and Smaller: Bronze construction, threaded connection.
   b. 2-1/2 inch and Larger: Cast-iron, flanged connection.
3. Disc: Bronze
4. Seat: Teflon or resin.
5. Pressure Gage Connections: Integral quick connection test ports located upstream and downstream of valve seat for portable differential pressure meter.
6. Handle Style: Hand wheel with vernier valve position scale and hidden memory stops.
7. CWP Rating: Minimum 125 psig.
8. Maximum Operating Temperature: 250°F.
9. Size: Line size unless device pressure drop does not conform to the following requirements then provide nearest conforming size.
   a. Full open pressure drop shall not exceed 3 feet water column at design flow.
   b. Minimum position (0.5 turn) pressure drop shall not be less than 3 feet water column at design flow.
10. Accessories: Preformed insulation jacket, ASTM 1784.

2.2 AIR-CONTROL DEVICES

A. Air vents aid in system filling. Air removal after initial startup is accomplished by air separator or boiler dip-tube. Leakage from automatic air vents may cause damage to ceilings and other finished surfaces. Manual air vents may be preferred over automatic air vents in finished spaces.

B. Manual Air Vents:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. AMTROL, Inc.
   b. Armstrong Pumps, Inc.
   c. Bell & Gossett; a Xylem brand.
   d. Nexus Valve, Inc.
2. Body: Bronze.
3. Internal Parts: Nonferrous.
4. Operator: Screwdriver or thumbscrew.
5. Inlet Connection: NPS 1/2.
6. Discharge Connection: NPS 1/8.
7. CWP Rating: 150 psig.
8. Maximum Operating Temperature: 225F.

2.3 STRAINERS

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

a. Armstrong.
b. Mueller Steam Specialty.
c. Spirax Sarco,
d. Watts.

2. Body: Bolted cover and threaded bottom blowoff outlet connection.
   a. Steel Piping System: ASTM A 126, Class B, cast iron.
   b. Copper Piping Systems: Bronze
3. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
4. Screen:
   a. Free area of strainer element no less than four times the pipe cross sectional area.
   b. Material
      1) Closed, chemically treated hydronic systems: Stainless-steel.
      2) Open or non-chemically treated hydronic systems: Brass
   c. Size
      1) 2-inch and Smaller: 20 mesh
      2) 2-1/2 inch to 4-inch: 1/16-inch perforations
      3) 5-inch and Larger: 1/8-inch perforations.
5. CWP Rating: 125 psig.

2.4 CONNECTORS

A. Flexible Mechanical Couplings: See to 23 21 13 - Above Ground Hydronic Piping, Grooved Mechanical-Joint Fittings and Couplings.
   1. Lengths are those recommended by Mason Industries to provide optimum vibration isolation. Shorter lengths are available where adequate space is not available, or vibration is not a potentially serious issue.
   2. Copper connectors are only available up to 4-inch. Since copper piping is relatively flexible, connectors do not provide significant benefit for vibration isolation, and are only needed for expansion compensation or seismic control.

B. Flexible Stainless Steel or Copper/Bronze Hose Connectors
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Kinetics Noise Control, Inc.
      b. Mason Industries, Inc.
   2. Basis of Design:
      a. 2-inch and Smaller: Mason Industries MN or CPS Series
      b. 2-1/2 inch and Larger: Mason Industries FFL or CPS Series
   3. Construction:
      a. Steel Piping Systems: Stainless steel braid and carbon steel fittings.
      b. Copper Piping Systems: Braided bronze hose with copper ends.
   4. Minimum Face to Face Length:
      a. 2-inch and smaller, 24 inches
      b. 2-1/2 inch and larger, 36 inches.
   5. Connection
      a. Steel
         1) 2-inch and Smaller: Male nipple.
         2) 2-1/2 inch and Larger: Flanged hoses with one fixed and one floating raised face carbon steel plate flange
      b. Copper: Sweat connection
      c. The buffer tank spec was taken from the old SWE master. It appears to have been developed for a specific heating application. A master version that includes other applications, configurations, and potential accessories should be developed

d. “Test Plugs” and “Site Flow Indicators” been removed from this section. Refer to 23 05 19 - Meters and Gages for HVAC Piping

2.5 Non-Freeze Draining-Type Roof Hydrants (RH-1):

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Jay R. Smith Mfg. Co.
2. Josam Company.
3. MIFAB, Inc.
4. Watts; a Watts Water Technologies company.
5. Woodford Manufacturing Company.
6. Zurn Industries, LLC.

B. Basis of Design: Jay R. Smith Mfg. Co. 5906.

C. Standard: ASME A112.21.3M.

D. Type: Non-freeze, exposed-outlet roof hydrant with coated cast-iron head, pail hook, and lift handle with lock option. Provide with deck flange/flashing clamp and under deck clamp.

E. Casing and Operating Rod: Bronze interior parts, galvanized-steel casing, plunger valve, and drain.

F. Inlet: NPS 3/4.

G. Outlet: Garden-hose thread complying with ASME B1.20.7.

H. Potable water piping and components shall comply with NSF 61 Annex G.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install equipment in accordance with manufacturer’s recommendations.

B. Balancing Devices:
1. Install in piping where shown on Drawings. Install with minimum lengths of straight upstream and downstream pipe without valves or fittings in accordance with manufacturer’s recommendations. Piping in straight upstream and downstream sections to be same size as balancing device connection.
2. Install so temperature and pressure probes can easily be inserted and removed.

C. Air Vents
1. Install automatic air vents and associated drain piping to floor drain or floor sink at the following locations.
a. High points in mechanical rooms.
2. Install manual air vents at all other high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.
3. Provide isolation valve at each air vent.
4. Installation and arrangement requirements for air separators and expansion tanks need to be developed. This should be coordinated with master details. Potentially, all of this could be done by reference to details if the details are considered to take care of all potential installation options of different separators and expansion tank types.

Until this is fully developed, user should make sure the detail adequately describes all installation requirements

D. Y-Pattern Strainers
1. Locate where shown on drawings and ahead of reducing valves, automatic control valves, and pumps.
2. Arrange for easy access.
3. Provide ball valve with hose end connection on blowoff outlet of hydronic system strainers two inches and larger.
4. Provide pressure gauges on strainers 4-inch and larger. Pipe to strainer inlet and outlet. Provide ball valve at each connection.

E. Connectors:
1. Install with no misalignment of piping and equipment connections.
2. Retain one of the following two paragraphs. Flexible spherical couplings should only be used in areas that can have a significant water leak without incurring significant damage such as ground floor mechanical rooms
3. For flexible mechanical joints, provide minimum of three flexible mechanical couplings between last branch tee fitting to the equipment and the equipment connection.
   a. Couplings may connection pipe to pipe, pipe to pipe fitting, or pipe to valve or other in-line piping accessory.
   b. Coupling shall be spaced with minimum 12 inches between coupling and one coupling shall be installed in pipe segment that is not parallel with the other two such as on either side of a 90 degree elbow. Installation of all three coupling in series in one pipe segment is not acceptable.

3.2 APPLICATION

A. Connectors: Provide where flexible pipe connections are shown on drawings or as otherwise specified to accommodate piping expansion, vibration control, or seismic movement.
1. Piping 2-inch and below: Flexible Stainless Steel or Copper/Bronze Hose Connectors
2. Piping 2-1/2 and larger: Flexible mechanical couplings
3. Provide connectors for all piping to accommodate seismic differential motion. See 23 05 48 - Vibration and Seismic Controls for HVAC, “Accommodation of Differential Seismic Motion”
4. Provide connectors at equipment connections for all equipment that has vibration isolation supports.

END OF SECTION

SECTION 232123

HYDRONIC PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Base Mounted pumps
2. Pump Specialty Fittings

1.2 DEFINITIONS

A. Buna-N: Nitrile rubber.

B. EPT: Ethylene propylene terpolymer.

1.3 QUALITY ASSURANCE

A. Pump and motor combination shall operate at specified system fluid temperatures without vapor binding or cavitation and are non-overloading in parallel or individual operation.

B. Pumps shall conform to ANSI/HI 9.6.1-1997 standards for Centrifugal and Vertical Pumps for NPSH Margin.

C. Pump impeller diameter shall not exceed 90% of maximum impeller diameter.

D. If equipment is approved which has different flow or pressure drop requirements than scheduled, contractor shall select new pumps with capacity and pressure capabilities adjusted to maintain scheduled pump efficiency and requirements. Select pumps so that the head-capacity curve slopes up to maximum pressure at shut-off. Contractor will provide all additional or larger electrical components required by an approved pump having greater horsepower than scheduled.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of pump. Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated. Indicate pump's operating point on curves.

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.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For pumps to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Mechanical Seals: One mechanical seal(s) for each pump.

PART 2 - PRODUCTS

2.1 BASE MOUNTED PUMPS

A. Separately Coupled, Base-Mounted, End-Suction Centrifugal Pumps (End Suction)

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Armstrong Pumps, Inc.
   2. Xylem-Bell and Gossett
   3. PACO Pumps; Grundfos Pumps Corporation, USA.
   4. TACO Comfort Solutions, Inc.
   5. Patterson Pump Company

C. Description: Factory-assembled and tested, long-coupled, end suction, single stage. Designed for base mounting with pump and motor shafts horizontal. Capable of being serviced without disturbing piping connections, electrical motor connections or pump to motor alignment. The pump(s) vibration limits shall conform to Hydraulic Institute ANSI/HI 9.6.4-2009 for recommended acceptable unfiltered field vibration limits (as measured per ANSI/HI 9.6.4-2009 Figure 9.6.4.2.3.1) for pumps with rolling contact bearings.

D. Pump Construction:
   1. Casing: Vertical split case, cast iron stainless steel fitted with threaded gage tappings at inlet and outlet, drain plug at bottom and air vent at top of volute, and flanged connections. Volute of cast iron with integrally cast pedestal volute support. Rated for 175 psi with integral cast iron flanges drilled for 125# ANSI companion flanges.
   2. Shaft and Bearing Assembly: Solid SAE1144 steel shaft with stainless steel shaft sleeve completely covering the wetted area under the seal. Bearing assembly shall support the shaft via two heavy-duty re-greaseable ball bearings. Bearing assembly replaceable without disturbing the system piping and equipped with foot support at the coupling end. Pump bearings re-greaseable without removal of the bearings from the bearing assembly. Thermal expansion of the shaft toward the impeller prevented by an inboard thrust bearing.
   3. Impeller: Stainless steel both hydraulically and dynamically balanced to ANSI/HI 9.6.4-2009, balance grade G6.3 and secured by a stainless-steel locking cap screw or nut.

E. Shaft Coupling and Coupling Guard: Provide center drop-out type coupling, capable of absorbing torsional vibration between the pump and motor. Pumps for variable speed application provided with a suitable coupling sleeve. Coupling shall allow for removal of pump’s wetted end without disturbing pump volute or movement of the pump’s motor and electrical connections. On variable speed applications, construct coupling of a neoprene material to maximize performance life. Provide ANSI and OSHA rated coupling guard. Coupling guard shall be dual rated ANSI B15.1 and OSHA 1910.219 compliant and contain viewing windows for inspection.

F. Baseplate: Structural steel or fabricated steel channel configuration fully enclosed at sides and ends, with securely welded cross members and fully open grouting area (for

field grouting). The minimum base plate stiffness shall conform to ANSI/HI 1.3.8.2.1-2009 for grouted Horizontal Baseplate Design standards.

G. Motors: Provided hereunder, see Section 23 05 13 – Common Motor Requirements for HVAC Equipment.

H. Motor Controller: Provided hereunder as scheduled, refer to Section 23 05 14 – Motor Control Devices for HVAC Equipment.

I. Capacity: As scheduled on drawings.

2.2 PUMP SPECIALTY FITTINGS

A. Suction Diffuser:
1. Angle pattern.
2. 175-psig pressure rating, 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.
7. Maximum Pressure Drop: 2.0 psi at design flow rate.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

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

C. Examine foundations and inertia bases for suitable conditions where pumps are to be installed.

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

3.2 PUMP INSTALLATION

A. Install pumps to allow access for periodic maintenance including removing motors, impellers, couplings, and accessories.

B. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.

C. Base Mounted Pumps:
1. Install base-mounted pumps on cast-in-place concrete equipment bases.
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 23 05 48 – Vibration and Seismic Controls for HVAC.

3.3 ALIGNMENT

A. Align pumps as recommended by pump and coupling manufacturer recommendations and Hydronics Institute standards. Engage a factory-authorized service representative to align all base mounted pumps.

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. After alignment is correct, tighten foundation bolts evenly but not too firmly. For base mounted pumps greater than 20 HP, completely fill baseplate with non-shrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

D. Record field adjustments and include in the O & M manual.

3.4 CONNECTIONS

A. Where installing piping adjacent to pump, allow space for service and maintenance.

B. Connect piping to pumps. Install valves that are same size as piping. Install reducers or increasers as required at pump connections.

C. Provide pump trim as detailed on drawings.

D. Provide pressure gauge. Connect gauge to pump suction and discharge casing gauge taps. Provide ball valve at each connection.

3.5 STARTUP SERVICE

A. Perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.
   2. Check piping connections for tightness.
   3. Clean strainers on suction piping.
   4. Perform the following startup checks for each pump before starting:
      a. Verify bearing lubrication.
      b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
      c. Verify that pump is rotating in the correct direction.
   5. Prime pump by opening suction valves and closing drains and prepare pump for operation.
   6. Start motor.
   7. Open discharge valve slowly.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain hydronic pumps.

END OF SECTION

SECTION 232300

REFRIGERANT PIPING AND SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Refrigerant pipes and fittings.
2. Refrigerant piping valves.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of valve and refrigerant piping.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to 2010 ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

B. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."

C. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.6 PRODUCT STORAGE AND HANDLING

A. Store piping with end caps in place to ensure that piping interior and exterior are clean when installed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Line Test Pressure for Refrigerant R-410A:
1. Suction Lines for Air-Conditioning Applications: 300 psig.
2. Hot-Gas and Liquid Lines: 535 psig.

2.2 COPPER TUBE AND FITTINGS

A. Copper Tube: Hard drawn ASTM B 280, Type ACR cleaned, dehydrated, and sealed. Annealed or hard drawn as scheduled.

B. Long Radius Wrought-Copper Fittings: ASME B16.22.

C. Wrought-Copper Unions: ASME B16.22.

D. Solder Filler Metals: ASTM B 32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.

E. Brazing Filler Metals: AWS A5.8/A5.8M.

F. Flexible Connectors:
1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
2. End Connections: Socket ends.
3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch-long assembly.
4. Working Pressure Rating: Factory test at minimum 500 psig.
5. Maximum Operating Temperature: 250 deg F.

2.3 VALVES AND SPECIALTIES

A. Diaphragm Packless Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Danfoss Inc.
b. Heldon Products; Henry Technologies.
c. Parker Hannifin Corp.
2. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
3. Diaphragm: Phosphor bronze and stainless steel with stainless-steel spring.
4. Operator: Rising stem and hand wheel.
5. Seat: Nylon.
6. End Connections: Socket, union, or flanged.
7. Working Pressure Rating: 500 psig.
8. Maximum Operating Temperature: 275 deg F.

PART 3 - EXECUTION

3.1 PIPING

A. Provide hard drawn ACR copper piping to be used in all applications.

3.2 FITTINGS

A. Joints
1. 7/8-inch and Smaller: Solder
2. 1-1/8 inch and Larger: Braze

3.3 INSULATION

A. Hard Drawn Piping: Insulate in accordance with Section 23 07 19 – HVAC Piping Insulation.

3.4 VALVE AND SPECIALTY APPLICATIONS

A. Provide diaphragm packless valves for isolation as shown on drawings or in accordance with the equipment manufacturer’s recommendations.

3.5 PIPING INSTALLATION

A. Install refrigerant piping according to ASHRAE 15.

B. Install hard drawn piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

C. Install annealed copper piping with no joints between equipment connections.

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

E. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

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

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

H. Install piping free of sags and bends.

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

J. Install refrigerant piping in protective conduit where installed belowground.

K. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

L. Slope refrigerant piping as follows:
   1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
   2. Install horizontal suction lines with a uniform slope downward to compressor.
   3. Install traps and double risers to entrain oil in vertical runs.
   4. Liquid lines may be installed level.

M. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

N. Install sleeve seals and escutcheons. Comply with requirements for sleeve seals specified in Section 23 05 17 – Sleeves, Sleeve Seals, and Escutcheons for HVAC Piping.

3.6 PIPE JOINT CONSTRUCTION

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

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

C. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."

D. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."

1. Use Type BCuP (copper-phosphorus) alloy for joining copper socket fittings with copper pipe.
2. Use Type BAg (cadmium-free silver) alloy for joining copper with bronze.

3.7 HANGERS AND SUPPORTS

A. Comply with requirements for pipe hangers and supports specified in Section 23 05 29 – Hangers and Supports for HVAC Piping and Equipment.

3.8 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
   1. Comply with ASME B31.5, Chapter VI.
   2. Test refrigerant piping and specialties.
   3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in "Performance Requirements" Article.
      a. Fill system with nitrogen to the required test pressure.
      b. System shall maintain test pressure at the manifold gage throughout duration of test.
      c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
      d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

B. Prepare test and inspection reports.

3.9 SYSTEM CHARGING

A. Charge system using the following procedures:
   1. Install core in filter dryers after leak test but before evacuation.
   2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.
   3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.

END OF SECTION

SECTION 233113

METAL DUCTWORK

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes metal ductwork, liner, and related fittings and sealants.

1.2 PERFORMANCE REQUIREMENTS

A. Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.

B. Structural Performance: Duct hangers and supports shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"

C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

1.3 ACTION SUBMITTALS

A. See Section 23 05 00 for general submittal requirements.

B. Materials List:
1. Shop fabricated ductwork:

C. Catalog Data:
1. Pre-manufactured Ductwork and Fittings.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

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. Comply with applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

C. Comply with applicable requirements in ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Ductwork Dimensions: Ductwork dimensions shown on drawings are internal dimensions. Adjust outer ductwork size to accommodate liner, double wall construction, or other conditions that would affect interior clear duct opening size.

2.2 SINGLE-WALL 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."

E. Sealing Requirements:
1. Concealed: Seal longitudinal seams and transverse joints with liquid duct sealer or tape-and-adhesive. Flanged, gasketed joints that meet seal requirements do not require separate duct sealant application.
2. Exposed: Seal non-flanged transverse joints with liquid duct sealer, specified herein, applied to male end fittings only, so that sealer is not visible when joint is assembled.

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: G60.
2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. 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.

D. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.4 SEALANT AND GASKETS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Ductmate Industries
2. McGill AirSeal LLC.
3. Carlisle HVAC Products

B. 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.

C. 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 w.g., positive and negative.
7. Service: Indoor and outdoor.
8. Service Temperature: Minus 40 to plus 200 deg F.
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).

D. 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 w.g., 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.

E. 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).

F. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

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, "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 Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

F. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

G. Trapeze and Riser Supports:
1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.

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 by Engineer.

B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install round and flat-oval 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, 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.

K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Section 23 33 00 – 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. Provide Seal Class in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible,"

B. Clean duct surfaces prior to applying sealant.

C. Prior to application, verify that ducts are dry and within specified temperature limits.

D. Open ends of completed and overnight work-in-progress shall be sealed.

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 thick.
   4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.

5. Do not use powder-actuated concrete fasteners for seismic restraints.
6. Confirm design of existing concrete slabs prior to installing fasteners. Where existing slabs contain embedded components such as tension cables. Locate embedded components and install fasteners to so that embedded components remain undamaged.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "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 of each elbow and within 48 inches 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 interval of 16 feet.

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 SEISMIC-RESTRAINT-DEVICE INSTALLATION

A. See Section 23 05 48 – Vibration and Seismic Controls for HVAC.

3.6 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Section 23 33 00 – Air Duct Accessories.

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.7 FIELD QUALITY CONTROL

A. Duct System Cleanliness Tests:
1. Visually inspect duct system to ensure that no visible contaminants are present.

3.8 START UP

A. Air Balance: Comply with requirements in Section 23 05 93 – Testing, Adjusting, and Balancing for HVAC.

3.9 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel.

B. Pressure Class
1. Rating shall be the largest of the following conditions.
   a. 2-inch minimum.
   b. 120% of the fan design static pressure.
   c. Where an automatically operated damper such as a fire and/or smoke damper or control damper can stop airflow: 100% of maximum achievable fan static pressure for fan and motor combination provided.

2. Ductwork connected to fan discharge shall be rated for positive pressure.
3. Ductwork connected to the fan inlet shall be rated for negative pressure.
4. Ductwork interconnecting two fans shall be rated for largest of the two conditions.

C. Seal Class
1. Seal Class depending on Pressure Class in accordance with SMACNA's " HVAC Duct Construction Standards – Metal and Flexible except as otherwise indicated.

D. Leakage Class
1. Leakage Class as required to meet recommended maximum leakage percentages as tabulated in ASHRAE Handbook "HVAC Systems and Equipment -2012, Chapter 19, Table 2."

E. All ductwork single wall .

F. Supply Ducts:
1. Ducts Connected to Heat Pumps:
   a. Pressure Class: Positive 2-inch w.g.

G. Return Ducts:
1. Ducts Connected to Heat Pumps:
   a. Pressure Class: 2-inch w.g.

H. Intermediate Reinforcement: Match duct material.

I. Elbow Configuration:
1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
   a. Velocity 800 fpm or Lower:
      1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
      2) Mitered Type RE 4 without vanes.
   b. Velocity 800 to 1500 fpm:
      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 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."

J. 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:
      1) Velocity less 1000 fpm: Conical tap or 45-degree entry.
      2) Velocity 1000 fpm or Higher: 45-degree entry.

END OF SECTION

SECTION 233300

AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Accessories for duct systems.

1.2 ACTION SUBMITTALS

A. Provide submittals for products listed in the Product Table below in accordance with Section 23 05 00 – General HVAC Provisions. Submittal requirements indicated by column number designation as follows:
1. Materials List
2. Catalog Data
3. Product Data
4. Performance Data
5. Wiring Diagrams
6. Shop Drawings
7. Installation Instructions
8. Special Requirement listed herein.

PRODUCT TABLE	1	2	3	4	5	6	7	8
Manual Volume Dampers		x						
Turning Vanes		x						
Fire and Smoke Dampers			X					
Plenum and Duct Mounted Access Doors			X					
Flexible Connectors		X						

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.4 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

B. 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.

2.2 MATERIALS

A. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
   1. Galvanized Coating Designation: G60.
   2. Exposed-Surface Finish: Mill phosphatized.

B. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

C. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.3 MANUAL VOLUME DAMPERS

A. Acceptable Manufacturers
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Greenheck
      b. Nailor Industries Inc.
      c. Pottorff.
      d. Ruskin Company.
      e. Trox USA Inc.
      f. Young Regulator Company.

B. Single Blade Rectangular Manual Volume Dampers:
   1. Operating Conditions:
      a. Maximum temperature: 180oF
      b. Maximum differential pressure: 1-inch water column.
      c. Maximum air velocity: 2,000 fpm.
      d. Standard leakage rating.
   2. Suitable for horizontal or vertical applications.
   3. Frames: Hat-shaped, welded or gusset reinforced corners. 18-gauge construction. Material to match connected ductwork.
   4. Blades:
      a. Single blade.
      b. 20-gauge construction. Material to match connected ductwork.
      c. Stiffen damper blades for stability.
   5. Blade Axles: Minimum ½ inch dia. plated steel or stainless steel, except stainless steel where adjacent ductwork is aluminum or stainless steel.
   6. Linkages: Concealed in jamb outside or air stream.
   7. Bearings:
      a. Oil-impregnated bronze, except stainless-steel sleeve where aluminum or stainless-steel frames are required.
      b. Dampers shall have axles full length of damper blades and bearings at both ends of operating shaft.
   8. Actuator:
      a. Manual locking quadrant, except where remote damper operator is required.
      b. Elevated platform for insulated duct mounting.

C. Multiple Blade Rectangular Manual Volume Dampers:
   1. Operating Conditions:
      a. Maximum temperature: 180oF
      b. Maximum differential pressure: 4-inch water column.
      c. Maximum air velocity: 2,000 fpm.

d. Standard leakage rating.
2. Suitable for horizontal or vertical applications.
3. Frames:
   a. Hat-shaped, welded or reinforced corners. Material to match connected ductwork.
      1) Galvanized steel or stainless steel: 16-gauge.
      2) Aluminum: 12-gauge.
   b. Mitered corners.
   c. Flanges for attaching to walls and flangeless frames for installing in ducts.
4. Blades:
   a. Opposed blade.
   b. Rolled Formed. Material to match connected ductwork.
      1) Galvanized steel or stainless steel: 16-gauge.
      2) Aluminum: 12-gauge.
   c. Stiffen damper blades.
5. Blade Axles: Minimum ½ inch diameter plated-steel or stainless-steel, except stainless-steel where adjacent ductwork is aluminum or stainless-steel.
6. Bearings:
   a. Oil-impregnated bronze, except stainless-steel sleeve where aluminum or stainless-steel frames are required.
   b. Dampers shall have axles full length of damper blades and bearings at both ends of operating shaft.
7. Actuator:
   a. Manual locking quadrant, except where remote damper operator is required.
   b. Elevated platform for insulated duct mounting.
8. Transitions: Provide factory transitions for connection to round and oval ductwork as required.

2.4 TURNING VANES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
1. Ductmate Industries, Inc.
2. Duro Dyne Inc.
3. Elgen Manufacturing.
4. SEMCO LLC.

B. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."

C. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

D. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

E. Vane Construction: Single wall for ducts up to 18 inches wide and double wall for larger dimensions.

2.5 FIRE AND SMOKE DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Cesco Products; a division of MESTEK, Inc.
   2. Greenheck Fan Corporation.
   3. Nailor Industries Inc.
   4. Pottorff.
   5. Ruskin Company.

B. Smoke Dampers
   1. General Requirements: Label according to UL 555S by an NRTL.
   2. Rated pressure and velocity to exceed design airflow conditions.
   3. Frame: Hat-shaped, 16-gauge thickness, galvanized sheet steel, with welded interlocking, gusseted or mechanically attached corners and mounting flange.
   4. Blades:
      a. Air velocities 1,500 fpm and less: Roll-formed, horizontal, interlocking, galvanized sheet steel.
      b. Air velocities greater than 1,500 fpm: Extruded aluminum horizontal air-foil.
      c. Leakage: Class I.
   5. Mounting Sleeve: Factory-installed, galvanized sheet steel; length to suit wall or floor application.
   6. Damper Motors: Two-position action, spring return, closes on power interruption.
      a. Motor Sizes: Large enough so driven load will not require motor to operate in service factor range above 1.0.
      b. Electrical Connection: Coordinate actuator voltage with Division 26 and 28, maximum power consumption 25 watts.
   7. Accessories:
      a. Auxiliary switches for signaling fan control or position indication. See Section 230923 – Building Automation Systems for HVAC for requirements.
      b. Test and reset switches, damper-mounted.

C. Combination Fire and Smoke Dampers
   1. Type: Dynamic; rated and labeled according to UL 555 and UL 555S by an NRTL.
   2. Rated pressure and velocity to exceed design airflow conditions.
   3. Fire Rating: 1-1/2 hour for fire barriers rated for 2-hours or less, 3 hour and 4-hour fire barriers.
   4. Frame: Hat-shaped, 16-gauge thickness, galvanized sheet steel, with welded interlocking, gusseted or mechanically attached corners and mounting flange.
   5. Heat-Responsive Device: Electric resettable device and switch package, factory installed, rated.
   6. Blades:
      a. Air velocities 1,500 fpm and less: Roll-formed, horizontal, interlocking, galvanized sheet steel.
      b. Air velocities greater than 1,500 fpm: Extruded aluminum horizontal airfoil.
   7. Leakage: Class I.
   8. Mounting Sleeve: Factory-installed, galvanized sheet steel; length to suit wall or floor application.
   9. Damper Motors: Two-position action, spring return, closes on power interruption.
      a. Motor Sizes: Large enough so driven load will not require motor to operate in service factor range above 1.0.
      b. Electrical Connection: Coordinate actuator voltage with Division 26 and 28, maximum power consumption 25 watts.
   10. Accessories:
      a. Auxiliary switches for signaling fan control or position indication.
      b. Test and reset switches, damper mounted.

2.6 PLENUM AND DUCT-MOUNTED ACCESS DOORS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   1. Cesco Products; a division of MESTEK, Inc.
   2. Greenheck Fan Corporation.
   3. Nailor Industries Inc.
   4. Pottorff.
   5. Ruskin

B. Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2, "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."
   1. Door:
      a. Double wall, rectangular.
      b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
      c. Vision panel, round plexiglass.
      d. Hinges and Latches: 1-by-1-inchbutt or piano hinge and cam latches.
      e. Fabricate doors airtight and suitable for duct pressure class.
   2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
   3. Minimum Requirements for Number of Hinges and Locks:
      a. Access doors less than 12 inches square: No hinges and two sash locks.
      b. Access doors up to 24 inches square: Continuous and two sash locks.
      c. Access doors larger than 24 by 24 inches: Continuous and two compression latches with outside and inside handles.
   4. Rating:
      a. Maximum Operating Pressure: Equal or exceed rating of installed ductwork.

C. Pressure Relief Access Door:
   1. Door and Frame Material: Galvanized sheet steel.
   2. Door: Double wall with insulation fill with metal thickness applicable for duct pressure class.
   3. Operation: Open outward for positive-pressure ducts and inward for negative-pressure ducts.
   4. Factory set at 3.0- to 8.0-inch wg
   5. Doors close when pressures are within set-point range.
   6. Hinge: Continuous piano.
   7. Latches: Cam.
   8. Seal: Neoprene or foam rubber.
   9. Insulation Fill: 1-inch-thick, fibrous-glass or polystyrene-foam board.

2.7 FLEXIBLE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Ductmate Industries, Inc.
   2. Duro Dyne Inc.
   3. Elgen Manufacturing.
   4. Hardcast, Inc.
   5. JP Lamborn Co.
   6. Ventfabrics, Inc.

B. Materials: Flame-retardant or noncombustible fabrics.

C. Coatings and Adhesives: Comply with UL 181, Class 1.

D. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
1. Minimum Weight: 26 oz./sq. yd.
2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
3. Service Temperature: Minus 40 to plus 200°F.

E. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.
1. Minimum Weight: 24 oz./sq. yd.
2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
3. Service Temperature: Minus 50 to plus 250 deg F.

2.8 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts.

C. Provide low leakage control dampers as close as possible to the inlet of building exhaust fans as required by Oregon Energy Efficiency Specialty Code.

D. Install products in locations that are accessible and that will permit adjustment and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

E. Manual Volume Dampers:
1. Install in ductwork where shown on drawings and as required to properly balance airflow rates to values shown on Drawings. Provide damper for each air inlet and outlet.
2. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.
3. Dampers must be accessible to allow inspection, adjustment, and replacement of components.
4. Dampers shall be rigid and secure not producing any audible noise due to vibration of components.
5. Set dampers to fully open position before testing, adjusting, and balancing.

F. Turning Vanes
1. Install in mitered ductwork elbows and as shown on drawings.
2. Install with leading and trailing edges parallel to entering and leaving airflow.

G. Fire and Smoke Dampers:
1. Install fire and smoke dampers according to UL listing.

H. Duct-mounted Access Doors:
1. Install on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
   a. On both sides of duct coils.
   b. Upstream from duct filters.
   c. At outdoor-air intakes and mixed-air plenums.
   d. At drain pans and seals.
   e. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
   f. At each change in direction and at maximum 50-foot spacing.
   g. Upstream from turning vanes.
   h. Upstream or downstream from duct silencers.
   i. Control devices requiring inspection.
   j. Elsewhere as indicated.
2. Install access doors with swing against duct static pressure.
3. Access Door Sizes:
   a. One-Hand or Inspection Access: 8 by 5 inches.
   b. Two-Hand Access: 12 by 6 inches.
   c. Head and Hand Access: 18 by 10 inches.
4. Label access doors according to Section 230553 – Identification for HVAC Piping and Equipment to indicate the purpose of access door.

I. Flexible Connectors
1. Install flexible connectors to connect ducts to equipment.
2. For fans developing static pressures of 5-inch wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.
3. Provide connectors at equipment connections for all equipment that has vibration isolation supports.

J. Test Holes
1. Install test holes at fan inlets and outlets, coil inlets and outlets, and elsewhere as indicated.

3.2 APPLICATION

A. Manual Volume Dampers:
1. Material: Volume damper construction frame and blade material shall match material of connected ductwork.
2. Type:
   a. Rectangular Single Blade Manual Volume Dampers: Rectangular ductwork where largest cross-sectional dimension is 18-inches and below.
   b. Rectangular Multiple Blade Manual Volume Dampers:
      1) Rectangular or oval ductwork where largest cross-sectional dimension greater than 18-inches.

B. Flexible Connectors
1. Indoor system: All indoor applications, except where otherwise required.
2. Outdoor system: All outdoor applications, except where otherwise required.

3.3 FIELD QUALITY CONTROL

A. Tests and Inspections:
   1. Operate dampers to verify full range of movement.
   2. Inspect locations of access doors and verify that purpose of access door can be performed.
   3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
   4. Inspect turning vanes for proper and secure installation.

END OF SECTION

SECTION 233713

AIR OUTLETS AND INLETS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Diffusers
2. Grilles

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.
1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling 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. Ceiling suspension assembly members.
2. Size and location of initial access modules for acoustical tile.
3. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
4. Duct access panels.

PART 2 - PRODUCTS

2.1 COMMON REQUIREMENTS

A. Source Quality Control
1. Verification of Performance: Rate diffusers according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following, unless specifically stated otherwise:
1. Anemostat Products; a Mestek company.
2. Krueger.
3. Nailor Industries Inc.
4. Price Industries.
5. Titus.

2.2 RECTANGULAR AND SQUARE CEILING DIFFUSERS

A. Square and Rectangular Neck Louvered Diffusers SD-1
1. Basis of Design: Titus TDC
2. Material: Steel.
3. Finish: Baked enamel, white.
4. Duct Inlet: Square or rectangular, size as shown on Drawings.

5. If adjustable pattern controller is specified and intended to be provided in specific locations, then another diffuser type is required to identify the locations where this function is required.
6. Pattern: Four-way core style, or as shown on drawings. Provide adjustable pattern controller to adjust vertical to horizontal blow pattern where shown on Drawings.
7. Mounting:
   a. Suspended Ceiling: Flush, border type and module size compatible with ceiling system.

2.3 RETURN GRILLES

A. Copy and repeat paragraph with unique ID Tags if more than one grille material is required.

B. Fixed Blade Grille RG/EG-1

C. Basis of Design: Titus 350 RL/RS

D. Material: Steel

E. Finish: Baked enamel, white

F. Blade Arrangement: 35-degree blade deflection. Spaced 3/4 inch apart. Blades parallel to long dimension if installed in ceiling or horizontal position. Blades parallel to floor if installed in wall or vertical position.

G. Frame: 1-1/4 inches wide.

H. Mounting:
   1. Surface: Countersunk screw.
   2. Suspended Ceiling: Flush, border type and module size compatible with ceiling system.
   3. Exposed: Countersunk screw.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where diffusers are installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

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

3.2 INSTALLATION

A. Install diffusers level and plumb.

B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. Install diffusers with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

D. Mounted devices tight to finished surface.

3.3 ADJUSTING

A. After installation, adjust diffusers to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION

SECTION 237420

PACKAGED, OUTDOOR HEATING AND COOLING UNIT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Packaged rooftop air source heat pump units.

1.2 DEFINITIONS

A. External Static Pressure: Static pressure difference between supply air and return air ductwork connections.

1.3 DESIGN REQUIREMENTS

A. Equipment performance calculated for actual project elevation.

B. Unit shall operate normally with an outdoor ambient temperature between 115°F and 0°F in cooling:

1.4 ACTION SUBMITTALS

A. Provide submittals for products listed in the Product Table below in accordance with Section 23 05 00 – General HVAC Provisions. Submittal requirements indicated by column number designation as follows.
1. Materials List
2. Catalog Data
3. Product Data
4. Performance Data
5. Wiring Diagrams
6. Shop Drawings
7. Installation Instructions
8. Special Requirement listed herein.

PRODUCT TABLE	1	2	3	4	5	6	7	8
All Products in this Section			x	x	x	x	x	X

B. Special Requirements:
1. Shop Drawings: Indicate assembly, unit dimensions, weight loading, required clearances, construction details, field connection details, and electrical characteristics and connection requirements.
2. Performance Calculations:
   a. Computer generated fan curves for each air handling unit shall be submitted with specific design operating point noted.
   b. Computer generated psychometric chart for each cooling coil with design points and final operating point clearly noted.
   c. Sound data for discharge, radiated and return positions by octave band for each unit.
   d. Calculations for required baserail heights to satisfy condensate trapping requirements of cooling coil shall be included.

3. Product Data: Provide literature of components.
    a. Provide literature for individual components that indicates dimensions, weights, capacities, ratings, and electrical characteristics and connection requirements.
    b. Provide data of filter media, filter performance data, filter assembly, and filter frames.

1.5 QUALITY ASSURANCE

A. Cooling performance shall be rated in accordance with AHRI testing procedures.

B. Units shall be factory assembled, internally wired, fully charged with R-410A. Install all specified accessories and components at factory prior to shipment.

C. Perform factory run test for each unit provided hereunder to verify cooling operation, fan and blower rotation and control sequence. Submit copy of certified test report to Owner's Authorized Representative.

D. Units shall be UL listed and labeled, classified in accordance with UL 1995/C 22.2, 236-05.

E. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products listed and labeled in accordance with UL 723 or 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.

F. Unit internal wiring shall be colored and numbered, and identification shall correspond with wiring diagrams.

G. Unit sound power levels shall not exceed specified values. Field testing is not required as part of this Work; however, the Owner reserves the right to retain an independent acoustical consultant to test sound levels at Owner's expense.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect and handle products to site.

B. Accept products on site in factory-fabricated protective containers, with factory-installed shipping skids. Inspect for damage.

C. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Daikin, Trane, Aaon or approved.

2.2 PACKAGED ROOFTOP AIR SOURCE HEAT PUMP (2 to 7-1/2 Tons)

A. General: Electric heating and cooling unit complete with fan(s), motor(s), motor contactor/drive, direct-expansion cooling coil, electric heating, compressor(s), economizer section, controls, filters, thermostat, and accessories. The units shall be downflow or horizontal airflow as shown on drawings.

B. Casing:
1. Exterior Panels: Double -wall construction, minimum 18 gauge galvanized steel
2. Casing Insulation:
   a. Material: Foil face fiberglass. Insulation shall be glued and mechanically fastened to panels. Panel design shall have no exposed insulation edges.
   b. Casing Panel R-Value: Minimum 3.85.
   c. Insulation Thickness: 1 inch.
   d. Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roof of unit.
3. Panels and Doors:
   a. Panels:
      1) Fabrication: Formed and reinforced with same materials and insulation thickness as casing.
      2) Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against air-pressure differential.
      3) Gasket: Neoprene, applied around entire perimeters of panel frames.
      4) Size: Large enough to allow inspection and maintenance of air-handling unit's internal components.
   b. Access Doors:
      1) Hinges: A minimum of two ball-bearing hinges or stainless steel piano hinge and two wedge-lever-type latches, operable from inside and outside. Arrange doors to be opened against air-pressure differential.
      2) Gasket: Neoprene, applied around entire perimeters of panel frames.
      3) Size: Large enough to allow inspection and maintenance of air-handling unit's internal components.
   c. Locations and Applications:
      1) Verify that the sections listed below are large enough for panels and doors. Verify applicability with manufacturers.
      2) Fan Section: Doors.
      3) Access Section: Doors.
      4) Coil Section: Inspection and access panels.
      5) Damper Section: Inspection and access panels.
      6) Filter Section: Doors large enough to allow periodic removal and installation of filters.
      7) Mixing Section: Doors.
4. Condensate Drain Pans:
   a. Location: At each cooling coil.
   b. Condensate Overflow Switch: Switch to shut the unit down in the event that a clogged condensate drain line prevents proper condensate removal from the unit.
   c. Construction:
      1) Single-wall, stainless steel sheet.
   d. Drain Connection:
      1) Located at lowest point of pan and sized to prevent overflow.
      2) Minimum Connection Size: NPS 1 (DN 25).
5. Finish: Weather-resistant baked enamel or powder coat finish. Unit surface shall be tested minimum 500-hour salt spray test in accordance with ASTM B117.
6. Roof Panel: Pitched one-piece top piece cover or, where seams are required, seams shall be double hemmed and gasket sealed to prevent water leakage.
7. Base Frame: Unit base shall be galvanized steel and be a full perimeter design. The base frame shall have integral forklift slots and rigging holes. The unit base shall

overhang the roof curb for positive water runoff and shall seat on the roof curb gasket to provide a positive, weather tight seal.

C. Supply Fan:
1. Plenum fan, galvanized steel, centrifugal fan wheel. Fans shall be statically and dynamically balanced at factory.
2. Mounting: For internal vibration isolation. Factory-mount fan with manufacturer's standard.
3. Motor: High efficiency, electrically commutated with adjustable speed controller

D. Exhaust Fan:
1. Powered exhaust fan: Direct drive, axial flow exhaust fan. Fan and motor dynamically balanced.

E. Motor: High efficiency, electrically commutated with adjustable speed controller

F. Direct Expansion Cooling System:
1. Compressor: Hermetic scroll, mounted on vibration isolators; with internal overcurrent and high-temperature protection, internal pressure relief, and crankcase heater.
   a. Capacity Control: Variable-speed.
2. Refrigeration Specialties
   a. Refrigerant: R-410A.
   b. Expansion valve with replaceable thermostatic element.
   c. Refrigerant filter/dryer.
   d. Manual-reset high-pressure safety switch.
   e. Automatic-reset low-pressure safety switch.
   f. Minimum off-time relay.
   g. Automatic-reset compressor motor thermal overload.
   h. Brass service valves installed in compressor suction and liquid lines.
   i. Switchable reversing valve for heating or cooling mode selection.
3. Evaporator and Condenser Coils:
   a. Seamless copper tubes mechanically bonded to aluminum plate fins.
   b. Factory tested at 450 psig minimum.
4. Outdoor Fan: Direct-drive, statically and dynamically balanced, draw-through configuration with vertical discharge position. Fan motors permanently lubricated with built-in thermal overload protection.
5. Electric-Resistance Heating Coils: Comply with UL 1995.
   a. Casing Assembly consisting of electric heating coils, fuses, and high temperature limit switch galvanized-steel frame.
   b. Open Heating Elements: Resistance wire of 80 percent nickel and 20 percent chromium supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.
   c. Overtemperature Protection: Disk-type, automatically resetting, thermal-cutout, safety device; serviceable through terminal box without removing heater from coil section.
   d. Secondary Protection: Load-carrying, manually resetting or manually replaceable, thermal cutouts; factory wired in series with each heater stage.
   e. Control Panel: Unit mounted with disconnecting means and overcurrent protection.
      1) SCR controller.
      2) Time-delay relay.
      3) Airflow proving switch.

G. Filters: Provided hereunder, refer to Section 23 41 00 – Particulate Air Filtration.

H. Dampers: Modulating outside air, return, and exhaust air dampers, spring return actuators capable of providing 100% outside air for economizer cooling.
   1. Outdoor, Return, and Exhaust-Air Dampers: Low-leakage, double-skin, airfoil-blade, galvanized-steel dampers with compressible jamb seals and extruded-vinyl blade edge seals in opposed-blade arrangement with steel operating rods rotating in sintered bronze or nylon bearings mounted in a single galvanized-steel frame, and with operating rods connected with a common linkage. Leakage rate shall not exceed 4 cfm/sq. ft. at 1-inch wg and 8 cfm/sq. ft. at 4-inch wg.
   2. Electronic Damper Operators:
      a. Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
      b. Coupling: V-bolt and V-shaped, toothed cradle.
      c. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
      d. Fail-Safe Operation: Mechanical, spring-return mechanism with external, manual gear release on non-spring-return actuators.

I. Electrical:
   1. Single point electrical connection of power to unit with unit-mounted disconnect switch accessible from outside unit and control-circuit transformer with built-in overcurrent protection.
   2. Power monitoring: 3-phase line monitor that protects against phase loss, phase reversal, and phase unbalance. LED indicators for ON and FAULT. Automatic reset from a fault condition.
   3. Unit wiring shall comply with NEC requirements and with all applicable UL standards.
   4. All wiring and electrical components provided with the unit shall be number and color-coded and labeled according to the electrical diagram provided.
   5. The unit shall be provided with a factory wired weatherproof control panel.
   6. Receptacle: Duplex GFCI, 120v/15amp outlet.
   7. Colored and numbered wiring corresponding with unit wiring diagram.

J. Controls:
   1. General: Factory-installed microprocessor controls, switches, power supplies, wiring, and other miscellaneous devices for all control functions.
      a. Refrigerant Pressure and Safety Control:
         1) Anti-short cycle timing and time delay between compressor start
   2. Economizer Cooling Control: Changeover from mechanical cooling to economizer operation fully automatic through adjustable outdoor air changeover setpoint. Maintain minimum outside air use for ventilation when in “occupied” mode. Coordinate with balancing contractor to determine outside air, return air, and exhaust air damper positions setpoints. Outside air and exhaust air dampers close when supply fan is off.
      a. Monitor economizer operation and provide fault detection in accordance with ASHRAE 90.1-2019 requirements.
   3. Control Interface: BACnet

K. Accessories:
   1. Filter differential pressure switch with sensor tubing on either side of filter. Set for final filter pressure loss.
   2. Remote potentiometer to adjust minimum economizer damper position.
   3. Safeties:
      a. Smoke detector.
      b. Condensate overflow switch.
      c. Frostat.
      d. Phase-loss protection.
      e. High and low pressure control.
      f. Electric coil airflow-proving switch.

4. Coil guards of painted, galvanized-steel wire.
5. Hail guards of galvanized steel, painted to match casing.
6. Concentric diffuser with white louvers and polished aluminum return grilles, insulated diffuser box with mounting flanges, and interior transition.
7. Door switches to disable heating or reset set point when open.
8. Outdoor-air intake weather hood with moisture eliminator**.**

L. Capacity and Performance: As scheduled on Drawings.

2.3 ROOF CURBS

A. Roof Curb:
1. Roof Curb: Provided by unit manufacturer. Custom fabricated transition curb for direct replacement of existing unit. Curb to attach to existing roof curb without modification of existing curb or roofing system..
2. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards. Design internal framing to accommodate ductwork, air plenums, piping and conduit as shown on Drawings.
3. Insulation: Factory or field applied closed-cell insulation with a minimum R-value of R-4.
4. Height: 16-inch curbs, except as otherwise specified or shown on Drawings. Adjust curb height for roof insulation thickness. Exposed curb height above insulation shall be not less than twelve inches.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install as shown on Drawings and as recommended by manufacturer.

B. Rig and set unit in place. Use spreader bars to protect unit from lifting cables.

C. Install unit level.

D. Provide removable copper type M or DWV condensate piping with trap at each drain connection.

E. Seal all piping and conduit penetrations in casing airtight.

F. Lubricate bearings and belt as required.

3.2 ADJUSTMENT

A. Check and realign all access doors and dampers to ensure smooth operation throughout entire range of travel.

B. Adjust belt tension and alignment.

C. Adjust motor starter overloads as required. Replace overload when necessary to provide reliable starting and appropriate protection.

3.3 START-UP

A. Perform startup service.

B. Upon start-up, check fan rotation and take amperage measurement for each phase. Document initial amperage measurements and include in O&M manual. If amperage measurement exceeds 110% of motor nameplate, stop unit immediately and notify Engineer.

C. Do not operate unit until ductwork is clean, filters are in place, bearings have been lubricated, and unit has been run tested under observation.

3.4 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION

SECTION 238123

COMPUTER ROOM AIR CONDITIONERS

PART 1 - GENERAL

1.1 SUMMARY

A. Computer room air conditioners are owner furnished, contractor installed. Product data included for reference.

B. Floor mount, environmental control system for precise control of indoor critical environments.

1.2 ACTION SUBMITTALS

A. Provide submittals for products listed in the Product Table below in accordance with Section 23 05 00 – General HVAC Provisions. Submittal requirements indicated by column number designation as follows:
1. Materials List
2. Catalog Data
3. Product Data
4. Performance Data
5. Wiring Diagrams
6. Shop Drawings
7. Installation Instructions
8. Special Requirement listed herein.

PRODUCT TABLE	1	2	3	4	5	6	7	8
Computer Room Air Conditioning Unit, floor mounted, 10-ton and above	X		X	X	X			X

B. Special Requirements:
1. Submit drawings indicating assembled dimensions, operating weight, load distribution, and required service and access clearances.
2. Submit product data including:
   a. Single-line diagrams
   b. Electrical and Capacity Data
   c. Piping and Electrical Connection Drawings

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
1. Mechanical-room layout and relationships between components and adjacent structural and mechanical elements.
2. Support location, type, and weight.
3. Field measurements.

B. Seismic Qualification Data: Certificates for air-handling units, accessories, and components, from manufacturer.
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

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.

1.4 DESIGN REQUIREMENTS

A. Unit shall be designed to achieve performance as scheduled on drawings and base on the following requirements:
1. Overall unit dimensions shall not exceed the dimensions shown on drawings, unless the specific location for each unit installation is reviewed and adequate space and clearances exist for installation, maintenance, repair and replacement. Refer to 23 05 00 - General HVAC Provisions, 2.01 - PRODUCTS AND MATERIALS.
2. Unit shall be capable of maintaining external static pressures as scheduled at all operating conditions. Fan static pressure scheduled on drawings are basis of design. Total operating fan static pressure shall be determined based on unit design.
3. Unit shall be able to operate at design conditions when filters are loaded to final resistance as specified.
4. Filter Holding Frames:
   a. Holding frames shall be selected based on standard and commonly available sizes with dimensions in inches. Metric sizes are not acceptable. Standard sizes include: 24-inches, 20-inches, 16-inches, and 12-inches. 24-inch x 24-inch filters are preferred.
   b. All filters in a holder frame shall be the same size whenever possible.
   c. Holding frames shall only hold one set of filters. Stacking multiple filters in a single frame is not acceptable.
   d. Maximum face velocity: 500 fpm.
5. Coil Face Velocity:
   a. Cooling coils: 400 fpm maximum velocity.
6. Fan Motor Selection: Fan motor shall be selected based on the following requirements:
   a. Motor rated horsepower shall not exceed size scheduled on drawings.
   b. Motor horsepower rating shall be equal or greater than 110% of fan horsepower scheduled on drawings.
   c. Motor horsepower shall be capable of operating unit when filters are loaded to final resistance as specified without exceeding the motor rated amperage.
7. If conditions exist that make any design requirement unattainable, Contractor shall request clarification from Engineer prior to preparing submittals.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: In addition to items otherwise specified, include the following:
1. Instructions for bearing lubrication, filter replacement, motor and drive replacement, and wiring diagrams.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Filters: One set(s) for each air conditioning unit. Filters shall be clean at date of Substantial Completion. Filters furnished herein shall be in addition to those provided to replace filters used during construction.

1.7 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

B. Coordinate sizes and locations of structural-steel support members, if any, with actual equipment provided.

1.8 QUALITY ASSURANCE

A. UL or ETL approved. Designed in accordance with UL 1995 Standard for air handling equipment.

B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.

C. AHRI Certification: Air-conditioning units and their components shall be factory tested according to AHRI 1360 and shall be listed and labeled by AHRI.

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.9 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of computer-room 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 Humidifiers: Manufacturer's standard, but not less than three years from date of Substantial Completion.
3. Warranty Period for Control Boards: Manufacturer's standard, but not less than three years from date of Substantial Completion.

PART 2 – PRODUCTS

2.1 COMPUTER ROOM AIR CONDITIONING UNIT, FLOOR MOUNTED, 10 TONS AND ABOVE

A. Acceptable Manufacturer: Liebert DS or owner approved.

B. Type: Precision cooling, dual-cooling source system with air cooled compressorized system and chilled water coil. Function as modulating chilled water system or compressorized cooling, or both. Factory assembled operation, completely assembled, piped and internally wired. Floor mounted, down-flow, under floor discharge.

C. Cabinet and Frame Construction: Welded frame of formed sheet metal finished to protect against corrosion. Exterior panels insulated with fire resistant minimum 1 in, 1.5 lb. density fiber insulation or equal. The main front panel shall have captive 1/4 turn fasteners. Factory exterior painted finish. Seismic anchor brackets.
1. Top return air inlet with factory installed grilles

D. Supply Fans:
1. Plug/plenum, single inlet, direct drive, electronically commutated motor, and variable speed.

E. Refrigeration System: Two independent refrigeration circuits, hot gas mufflers, liquid line filter driers, refrigerant sight glass with moisture indicator, external equalized expansion valves and liquid line solenoid valves, R-407C refrigerant. Compressors located outside the airstream and removable/serviceable from the front of the unit.
1. Compressors: Digital scroll-type. Minimum operating capacity 20%, with full modulation up to 100%. Compressor solenoid valve to unload compressor for variable

capacity operation. Compressor shall be suction gas cooled motor, vibration isolators, thermal overloads, automatic reset high pressure switch with lockout after three failures, rotalock service valves, pump down low-pressure transducer, suction line strainer, crankcase heater, and a maximum operating speed of 3500 RPM.

2. Evaporator coil: A-frame design, rifled copper tubes, aluminum fins, maximum face velocity of 400 fpm. Stainless-steel condensate drain pan.

F. Chilled water coil:
   1. Copper tubes and aluminum fins.
   2. The water circuit shall include a three-way modulating valve.
   3. Pressure rating: 150 psi

G. Humidifier: Factory-installed, pre-piped, infrared type consisting of high intensity quartz lamps mounted above and out of the water supply. The humidifier shall be removable from the front of the cabinet. Stainless-steel humidifier pan, arranged to be removable without disconnecting high voltage electrical connections. Automatic water supply system, adjustable water-overfeed, high-water detector, factory-provided, minimum 1" air-gap backflow preventer.

H. Filter Section: MERV-8, Interior filter housing.

I. Re-heat: Low watt density, 3 stage electric reheat with 304 stainless steel fin tubular construction with thermal safety switches.

J. Microprocessor Control System: Factory-configured microprocessor-based control processor with tunable PID control capabilities. Control system shall include Ethernet communication network capacity of digital communications with accessory equipment.
   1. Control functions shall include:
      a. Compressor short cycle control: System shall include a start to next start delay.
      b. System auto restart: System automatically restarts after a power failure. Programmable time delay.
      c. Sequential Load Activation: Sequence operational loads on with minimum one second delay to minimize total inrush current.
      d. Low Pressure Monitoring: Unit shall be equipped with low pressure transducers to monitor individual compressor suction pressure.
      e. Winter Start Time Delay: An adjustable timer shall bypass the low pressure monitoring input to assist with compressor starting during cold weather.
      f. Chilled water coil cycles: Automatic primary cooling mode shall be chilled water. Utilize control algorithm to maximize cooling with chilled water. Automatically use compressorized system and combination of both to minimize energy use. When operating primarily in compressor mode, periodically flush water coils to prevent contaminant build-up.
      g. Advanced Freeze Protection: System monitors the pressure of each circuit with a transducer to prevent the coil from freezing on a drop in suction pressure.
      h. Advanced High Pressure Protection: High pressure monitoring shall control the compressor operation and condenser fans to reduce system discharge pressure.
      i. Predictive Humidity Control: Calculates moisture content of room and prevents unnecessary humidification and dehumidification cycles.
      j. Capabilities for variable volume operation with replacement of supply fan motor starter with a variable speed drive.
      k. Compressor Control:
         1) High and Low Temperature Limit Protection
         2) Run Time Monitoring
         3) Sequencing
         4) Manual operation or disabling

l. Multi-Unit Coordination: System controls multiple units to prevent simultaneous heating and cooling, equalize run time, provide staging control and provide the following modes of operation.
   1) Parallel Operation – Units operate in parallel.
   2) Independent Operation – Units operate independently of each other.
   3) Optimized Operation – Units average room sensors for heating, cooling, humidification and dehumidification to provide common setpoints for multiple units.

2. Building Automation System Control Interface: Provide control interface having BACnet IP communication protocol for communication of read only and read/write points and alarm indication.
3. Operator Interface Display: 128x64 dot matrix graphic front monitor display and control keys for user inputs. Display shall be viewable while the unit panels are open or closed. Display shall be password protected and menu driven.
   a. User menus:
      1) Active alarms: Memory for 200 alarms with time and date stamp.
      2) Event log: Memory for 400 most events with ID number, time and date stamp.
      3) Graphic data: Eight graphic records including return air temperature, return air humidity, supply air temperature, outdoor temperature and four custom graphs.
      4) Unit view/status overview: Monitors room conditions, operational status in % of each function, date and time.
      5) Total run hours: Accumulative component operating hours for major components including compressors, water economizer coil, fan motor, humidifier and reheat.
      6) Various sensors: Setup and display of optional custom sensors for four customer accessible analog inputs; 4 to 20 mA, 0 to 5VDC, or 0 to 10VDC. Gains for each analog input programmable and viewable from display.
      7) Service contacts: Display of local service contact name and phone number.
   b. Service menus:
      1) Setpoints, standby setting range:
         a) Temperature Setpoint 65-85ºF
         b) Temperature Sensitivity +1-10ºF
         c) Humidity Setpoint 20-80% RH
         d) Humidity Sensitivity 1-30% RH
         e) High Temperature Alarm 35-90ºF
         f) Low Temperature Alarm 35-90ºF
         g) High Humidity Alarm 15-85% RH
         h) Low Humidity Alarm 15-85% RH
      2) Standby Settings/Lead-Lag: Parameters for planned rotation or emergency rotation of operating and standby units.
      3) Timers/sleep mode: Customer settings for turning on/off unit.
      4) Alarm setup: Customer settings for alarm notification (audible/local/remote):
         a) High Temperature
         b) Low Temperature
         c) High Humidity
         d) Low Humidity
         e) Compressor Overload
         f) Main Fan Overload
         g) Humidifier Problem
         h) High Head Pressure
         i) Change Filter
         j) Fan Failure
         k) Low Suction Pressure
         l) Unit Off

m) Audible Alarm: Audible alarm shall annunciate any alarm that is enabled by the operator.
n) Common Alarm: Programmable common alarm shall be provided to interface user selected alarms with a remote alarm device.
o) Remote Monitoring: All alarms shall be communicated to the Liebert monitoring system with the following information: Date and time of occurrence, unit number and present temperature and humidity.

5) Sensor calibration: Parameters for unit sensors to be calibrated with external sensors.
6) Maintenance/wellness settings: Parameters for reporting of potential component problems before they occur.
7) Options setup: Operation settings for the installed components.
8) System/network setup: Unit-to-Unit communication and setup for teamwork modes of operation for up to 32 units. Teamwork mode reduces energy consumption by preventing multiple units from operation in opposite modes.
9) Auxiliary boards and diagnostics/service mode: Setup of optional expansion boards.

c. Advanced menus
1) Change Passwords.

d. Diagnostics/Service Mode: Self-diagnostics to aid in troubleshooting.
1) Microcontroller board diagnosed and reported as pass/not pass.
2) Control inputs indicated as on or off at the front display.
3) Control outputs can be turned on or off from the front display
4) Each control output shall be indicated by an LED on a circuit board.

K. Accessories:
1. Smoke Detector: Factory installed and wired to shutdown supply fan when smoke is detected in intake.
2. Liquid detection switch: One solid state water sensor per unit for installation in bottom of each cabinet.
3. Top plenum connection with hinged filter access door. Duct connection installed with removable duct connector. See detail on Drawings. Coordinate duct extension with Section 23 31 13 - Metal Ductwork.
4. Main Fan Overload
5. Compressor Overload
6. Floor Stand: Match floor plenum height, 18 in.
7. Return Air Plenum for Downflow Units

L. Certifications: ARHI certified rating, UL listed.

M. Electrical:
1. Single point electrical connection.
2. Disconnect switch: Factory mounted OSHA lockable electrical disconnect switch. Accessible from outside of unit with door closed.
3. Short Circuit Current Rating (SCCR): Minimum 35,000 A.

N. Capacity and Performance: As scheduled on Drawings.

2.2 AIR COOLED CONDENSER

A. Acceptable Manufacturer: Liebert DS or owner approved.

B. General: Outdoor, remote air-cooled, solution cooler.

C. Housing: Aluminum frame

D. Coils: Aluminum microchannel.
   1. Series of flat tubes containing a series of multiple, parallel-flow microchannels layered between refrigerant header manifolds.
   2. Single- or multiple-pass arrangement.
   3. Factory tested at 300 psig minimum.

E. Outdoor Fans:
   1. Fans: Direct-drive propeller type with statically and dynamically balanced fan blades, arranged for vertical air discharge.
   2. Removable safety guards with corrosion-resistant coating.
   3. Fan motors: Electronically commutated with built-in overcurrent- and thermal-overload protection.

F. Certifications: AHRI certified rating, UL listed.

G. Electrical
   1. Connections: Single point electrical connections for power. Integral electric control panel and OSHA lockable disconnect switch. NEMA 3R or 4 enclosure.
   2. Control Panel: Factory mounted control panel and flow switch(es). Provide pump motor contactors, fuses, overload heaters and flow switch. Control panel shall have a lead/ lag switch for the pumps. Standby pump shall automatically start upon failure of the lead pump.

H. Capacity and Performance: As scheduled on Drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for refrigerant, hydronic, and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.

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

3.2 INSTALLATION

A. General: Install indoor unit and condenser unit in accordance with manufacturer's installation instruction. Install units plumb and level, firmly anchored in locations indicated, and maintain manufacturer's recommended clearances.

B. Coordination: Provide technical coordination with section 23 0900 for controls points communication requirements and integration into building controls system.

C. Arrange installation of units to provide access space around units for service and maintenance.

D. Unit Operation: During equipment setup, arrange units to operate in parallel to maintain space conditions. In the event one unit fails, the second unit will provide cooling for entire room, responding to conditions reported by multiple temperature sensors in room.

3.3 PIPING CONNECTIONS

A. Where installing piping adjacent to air conditioning unit, allow for service and maintenance.

B. Connect piping to air conditioning units with flexible connectors as specified in 23 21 16 – Hydronic Piping Specialties.

C. Connect condensate drain pans using NPS 1-1/4 (DN 32), ASTM B 88, Type M (ASTM B 88M, Type C) copper tubing. Extend to nearest equipment or floor drain. Construct trap as detailed on drawings at connection to drain pan and install cleanouts at changes in direction.

D. Refer to Section 23 23 00 – Refrigerant Piping and Specialties for refrigerant piping installation.

3.4 ELECTRICAL CONNECTIONS

A. Coordinate power wiring with Division 26.

B. Coordinate equipment grounding with Division 26.

C. Coordinate interconnecting control wiring for Multi-Unit controls with Division 27.

D. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
   1. Leak Test: After installation, fill water coils with water, and test coils and connections for leaks.
   2. Charge refrigerant coils with refrigerant and test for leaks.
   3. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
   4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.6 START-UP

A. Manufacturer's certified representative to provide the following services:
   1. Inspect after installation to ensure equipment is installed in accordance with manufacturer's recommendation.
   2. Supervise initial start-up.
   3. Adjust control system parameters and setpoints to obtain specified performance.
   4. Test safety control devices.
   5. Submit installation and start-up report to Architect and Owner’s Authorized Representative. Document initial control system parameter and setpoints. Provide electronic copy of control system configuration file where applicable.
   6. Provide minimum 4 hours of training, including operation and maintenance.

3.7 DEMONSTRATION

A. Demonstrate system operation and adjustment of control system setpoints and parameters to Owner’s Authorized Representative.

END OF SECTION

SECTION 260500

GENERAL ELECTRICAL PROVISIONS

PART 1 - GENERAL

1.1 CONTRACT DOCUMENTS

A. General electrical provisions apply to all work performed in Division 26.

B. The Contract Documents are complementary. What is required by any one, as affects this Division, shall be as binding as if repeated herein.

C. Separation of this Division from other Contract Documents shall not be construed as segregation of the Work.

D. Location of equipment on Drawings is approximate. Plan exact location with respect to site measurements and work of other trades prior to starting work. If measurements differ slightly, modify work. If measurements differ substantially, notify Engineer and Owner's Authorized Representative prior to fabrication.

E. Make minor changes in equipment connections and equipment locations as directed or required before rough-in without extra cost.

F. Use of the word "Provide" shall be equivalent to "Furnish and Install."

G. For products specified by listing one or more manufacturers, followed by "Similar to" and one manufacture's model number, the following requirements apply:
   1. Approval of each listed manufacturer is contingent upon that manufacturer having a product which meets the specification, fits in the available space, and is comparable to the listed model.
   2. Electrical and space requirements indicated on drawings are based on the listed model and may not be suitable for all manufacturers listed. Provide revisions required to accommodate the model actually furnished.

H. For products specified by listing one or more manufacturers, followed by a model number for each manufacturer, the following requirements apply:

I. Provide one of the listed model numbers or an approved substitution.

J. Electrical and space requirements indicated on the Drawings are based on one of the listed models and may not be suitable for all models listed. Provide revisions required to accommodate the model actually furnished.

1.2 DEFINITIONS

A. Authority Having Jurisdiction (AHJ): The governmental agency or sub-agency which regulates the construction process.

B. Owner's Authorized Representative (OAR): Owner's representative with authority to act on Owner's behalf.

C. Provide: Equivalent to "Furnish and Install."

1.3 COORDINATION

A. Reference drawings of other trades to avert possible installation conflicts. Should major changes from original drawings be necessary to resolve such conflicts, notify Engineer and secure written approval and agreement on necessary adjustments before commencing work.

B. Architectural drawings govern all other drawings. Reference Architectural drawings for door swings, counter heights and similar items affecting work before rough-in.

C. Coordinate identification systems with other trades. All electrical systems shall use identical wiring, conduit, and equipment identification and regulatory signage.

1.4 SUBMITTALS AND SHOP DRAWINGS

A. Action Submittal Content
1. Action submittal information not expressly required by the specifications will not be reviewed.
2. Action submittal information shall be provided in sufficient detail to establish conformance with specified requirements. Where submitted literature includes multiple models, features, or options, the specific models, features, or options proposed shall be clearly indicated. Where a brief inspection shows that product data is not complete, the submittal will be rejected without review.
3. Action submittal data shall be clear, concise, legible, and relevant. Where data is not properly organized and contains significant information that is not relevant, the submittal will be rejected without review.
4. Action submittal requirements are listed in individual specification sections. The following definitions apply.
   a. Materials List: Provide tabular list of materials including specification reference, specification product name, manufacturer, model/part number, and size and/or quantity where appropriate. Do not include supplemental data, except where specifically requested.
   b. Catalog data: Manufacturer's standard product cut sheet.
   c. Product Data: Detailed data including dimensions, weight, materials of construction, connections, and all other information needed to confirm that the product conforms to all requirements listed in the individual specification section.
   d. Performance Data: Capacity, input, output, flow, etc. as required to confirm that the product meets the performance requirements scheduled in the Specifications or on the Drawings.
   e. Wiring Diagrams: Power and control wiring diagrams.
   f. Shop Drawings: Construction drawings of items manufactured specifically for this project including dimensions, construction details, weights, and additional information to identify the physical features of the system or piece of equipment.
   g. Installation Instructions
   h. Special Requirements Listed: Additional requirements indicated in individual specification sections.

B. Delegated Design
1. Performance and Design Criteria: Where professional design services or certifications by a design professional are specifically required of Contractor by the Contract Documents, provide products and systems complying with specific performance and design criteria indicated.
   a. If criteria indicated are not sufficient to perform services or certification required, submit a written request for additional information to Engineer.
2. Delegated-Design Services Certification: In addition to shop drawings, product data, and other required submittals, submit digitally signed PDF electronic file, signed and

sealed by the responsible design professional, for each product and system specifically assigned to Contractor to be designed or certified by a design professional.

a. Indicate that products and systems comply with performance and design criteria in the Contract Documents. Include list of codes, loads, and other factors used in performing these services.

1.5 QUALITY ASSURANCE

A. All materials and equipment provided hereunder shall be installed and started in complete conformance with the manufacturer's recommendations.

B. Asbestos products or equipment or materials containing asbestos shall not be used.

C. Certify that each welder has passed the American Welding Society (AWS) qualification tests for the welding processes involved, and that certification is current.

1.6 DESIGN REQUIREMENTS

A. Equipment and systems provided hereunder shall be rated to provide performance specified and scheduled on Drawings at the elevation of the project site.

B. Materials and equipment provided hereunder shall be rated for the service conditions of the system to which they are connected including but not limited to temperature, pressure, and humidity.

1.7 CODES AND STANDARDS

A. Applicable codes and standards shall determine minimum requirements for materials, methods, and labor practices not otherwise stated herein.

B. Work shall comply with the Americans with Disabilities Act (ADA).

1.8 TEMPORARY SERVICES

A. Provide in accordance with Division 01 as required for completion of work. Provide additional filters as required to keep areas clean during construction.

B. Maintain existing systems operational. Owner will be responsible to operate and maintain existing equipment during the course of the project. However, any damage to existing equipment resulting directly from work under this Contract shall be repaired by the Contractor at no expense to Owner.

1.9 OPERATIONS AND MAINTENANCE MANUALS

A. Prepare a digital file in Portable Document Format (PDF), clearly indexed with bookmarks for each item or product. Include a directory of all subcontractors and maintenance contractors with names, addresses, and telephone numbers, indicating the area of responsibility for each. Index bookmarks shall match submittal schedule and include any additional information required for operations and maintenance, whether in submitted schedule or not.

B. Maintenance instructions shall indicate routine-type work with step-by-step instructions that should be performed to ensure long life and proper operations. Recommended frequency of performance shall also be included.

C. Provide copy of approved submittal for each product included in manual

D. Provide printed copy and electronic configuration files for all packaged equipment control systems furnished with equipment.

E. Mark the model actually provided where the literature covers more than one model. Include four copies of all submittal data corrected to "as-built" conditions within the manual.

F. Provide a composite summary table indicating each item of equipment listed in the operations and maintenance manual and its required maintenance and time period. This summary table shall be the first section in the O&M manual.

G. Manual Content: Manuals shall contain complete information for each item of mechanical electrical or other operating equipment. Include as applicable:
1. Manufacturer's instructions for installation, startup, operation, inspection, and maintenance
2. Performance capacity
3. Catalog data sheets
4. Parts list
5. Maintenance schedules

1.10 RECORD DRAWINGS

A. Provide record "as-built" drawings in accordance with Division 1 requirements. Show all deviations from contract drawings and location of underground lines by accurate dimensions from building lines. Show depth of stub outs and underground lines. Dimension all concealed piping from column grids or building lines. Concealed raceways, that contain feeder cables, communication conduits that are 1.5-inch diameter or greater shall be dimensioned from column grids or building lines. Alternately, provide electronically using PDF markup of contract drawings.

1.11 DEMONSTRATION

A. General: After installation is complete, demonstrate to Engineer and Owner’s Authorized Representative satisfaction as being complete and operational and entirely in conformance with Contract Documents.

B. Preparation: Prior to demonstration, submit check-off list indicating completeness of submittals and certificates of compliance for review to Owner’s Authorized Representative. Operate completed system for one week. Verify that control verification is complete and verification report has been approved by Engineer.

C. Arrange for demonstration with Owner, Engineer, required factory technicians, and installer at least one week in advance of demonstration.

1.12 WARRANTY

A. Warrant all Work included in the Specification for a period of one year from the date of substantial completion, under provisions of Division 1.

B. During warranty period, remedy without delay or expense to Owner any defects providing, in judgement of Engineer, that such defects are not a result of misuse or abuse on part of Owner.

C. Warrant that all equipment and installations are in compliance with OSHA regulations.

PART 2 - PRODUCTS

2.1 PRODUCTS AND MATERIALS

A. All materials employed in permanent construction shall be new, full weight, in first class condition, and suitable for space provided. All similar equipment and materials shall be of one manufacturer.

B. Equipment used as the basis of design is scheduled on Drawings or designated in product specifications. If Contractor chooses to use equipment that is not the basis of design, Contractor is responsible for all re-design and construction costs associated with variations in arrangement, dimension, or capacity. Such work may include, but is not limited to, changes to facility structure or dimensions and revisions to associated mechanical and electrical systems needed to provide equal system performance and maintainability.

2.2 ELECTRICAL EQUIPMENT

A. Electrical Disconnect Switch: Electrical disconnect switches specified for mechanical equipment shall conform to OSHA Lock-out/Tag-out requirements.

B. All electrical equipment shall be listed as approved for its application by the Underwriters Laboratory or other testing agency approved by the State of Oregon Electrical and Elevator Board. Approval indicates agency meets testing standard requirements for electrical safety required by Oregon Revised Statutes 479.510 through 479.855 and Oregon Administrative Rules.

C. Enclosure: Provide the following electrical equipment enclosure types.
1. NEMA 1: Dry, enclosed locations where the ambient temperature will not be outside of the equipment temperature ratings.
2. NEMA 12: Enclosed mechanical spaces equipped with floor drains where dripping or splashing may occur and where the ambient temperature will not be outside of the equipment temperature ratings.
3. NEMA 3R: Outdoors or in spaces where sustained water spray is possible.
4. NEMA 3R: with Temperature Control: Outdoors or in unconditioned spaces where ambient temperatures will be outside of the equipment temperature ratings.
5. NEMA 4X: Outdoors or in spaces that are corrosive environments.

2.3 EQUIPMENT CONNECTIONS

A. Provide a complete electrical connection for all items of equipment including incidental wiring, materials, devices and labor necessary for a complete operating system. The location and method for connection to each item of equipment shall be verified prior to rough-in. The voltage and phase of each item of equipment shall be checked prior to connecting. Motor rotations shall be made in the proper direction. Pump motors are not to be test run until liquid is in the system and proper lubrication to all bearings in unit is checked.

B. Conduit, wire and circuit breaker sizes for mechanical and similar equipment are based on the equipment ratings of one manufacturer. The equipment actually furnished may have different electrical characteristics. Conduit, wire, and circuit breakers shall not be ordered or installed until exact electrical requirements are obtained. The Contractor is responsible for this coordination.

2.4 FIRESTOPPING

A. See Division 07

B. Acceptable Manufacturers: 3M, Hilti, Tremco, Nelson Firestop Products.

C. Provide firestopping for the following:
1. All penetrations through fire resistance rated floors, walls and partitions including openings containing pipes, ducts and other penetrating items.
2. All penetrations through non-fire resistance rated floors where the vertical service riser penetrates three or more floors.

D. Firestop system shall be UL Classified for the application and correspond to those indicated by reference to designation listed by UL Fire Resistance Directory.

E. Material shall be tested in accordance to UL-1479, ASTM E-814 for the specific fire-rated construction conditions confirming to construction assembly type, penetration item type, annular space requirements, and fire-rating involved.

PART 3 - EXECUTION

3.1 ARRANGEMENT AND INSTALLATION OF ELECTRICAL EQUIPMENT AND CONDUIT

A. Coordinate location of conduit, sleeves, inserts, hangers, cable trays and equipment. Locate conduit, sleeves, inserts, hangers, cable tray and equipment clear of windows, doors, openings, lights, ducts, piping, and other services and utilities. Follow manufacturer's published recommendations for installation methods not otherwise specified.

B. Equipment and Conduit Support: Coordinate structural systems necessary for conduit and equipment support with pipe and equipment locations to permit proper installation.

C. Location of conduit sleeves, trenches and chases shall be accurately coordinated with equipment and conduit locations.

D. Minor Conduit: Small diameter conduit runs from receptacles, lighting, equipment, and similar minor services are generally not shown but must be provided. Contractor is responsible to provide all such minor conduit where needed to maintain electrical spaces clean and neat and to allow full equipment function and maintenance.

E. Work in Existing Building: Cut required openings through existing masonry and reinforced concrete using diamond core drills. Use of pneumatic hammer type drills, impact type electric drills, and hand or manual hammer type drills, will be permitted only with approval of the Owner’s Authorized Representative. Locate openings that will least affect structural slabs, columns, ribs or beams. Refer to the Engineer for determination of proper design for openings through structural sections and obtain layout approval prior to cutting or drilling into structure. After Engineer's approval, carefully cut opening through construction no larger than absolutely necessary for the required installation.

F. Inaccessible Equipment
1. Where the Owner’s Authorized Representative determines that the Contractor has installed equipment not conveniently accessible for operation and maintenance, equipment shall be removed and reinstalled or remedial action performed as directed at no additional cost to the Owner.

2. The term "conveniently accessible" is defined as capable of being reached without the use of ladders, or without climbing or crawling under or over obstacles such as motors, fans, pumps, belt guards, transformers, high voltage lines, piping, and ductwork.

3.2 EXISTING EQUIPMENT REUSED OR RELOCATED

A. All equipment designated as existing or furnished by Owner shall be cleaned and repaired before reinstallation. Any items requiring repair shall be brought to the attention of the construction manager before the item is reinstalled. Damage not brought to the attention of the construction manager shall be deemed the result of reinstallation of the item and shall be repaired without expense to the Owner.

3.3 ELECTRICAL SYSTEMS FIRESTOPPING

A. Do not cover firestop installations until they are examined by the Authority Having Jurisdiction, if required.

B. Install firestopping in accordance with manufacturer’s recommendations and conditions of product UL listing.

3.4 CLEANING SYSTEMS

A. General: After all equipment, conduits and cable tray are installed, system shall be thoroughly cleaned. Remove all nonessential stickers and labels from equipment or fixtures. Clean all light fixture lenses. Clean interior of conduit systems prior to installation of wiring.

B. Repair or replace any discolorations or damage to systems, building finish, or furnishings resulting from Contractor’s failure to properly clean system.

3.5 START UP

A. The Electrical Contractor shall be responsible for proper operation of all systems and shall coordinate startup procedures, calibration and system checkout. System operational problems shall be diagnosed and corrected as required for system operation prior to Substantial Completion inspection.

B. Start equipment in accordance with manufacturer’s recommendations and under manufacturer’s supervision where required. Ensure that associated breakers, relays, electrical overloads, and other devices intended to protect the equipment are installed and functional prior to startup.

3.6 EXTRA STOCK

A. Provide extra stock, as described in individual sections, to Owner in accordance with Division 1.

END OF SECTION

SECTION 260501

ELECTRICAL DEMOLITION

PART 1 - GENERAL

1.1 SCOPE

A. It is the intent of these documents to provide the necessary information and adjustments to the electrical system required to meet Code and accommodate installation of the new work.

B. Contractor shall coordinate with the Owner so that work can be scheduled not to interrupt operations, normal activities, building access, access to different areas. The Owner will cooperate to the best of their ability to assist in a coordinated schedule but will remain the final authority as to time of work permitted.

1.2 EXISTING CONDITIONS

A. The locations of existing utilities and equipment are shown in an approximate way only and have not been independently verified by the Owner or its representative. The Contractor shall determine the exact location of all existing utilities before commencing work and agrees to be fully responsible for any and all damages which might be occasioned by the Contractor's failure to exactly locate and preserve any and all utilities and equipment. Replace damaged items with new material to match existing. Promptly notify Owner if utilities are found which are not shown on the Drawings.

PART 2 - PRODUCTS

2.1 MATERIALS

A. All materials accumulated during the demolition process are the Owner's property and shall be removed from the job site as directed by the Owner.

PART 3 - EXECUTION

3.1 DEMOLITION

A. Disconnect all existing mechanical equipment scheduled for removal, relocation or abandonment. See mechanical drawings for scope of work. Remove abandoned cables and unusable raceways. Relabel panels and motor control centers to reflect changes.

B. Maintain electrical continuity of all existing systems. Remove or relocate electrical boxes, conduit, wiring, equipment, fixtures, etc. as may be encountered in removed or remodeled areas in the existing construction affected by this work. Wiring which serves usable existing outlets shall be removed and restored clear of the construction or demolition. If existing junction boxes will be made inaccessible, or if abandoned outlets serve as feed through boxes for other existing electrical equipment which is being retained, new conduit and wire shall be provided to bypass the abandoned outlets. If existing conduits pass through partitions or ceiling which are being removed or remodeled, new conduit and wire shall be provided to reroute clear of the construction or demolition and maintain service to the existing load.

C. Extend circuiting and devices in all existing walls to be furred out.

D. Existing electrical outlets and light fixtures are denoted by dotted or dashed lines. Verify exact location of existing electrical outlets and light fixtures in the field. Only partial existing electrical shown. Locations of items shown on the Drawings as existing are partially based on as built and other drawings which may contain errors. The contractor shall verify the accuracy of the information shown prior to bidding and provide such labor and material as is necessary to accomplish the intent of the contract documents.

E. Remove all abandoned wiring to leave site clean.

F. Keep outages to occupied areas to a minimum and prearrange all outages with the Owner's representative. Requests for outages shall state the specific dates and hours and the maximum durations, with the outages kept to these specific dates and hours and the maximum durations. This Contractor will be liable for any damages resulting from un-scheduled outages or for those not confined to the preapproved times. Outages shall take place at times when the facility is not in operation or occupied by non-essential personnel. Include all costs for overtime labor as necessary to maintain electrical services in the initial bid proposal. Temporary wiring and facilities, if used, shall be removed and the site left clean before final acceptance. Requests for outages must be submitted at least (5) days prior to intended shutdown time.

G. No circuit breaker or disconnects shall be turned off without prior approval from Owner. Coordinate with the Owner's representative responsible for the area or equipment affected for any electrical interruptions which affect the operation of the remaining portions of the facility.

H. Verify with the General Contractor a location for storage of materials, supplies, tools, rubbish, etc. prior to start of work.

END OF SECTION

SECTION 260519

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Copper building wire rated 600 V or less.
2. Connectors, splices, and terminations rated 600 V and less.

1.3 DEFINITIONS

A. RoHS: Restriction of Hazardous Substances.

B. VFD: Variable-frequency drive.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Product Schedule: Indicate type, use, location, and termination locations.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA.
1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

PART 2 - PRODUCTS

2.1 COPPER BUILDING WIRE

A. Description: Flexible, insulated and uninsulated, drawn copper current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.

B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
1. American Bare Conductor.
2. Cerro Wire LLC.
3. General Cable Technologies Corporation.
4. Okonite Company (The).

5. Southwire Company.

C. Standards:
1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
2. RoHS compliant.
3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

D. Conductors: Copper, complying with ASTM B 3 for bare annealed copper and with ASTM B 8 for stranded conductors.

E. Conductor Insulation:
1. Type THHN and Type THWN-2: Comply with UL 83.
2. Type XHHW-2: Comply with UL 44.

F. 98 percent conductivity, minimum.

G. Branch Circuit Wiring: Conductors smaller than No. 12 AWG for power system branch circuits not permitted.

H. Motor control wires shall be No. 14 minimum.

2.2 CONNECTORS AND SPLICES

A. Description: Factory-fabricated connectors, splices, and lugs of size, ampacity rating, material, type, and class for application and service indicated; listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
1. 3M Electrical Products.
2. AFC Cable Systems.
3. Gardner Bender.
4. Ideal Industries, Inc.
5. Burndy
6. Thomas & Betts Corporation.

C. Jacketed Cable Connectors: For steel and aluminum jacketed cables, zinc die-cast with set screws, designed to connect conductors specified in this Section.

D. Lugs: One piece, seamless, designed to terminate conductors specified in this Section.
1. Material: Copper
2. Type: Two hole with standard barrels.
3. Termination: Compression Crimp

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper. Stranded conductors only.

B. Branch Circuits: Copper. Stranded conductors only.

C. VFD Output Circuits Cable: Shall utilize stranded, type XHHW-2 conductors.

D. Power-Limited Fire Alarm and Control: Solid for No. 14 AWG and smaller.

E. Exposed Feeders: Type THHN/THWN-2, single conductors in raceway.

F. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN/THWN-2, single conductors in raceway.

G. Feeders Installed below Raised Flooring: Type THHN/THWN-2, single conductors in raceway.

3.2 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.

B. Use no wire smaller than No. 12 AWG for power and lighting circuits and no smaller than No. 16 AWG for control wiring.

C. Use No 10 AWG conductors for 20 amperes, 120-volt branch circuit home runs longer than 100 feet, and for 20 ampere, 277-volt branch circuit home runs longer than 200 feet. Neutral conductor shall be sized the same as corresponding phase conductors.

D. Metal-clad (MC) cable permitted for final connection to one light fixture from a single junction box. Daisy chaining fixtures or junction boxes with MC cable is not permitted.

E. Provide dedicated neutral conductor with each branch circuit, do not use a shared neutral conductor between phases unless specifically requested or directed.

F. For remodel work or where shared neutrals are used by equipment such as system furniture, provide a breaker handle tie as required for the phases sharing the neutral conductor.

G. Conductor length for parallel feeders shall be identical.

H. Complete raceway installation between conductor and cable termination points according to Section 260533 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.

I. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

J. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

K. Couplings and conduit connectors shall have pre-insulated bushings in place prior to pulling wires.

L. Splice only in accessible junction or outlet boxes. Splice in feeders and services are not permitted. Splice or taps in branch circuits permitted only in junction boxes where circuits divide.

M. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.

N. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."

O. Lace or clip groups of feeder conductors at distribution centers, pullboxes, and wireways.

P. Provide copper grounding conductors and straps. A ground wire shall be pulled through conduits and used as the equipment grounding conductor.

Q. Wire and cable shall be brought to the job site in the original containers bearing the U.L. label.

R. Installing wires of different voltage systems in the same raceway, box, gutter or other enclosure is prohibited.

S. Radius of cable bends shall not be less than ten times the outer diameter of the cable.

3.3 CONNECTIONS

A. 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-486B.

B. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

C. Follow manufacturer’s instructions using manufacturer’s recommended tools.

D. Stripping Insulation: Carefully strip, avoid nicking conductor. No “ringing”.

E. Design: Connectors shall be designed and approved for the purpose used. Connectors between aluminum and copper shall be listed “AL/CU” for the purpose of preventing electrolytic action.

F. Bare Connectors and Conductor Free Ends: Wrap with insulating rubber or friction tape to equivalent insulation of wire.

G. Ground Continuity to Metallic Surfaces: Remove any paint coating and polish surface beneath connection.

H. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches of slack.

I. No splices or taps permitted in feeder branch circuiting terminating at a single outlet.

J. Conductor and cable copper shall not be reduced at the terminal for making connections.

3.4 IDENTIFICATION

A. Color-coding for Phase- and Voltage-Level Identification, 600 V or Less: Use colors listed below for ungrounded service, feeder, and branch-circuit conductors.
   1. Color shall be factory applied integral pigmentation or field applied for sizes larger than No. 6 AWG if authorities having jurisdiction permit. Where field applied, apply colored plastic tape in spiral half-lap over exposed conductor portions in manholes, boxes, panels, switchboards, and other enclosures.
   2. Colors for 208/120-V circuits:

a. Phase A: Black.
b. Phase B: Red.
c. Phase C: Blue.
d. Neutral: White with corresponding phase color stripe.

3. Colors for 480/277-V circuits:
   a. Phase A: Brown.
   b. Phase B: Orange.
   c. Phase C: Yellow.
   d. Neutral: Gray with corresponding phase color stripe.
4. Color for Equipment Grounds: Green
5. Color for Isolated Grounds: Green with yellow stripe.

B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

3.5 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 078413 "Penetration Firestopping."

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections.
1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors for compliance with requirements.
2. Perform each of the following visual and electrical tests:
   a. Inspect exposed sections of conductor and cable for physical damage and correct connection according to the single-line diagram.
   b. Test bolted connections for high resistance using one of the following:
      1) A low-resistance ohmmeter.
      2) Calibrated torque wrench.
   c. Inspect compression-applied connectors for correct cable match and indentation.
   d. Inspect for correct identification.
   e. Inspect cable jacket and condition.
   f. Continuity test on each conductor and cable.
   g. Uniform resistance of parallel conductors.
   h. Perform insulation-resistance test on each conductor with respect to ground and adjacent conductors. Applied potential shall be 500 volts dc for 300-volt rated cable and 1000 volts dc for 600-volt rated cable. Test duration shall be one minute.

B. Cables will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports to record the following:
1. Procedures used.
2. Results that comply with requirements.
3. Results that do not comply with requirements, and corrective action taken to achieve compliance with requirements.

END OF SECTION

SECTION 260526

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 – GENERAL

1.1 SECTION INCLUDES

A. Electric and power system grounding

B. Communication system grounding

1.2 REQUIREMENTS OF REGULATORY AGENCIES

A. Provide grounds in accordance with National Electrical Code and additional requirements as required herein.

B. NEC references below are based on the 2011 edition.

1.3 SUBMITTALS

A. Provide submittals for products listed in the Product Table below in accordance with Section 26 05 00 – Common Work Results for Electrical. Submittal requirements indicated by column number designation as follows:
1. Materials List
2. Catalog Data
3. Product Data
4. Performance Data
5. Wiring Diagrams
6. Shop Drawings
7. Installation Instructions
8. Special Requirement listed herein.

PRODUCT TABLE	1	2	3	4	5	6	7	8
Grounding conductors		X						

PART 2 - PRODUCTS

2.1 GROUNDING CONDUCTORS

A. Size: Grounding Electrode Conductor: Table 250-66. Equipment grounding conductor: Table 250-122.

B. Material: Copper.

C. Protection: Conductors not in raceway or concealed shall be insulated. Provide conduit where shown or required for physical protection.

D. Bonding Jumpers: Same requirements.

PART 3 - EXECUTION

3.1 POWER SYSTEM GROUNDING

A. Circuit Grounding: Install grounding bushings, studs, and jumpers at distribution centers, pullboxes, motor control centers, panelboards, and junction boxes.

B. Ground Connections: Clean surfaces thoroughly before applying ground lugs or clamps. If surface is coated, the coating must be removed down to the bare metal. After the coating has been removed, apply a noncorrosive approved compound to cleaned surface and install lugs or clamps. Where galvanizing is removed from metal, it shall be painted or touched up.

C. Conduit Systems:
1. Ground all metallic conduit systems.
2. Non-metallic conduit systems shall contain a grounding conductor.
3. Conduit provided for mechanical protection containing only a grounding conductor, bond to that conductor at the entrance and exit from the conduit.

D. Feeders and Branch Circuits: Install green grounding conductors with feeders and branch circuits as follows:
1. Feeders
2. Circuits serving preparation and kitchen equipment
3. Receptacle outlets
4. Directly connected laboratory equipment
5. Motors and motor controllers
6. Fixed equipment and appliances
7. Items of equipment where the final connection is made with flexible metal conduit shall have a grounding wire
8. Additional locations and systems as shown

E. Boxes, Cabinets, Enclosures, and Panelboards:
1. Bond the grounding wires to each pullbox, junction box, outlet box, cabinets, and other enclosures through which the ground wires pass (except for special grounding systems for intensive care units and other critical units shown.
2. Provide lugs in each box and enclosure for ground wire termination.
3. Provide ground bars in panelboards, bolted to the housing, with sufficient lugs for terminating the ground wires.

F. Ground lighting fixtures to the green grounding conductor of the wiring system when the green ground is provided; otherwise, ground the fixtures through the conduit systems. Fixtures connected with flexible conduit shall have a green ground wire included with the power wires from the fixture through the flexible conduit to the first outlet box.

END OF SECTION

SECTION 260529

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Steel slotted support systems.
2. Aluminum slotted support systems.
3. Nonmetallic slotted support systems.
4. Conduit and cable support devices.
5. Support for conductors in vertical conduit.
6. Structural steel for fabricated supports and restraints.
7. Mounting, anchoring, and attachment components, including powder-actuated fasteners, mechanical expansion anchors, concrete inserts, clamps, through bolts, toggle bolts, and hanger rods.
8. Fabricated metal equipment support assemblies.

B. Related Requirements:
1. Section 260548 "Seismic Controls for Electrical Systems" for products and installation requirements necessary for compliance with seismic criteria.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.
1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:
a. Slotted support systems, hardware, and accessories.
b. Clamps.
c. Hangers.
d. Sockets.
e. Eye nuts.
f. Fasteners.
g. Anchors.
h. Saddles.
i. Brackets.
2. Include rated capacities and furnished specialties and accessories.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. For fabrication and installation details for electrical hangers and support systems.
1. Hangers. Include product data for components.
2. Slotted support systems.
3. Equipment supports.
4. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

C. Delegated-Design Submittal: For hangers and supports for electrical systems.
   1. Include design calculations and details of hangers.
   2. Include design calculations for seismic restraints.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Suspended ceiling components.
   2. Ductwork, piping, fittings, and supports.
   3. Structural members to which hangers and supports will be attached.
   4. Size and location of initial access modules for acoustical tile.
   5. Items penetrating finished ceiling, including the following:
      a. Luminaires.
      b. Air outlets and inlets.
      c. Speakers.
      d. Sprinklers.
      e. Access panels.
      f. Projectors.

B. Seismic Qualification Data: Certificates, for hangers and supports for electrical equipment and systems, accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Welding certificates.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M .

B. Welding Qualifications: Qualify procedures and personnel according to the following:
   1. AWS D1.1/D1.1M.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design hanger and support system.

B. Seismic Performance: Hangers and supports shall withstand the effects of earthquake motions determined according to ASCE/SEI 7
   1. The term "withstand" means "the supported equipment and systems will remain in place without separation of any parts when subjected to the seismic forces specified”
   2. Component Importance Factor: 1.0

C. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame Rating: Class 1.
2. Self-extinguishing according to ASTM D 635.

2.2 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Preformed steel channels and angles with minimum 13/32-inch-diameter holes at a maximum of 8 inches o.c. in at least one surface.
1. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
2. Material for Channel, Fittings, and Accessories: Galvanized Steel
3. Channel Width: Selected for applicable load criteria
4. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
5. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
6. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
7. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

B. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

C. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be made of malleable iron.

D. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M steel plates, shapes, and bars; black and galvanized.

E. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened Portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened Portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
3. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: All-steel springhead type.
7. Hanger Rods: Threaded steel.

2.3 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Section 055000 "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with the following standards for application and installation requirements of hangers and supports, except where requirements on Drawings or in this Section are stricter:
   1. NECA 1.

B. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.

C. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."

D. Maximum Support Spacing and Minimum Hanger Rod Size for Raceways: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch in diameter.

E. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings, and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this article.

B. Raceway Support Methods: In addition to methods described in NECA 1, EMT, IMC, and RMC may be supported by openings through structure members, according to NFPA 70.

C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
   1. To Wood: Fasten with lag screws or through bolts.
   2. To New Concrete: Bolt to concrete inserts.
   3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
   4. To Existing Concrete: Expansion anchor fasteners.
   5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.
   6. To Steel: Beam clamps (MSS SP 58, Type 19, 21, 23, 25, or 27), complying with MSS SP 69
   7. To Light Steel: Sheet metal screws.
   8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to

substrate by means that comply with seismic-restraint strength and anchorage requirements.

E. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Section 055000 "Metal Fabrications" for site-fabricated metal supports.

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

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

3.4 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 minimum dry film thickness of 2.0 mils.

B. Touchup: Comply with requirements in Section 09 91 13 “Exterior Painting” and Section 09 91 23 “Interior Painting” for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

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

END OF SECTION

SECTION 260533

RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Metal conduits and fittings.
2. Nonmetallic conduits and fittings.
3. Metal wireways and auxiliary gutters.
4. Boxes, enclosures, and cabinets.

1.3 DEFINITIONS

A. GRC: Galvanized rigid steel conduit.

B. IMC: Intermediate metal conduit.

1.4 ACTION SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:
1. Structural members in paths of conduit groups with common supports.
2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.

B. Qualification Data: For professional engineer.

C. Seismic Qualification Data: Certificates, for enclosures, cabinets, and conduit racks and their mounting provisions, including those for internal components, from manufacturer.
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
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.
4. Detailed description of conduit support devices and interconnections on which the certification is based and their installation requirements.

D. Source quality-control reports.

PART 2 - PRODUCTS

2.1 METAL CONDUITS AND FITTINGS

A. Metal Conduit:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. Allied Tube & Conduit; a part of Atkore International.
   b. Calconduit.
   c. Thomas & Betts Corporation; A Member of the ABB Group.
   d. Western Tube and Conduit Corporation.
   e. Wheatland Tube Company.
2. Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. GRC: Comply with ANSI C80.1 and UL 6.
4. IMC: Comply with ANSI C80.6 and UL 1242.
5. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit.
   a. Comply with NEMA RN 1.
   b. Coating Thickness: 0.040 inch, minimum.
6. EMT: Comply with ANSI C80.3 and UL 797.

B. Metal Fittings:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. Allied Tube & Conduit; a part of Atkore International.
   b. O-Z/Gedney; a brand of Emerson Industrial Automation.
   c. Thomas & Betts Corporation; A Member of the ABB Group.
   d. Western Tube and Conduit Corporation.
   e. Wheatland Tube Company.
2. Comply with NEMA FB 1 and UL 514B.
3. Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
4. Fittings, General: Listed and labeled for type of conduit, location, and use.
5. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 1203 and NFPA 70.
6. Fittings for EMT:
   a. Material: Steel.
   b. Type: Setscrew.
7. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
8. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch, with overlapping sleeves protecting threaded joints.

C. Joint Compound for IMC, GRC, or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 NONMETALLIC CONDUITS AND FITTINGS

A. Nonmetallic Conduit:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. Anamet Electrical, Inc.
   b. CANTEX INC.
   c. Kraloy.
   d. Thomas & Betts Corporation; A Member of the ABB Group.
2. Listing and Labeling: Nonmetallic conduit shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. ENT: Comply with NEMA TC 13 and UL 1653.
4. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.
5. LFNC: Comply with UL 1660.

B. Nonmetallic Fittings:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Anamet Electrical, Inc.
   b. CANTEX INC.
   c. Kraloy.
   d. RACO; Hubbell.
   e. Thomas & Betts Corporation; A Member of the ABB Group.
2. Fittings, General: Listed and labeled for type of conduit, location, and use.
3. Fittings for ENT and RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.
   a. Fittings for LFNC: Comply with UL 514B.
4. Solvents and Adhesives: As recommended by conduit manufacturer.

2.3 METAL WIREWAYS AND AUXILIARY GUTTERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. B-line, an Eaton business.
2. Hoffman; a brand of nVent.
3. MonoSystems, Inc.
4. Square D.

B. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1 or Type 3R unless otherwise indicated, and sized according to NFPA 70.
1. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

D. Wireway Covers: Screw-cover type unless otherwise indicated.

E. Finish: Manufacturer's standard enamel finish.

2.4 SURFACE RACEWAYS

A. Listing and Labeling: Surface raceways and tele-power poles shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Surface Metal Raceways: Galvanized steel with snap-on covers complying with UL 5. Manufacturer's standard enamel finish in color selected by Architect**.**
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Wiremold / Legrand.
      b. Hubbell Incorporated; Wiring Device-Kellems.
      c. MonoSystems, Inc.
      d. Panduit Corp.

2.5 BOXES, ENCLOSURES, AND CABINETS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   1. Crouse-Hinds, an Eaton business.
   2. FSR Inc.
   3. Hoffman; a brand of nVent.
   4. Hubbell Incorporated.
   5. O-Z/Gedney; a brand of Emerson Industrial Automation.
   6. Wiremold / Legrand.

B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.

C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

D. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

E. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

F. Device Box Dimensions: 4 inches square by 2-1/8 inches deep minimum.

G. Gangable boxes are allowed.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below unless otherwise indicated:
   1. Exposed Conduit: GRC
   2. Concealed Conduit, Aboveground: GRC or IMC
   3. Underground Conduit: RNC, Type EPC-40-PVC
   4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC
   5. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R

B. Indoors: Apply raceway products as specified below unless otherwise indicated:
   1. Exposed, Not Subject to Physical Damage: EMT

2. Exposed, Not Subject to Severe Physical Damage: EMT
3. Exposed and Subject to Severe Physical Damage: GRC. Raceway locations include the following:
   a. Loading dock.
   b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
   c. Mechanical rooms.
   d. Gymnasiums.
4. Concealed in Ceilings and Interior Walls and Partitions: EMT
5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
6. Damp or Wet Locations: GRC
7. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 nonmetallic in institutional and commercial kitchens and damp or wet locations.

C. Minimum Raceway Size: 3/4 -inch trade size.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.
1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
3. EMT: Use setscrew, steel fittings. Comply with NEMA FB 2.10.
4. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.

E. Install nonferrous conduit or tubing for circuits operating above 60 Hz. Where aluminum raceways are installed for such circuits and pass through concrete, install in nonmetallic sleeve.

F. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.

G. Install surface raceways only where indicated on Drawings.

H. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F

3.2 INSTALLATION

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.

B. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum conduits. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.

C. Do not install raceways or electrical items on any "explosion-relief" walls or rotating equipment.

D. Do not fasten conduits onto the bottom side of a metal deck roof.

E. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

F. Complete raceway installation before starting conductor installation.

G. Arrange stub-ups so curved portions of bends are not visible above finished slab.

H. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches of changes in direction.

I. Make bends in raceway using large-radius preformed ells. Field bending shall be according to NFPA 70 minimum radii requirements. Use only equipment specifically designed for material and size involved.

J. Conceal conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.

K. Support conduit within 12 inches of enclosures to which attached.

L. Raceways Embedded in Slabs:
1. Run conduit larger than 1-inch trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure raceways to reinforcement at maximum 10-foot intervals.
2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
3. Arrange raceways to keep a minimum of 1 inch of concrete cover in all directions.
4. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.
5. Change from ENT to GRC before rising above floor.

M. Stub-Ups to Above Recessed Ceilings:
1. Use EMT, IMC, or RMC for raceways.
2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

N. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

O. Coat field-cut threads on PVC-coated raceway with a corrosion-preventing conductive compound prior to assembly.

P. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than No. 4 AWG.

Q. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch trade size and insulated throat metal bushings on 1-1/2-inch trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.

R. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.

S. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.

T. Cut conduit perpendicular to the length. For conduits 2-inch trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.

U. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.

V. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings according to NFPA 70.

W. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:
1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where an underground service raceway enters a building or structure.
3. Conduit extending from interior to exterior of building.
4. Conduit extending into pressurized duct and equipment.
5. Conduit extending into pressurized zones that are automatically controlled to maintain different pressure set points.
6. Where otherwise required by NFPA 70.

X. Comply with manufacturer's written instructions for solvent welding RNC and fittings.

Y. Expansion-Joint Fittings:
1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F and that has straight-run length that exceeds 25 feet. Install in each run of aboveground RMC and EMT conduit that is located where environmental temperature change may exceed 100 deg F and that has straight-run length that exceeds 100 feet.
2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:
    a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
    b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
    c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F temperature change.
3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F of temperature change for metal conduits.
4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

Z. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 48 inches of flexible conduit for recessed and semi-recessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
1. Use LFMC in damp or wet locations subject to severe physical damage.
2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.

AA. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.

BB. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.

CC. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.

DD. Locate boxes so that cover or plate will not span different building finishes.

EE. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.

FF. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

GG. Set metal floor boxes level and flush with finished floor surface.

HH. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.3 FIRESTOPPING

A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.4 PROTECTION

A. Protect coatings, finishes, and cabinets from damage and deterioration.
   1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
   2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION

SECTION 260553

IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 – GENERAL

1.1 SECTION INCLUDES

A. Nameplates

B. Wire and cable markers

C. Pull box and junction box identification

D. Device plate identification

1.2 REQUIREMENTS OF REGULATORY AGENCIES

A. Identification shall conform to the latest edition of the National Electrical Code (NEC), Articles 110-21 and as a minimum requirement.

1.3 SUBMITTALS

A. Provide submittals for products listed in the Product Table below in accordance with Section 26 05 00 – Common Work Results for Electrical. Submittal requirements indicated by column number designation as follows:
1. Materials List
2. Catalog Data
3. Product Data
4. Performance Data
5. Wiring Diagrams
6. Shop Drawings
7. Installation Instructions
8. Special Requirement listed herein.

PRODUCT TABLE	1	2	3	4	5	6	7	8
Engraved laminated plastic		X						
Wire and cable markers		X						
Adhesive film labels		X						

PART 2 – PRODUCTS

2.1 MATERIALS

A. Nameplates:
1. Three layer, black front and back with white core laminated plastic.
2. Engraved through outer layer to show white characters on black background.
3. Beveled edges.-
4. Other colors as specified.

B. Wire and Cable Markers:
1. Heat shrink thermo-labels.
2. Brady or Panduit.

C. Labels:

1. Adhesive Film Labels: Machine printed, in black on clear background, by thermal transfer or equivalent process.
2. Emergency receptacles/wall switches: Black on red background.

D. Panelboard Directory Card: Fiberboard neatly typed for newly installed panels. Circuit changes to existing panels shall be noted on the directory card by hand printing in ink. When more than five changes have been made on the directory card, a new card shall be typed.

PART 3 – EXECUTION

3.1 GENERAL

A. During finish construction, labeling is to be reviewed and approved by the Owner.

B. Zoned systems must be clearly defined and labeled.

C. Label at all entries into new spaces and/or through walls.

D. Covering or painting of any sign/label requires replacement.

E. Mark and label new wiring and place in tray. Include installation date.

3.2 NAMEPLATE INSTALLATION

A. Degrease and clean surfaces to receive nameplates.

B. Install nameplates parallel to equipment lines.

C. Secure nameplates to equipment fronts using screws or drive rivets.
1. Secure nameplate to inside face of recessed panelboard doors in finished locations.
2. Secure nameplate to outside face of panelboards in unfinished locations.

D. Where switches control remote lighting or power outlets, or where switches in the same outlet (two or more) serve different purposes such as lights, power, intercom, etc., or different areas such as corridor and outside, furnish either engraved nameplates or adhesive film labels with 1/8 inch black letters indicating function of each switch or outlet.

E. Use adhesive film labels for identification of individual wall switch and receptacle cover plates.

3.3 WIRE IDENTIFICATION

A. Labeling shall be non-destructible type which may not be removed during installation.

B. Provide wire markers on each conductor in panelboards, gutters, pull boxes, and at load connection.

C. Identify with branch circuit or feeder number for power and lighting circuits.

D. Tag lighting feeds with circuit number and panel ID.

E. Identify control wire number as indicated on equipment manufacturer’s shop drawings.

3.4 NAMEPLATE ENGRAVING SCHEDULE

A. Identify all electrical distribution, control equipment and disconnect switches at loads served.

B. 1/4-inch nameplates are to be fastened with sheet metal screws.

C. Disconnect switches and control units shall include circuit number and panel ID.

D. Letter Height:
1. 1/8 inch for individual switches and loads served.
2. 1/4 inch for distribution and control equipment identification.
3. 1/8 inch identifying voltage rating and source.

E. Transformers:
1. 1/4 inch; identifying equipment designation.
2. 1/8 inch; identifying primary source, and secondary load and location.

3.5 PULL BOX AND JUNCTION BOX IDENTIFICATION

A. Provide permanent signage, interior and exterior at all utility boxes, vaults, manholes, etc.

B. Install labels on inside of junction boxes and adhesive film label on the box cover.

C. Identify each junction box with complete system description. Examples:
1. 480V system
2. 208 V system

D. Methods:
1. Neat hand lettering with permanent black marker.
2. Engraved nameplates.
3. Adhesive film labels.

E. Locations:
1. On outside of box cover where concealed.
2. In exposed box locations, locate on inside of box cover.
3. Identify main pull boxes by number and indicate numbers on record drawings.

3.6 DEVICE PLATE IDENTIFICATION

A. 1/8 inch letter height.

B. Black letter color.

C. Location:
1. Bottom center of device plate for single gang and multiple gang outlets.
   a. Provide branch circuit identification (example: “B-16” indicating panel “B” circuit #16).

D. Emergency devices:
1. Plates with either engraved letting or adhesive film labels that read “EMERGENCY POWER”.

END OF SECTION

SECTION 262416

PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Panelboards are owner furnished, contractor installed. Product data included for reference.

B. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
1. Distribution panelboards.
2. Lighting and appliance branch-circuit panelboards.
3. Load centers.
4. Electronic-grade panelboards.

1.3 DEFINITIONS

A. ATS: Acceptance testing specification.

B. GFCI: Ground-fault circuit interrupter.

C. GFEP: Ground-fault equipment protection.

D. MCCB: Molded-case circuit breaker.

E. SPD: Surge protective device.

F. VPR: Voltage protection rating.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of panelboard.
1. Include materials, switching and overcurrent protective devices, SPDs, accessories, and components indicated.
2. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each panelboard and related equipment.
1. Include dimensioned plans, elevations, sections, and details.
2. Show tabulations of installed devices with nameplates, conductor termination sizes, equipment features, and ratings.
3. Detail enclosure types including mounting and anchorage, environmental protection, knockouts, corner treatments, covers and doors, gaskets, hinges, and locks.
4. Detail bus configuration, current, and voltage ratings.
5. Short-circuit current rating of panelboards and overcurrent protective devices.
6. Include evidence of NRTL listing for series rating of installed devices.
7. Include evidence of NRTL listing for SPD as installed in panelboard.

8. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
9. Include wiring diagrams for power, signal, and control wiring.
10. Key interlock scheme drawing and sequence of operations.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 include the following:
1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications: ISO 9001 or 9002 certified.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.

B. Handle and prepare panelboards for installation according to NECA 407.

1.8 FIELD CONDITIONS

A. Environmental Limitations:
1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
a. Ambient Temperature: Not exceeding 23 deg F to plus 104 deg F.
b. Altitude: Not exceeding 6,600 feet.

B. Service Conditions: NEMA PB 1, usual service conditions, as follows:
1. Ambient temperatures within limits specified.
2. Altitude not exceeding 6600 feet.

C. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
1. Notify Owner no fewer than 7 days in advance of proposed interruption of electric service.
2. Do not proceed with interruption of electric service without Owner's written permission.
3. Comply with NFPA 70E.

1.9 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace panelboards that fail in materials or workmanship within specified warranty period.
   1. Panelboard Warranty Period: 12 months from date of Substantial Completion.

B. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace SPD that fails in materials or workmanship within specified warranty period.
   1. SPD Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PANELBOARDS AND LOAD CENTERS COMMON REQUIREMENTS

A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Section 26 05 48.16 – Seismic Controls for Electrical Systems.

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

C. 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.

D. Comply with NEMA PB 1.

E. Comply with NFPA 70.

F. Enclosures: Dead-front cabinets.
   1. Rated for environmental conditions at installed location.
      a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
      b. Outdoor Locations: NEMA 250, Type 3R.
      c. Kitchen or Wash-Down Areas: NEMA 250, Type 4X.
      d. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
   2. Height: 84 inches maximum.
   3. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box. Trims shall cover all live parts and shall have no exposed hardware.
   4. Door in door. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover. Trims shall cover all live parts and shall have no exposed hardware.
   5. Finishes:
      a. Panels and Trim: Steel and galvanized steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
      b. Back Boxes: Galvanized steel.
      c. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components.

G. Incoming Mains:
   1. Main Breaker: Main lug interiors up to 400 amperes shall be field convertible to main breaker.

H. Phase, Neutral, and Ground Buses:

1. Material: Hard-drawn copper, 98 percent conductivity.
   a. Plating shall run entire length of bus.
   b. Bus shall be fully rated the entire length.
2. Interiors shall be factory assembled into a unit. Replacing switching and protective devices shall not disturb adjacent units or require removing the main bus connectors.
3. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
4. Full-Sized Neutral: Equipped with full-capacity bonding strap for service entrance applications. Mount electrically isolated from enclosure. Do not mount neutral bus in gutter.
5. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and listed and labeled by an NRTL acceptable to authority having jurisdiction, as suitable for nonlinear loads in electronic-grade panelboards and others designated on Drawings. Connectors shall be sized for double-sized or parallel conductors as indicated on Drawings. Do not mount neutral bus in gutter.

I. Conductor Connectors: Suitable for use with conductor material and sizes.
1. Material: Hard-drawn copper, 98 percent conductivity.
2. Terminations shall allow use of 75 deg C rated conductors without derating.
3. Size: Lugs suitable for indicated conductor sizes, with additional gutter space, if required, for larger conductors.
4. Main and Neutral Lugs: Mechanical type, with a lug on the neutral bar for each pole in the panelboard.
5. Ground Lugs and Bus-Configured Terminators: Mechanical type, with a lug on the bar for each pole in the panelboard.
6. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
7. Subfeed (Double) Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
8. Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus.

J. Future Devices: Panelboards or load centers shall have mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

K. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Assembly listed by an NRTL for 100 percent interrupting capacity.
1. Panelboards and overcurrent protective devices rated 240 V or less shall have short-circuit ratings as shown on Drawings, but not less than 10,000 A rms symmetrical.
2. Panelboards and overcurrent protective devices rated above 240 V and less than 600 V shall have short-circuit ratings as shown on Drawings, but not less than 14,000 A rms symmetrical.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
1. 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. Surge Suppression: Factory installed as an integral part of indicated panelboards, complying with UL 1449 SPD Type 1.

2.3 POWER PANELBOARDS

A. Manufacturers:
   1. Eaton
   2. Siemens
   3. Square D

B. Panelboards: NEMA PB 1, distribution type.

C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.

D. Branch Overcurrent Protective Devices for Circuit-Breaker: Bolt-on circuit breakers.

2.4 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Manufacturers:
   1. Eaton
   2. Siemens
   3. Square D

B. MCCB: Comply with UL 489, with interrupting capacity to meet available fault currents.
   1. Thermal-Magnetic Circuit Breakers:
      a. Inverse time-current element for low-level overloads.
      b. Instantaneous magnetic trip element for short circuits.
      c. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
   2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
   3. Electronic Trip Circuit Breakers:
      a. RMS sensing.
      b. Field-replaceable rating plug or electronic trip.
      c. Digital display of settings, trip targets, and indicated metering displays.
      d. Multi-button keypad to access programmable functions and monitored data.
      e. Ten-event, trip-history log. Each trip event shall be recorded with type, phase, and magnitude of fault that caused the trip.
      f. Integral test jack for connection to portable test set or laptop computer.
      g. Field-Adjustable Settings:
         1) Instantaneous trip.
         2) Long- and short-time pickup levels.
         3) Long and short time adjustments.
         4) Ground-fault pickup level, time delay, and I squared T response.
   4. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
   5. GFEP Circuit Breakers: Class B ground-fault protection (30-mA trip).
   6. Arc-Fault Circuit Interrupter Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.
   7. MCCB Features and Accessories:
      a. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.

2.5 IDENTIFICATION

A. Panelboard Label: Manufacturer's name and trademark, voltage, amperage, number of phases, and number of poles shall be located on the interior of the panelboard door.

B. Breaker Labels: Faceplate shall list current rating, UL and IEC certification standards, and AIC rating.

C. Circuit Directory: Computer-generated circuit directory mounted inside panelboard door with transparent plastic protective cover.
   1. Circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify actual conditions with field measurements prior to ordering panelboards to verify that equipment fits in allocated space in, and comply with, minimum required clearances specified in NFPA 70.

B. Receive, inspect, handle, and store panelboards according to NECA 407.

C. Examine panelboards before installation. Reject panelboards that are damaged, rusted, or have been subjected to water saturation.

D. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.

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

3.2 INSTALLATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Comply with NECA 1.

C. Install panelboards and accessories according to NECA 407.

D. Equipment Mounting:
   1. Attach panelboard to the vertical finished or structural surface behind the panelboard.
   2. Comply with requirements for seismic control devices specified in Section 26 05 48 "Seismic Controls for Electrical Systems."

E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.

F. Comply with mounting and anchoring requirements specified in Section 26 05 48 – Seismic Controls for Electrical Systems.

G. Mount top of trim 72” above finished floor unless otherwise indicated.

H. Mount panelboard cabinet plumb and rigid without distortion of box.

I. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

J. Install overcurrent protective devices and controllers not already factory installed.

K. Make grounding connections and bond neutral for services and separately derived systems to ground. Make connections to grounding electrodes, separate grounds for isolated ground bars, and connections to separate ground bars.

L. Install filler plates in unused spaces.

M. Stub four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch empty conduits into raised floor space or below slab not on grade.

N. Arrange conductors in gutters into groups and bundle and wrap with wire ties**.**

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Acceptance Testing Preparation:
1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections:
1. Perform each visual and mechanical inspection and electrical test for low-voltage air circuit breakers stated in NETA ATS, Paragraph 7.6 Circuit Breakers. optional tests. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

D. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results, with comparisons of the two scans. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.4 ADJUSTING

A. Adjust moving parts and operable components to function smoothly and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Section 26 01 30 "Short Circuit and Overcurrent Protective Device Coordination Study."

3.5 PROTECTION

A. Temporary Heating: Prior to energizing panelboards, apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION

SECTION 262913

MOTOR AND CIRCUIT DISCONNECTS

PART 1 – GENERAL

1.1 SECTION INCLUDES

A. Provide and install motor disconnects as shown and as required by Code.

B. Provide and install circuit disconnects as shown and as required by Code.

C. Disconnects to include mounting stands, brackets, plates, supports, and required hardware and accessories for complete installation.

1.2 REFERENCE STANDARDS

A. Underwriters' Laboratory (UL)
1. Annual Product Directories
2. UL-98 Enclosed Switches

B. National Electrical Manufacturer's Association (NEMA)
1. NEMA KS-1 Enclosed Switches

1.3 REQUIREMENTS OF REGULATORY AGENCIES

A. Conform to National Electrical Code and to applicable inspection authority.

B. Provide circuit and motor disconnects in the proper enclosure as required by NEC for the location installed unless more stringent requirements otherwise noted on the Drawings or herein.

1.4 SUBMITTALS

A. Provide submittals for products listed in the Product Table below in accordance with Section 26 05 00 – Common Work Results for Electrical. Submittal requirements indicated by column number designation as follows:
1. Materials List
2. Catalog Data
3. Product Data
4. Performance Data
5. Wiring Diagrams
6. Shop Drawings
7. Installation Instructions
8. Special Requirement listed herein.

PRODUCT TABLE	1	2	3	4	5	6	7	8
Components			X	X				
Single Phase Manual Motor Controller			X	X				

PART 2 - PRODUCTS

2.1 COMPONENTS

A. Motor and circuit disconnects shall have an Underwriters' Laboratory label.

B. Three-Phase Disconnect Switches: Three-pole heavy duty quick make, quick break 600 volt. Number of poles and ampacity as noted or required by Code. Fusible where noted with fuse clips suitable for dual element fuses unless current limiting fuses are noted. Short circuit rating sufficient to withstand the available fault current or let-through current before the fuse melts without damage or changes in rating.

C. Compression or set-screw lugs approved for use with copper wire.

D. ON/OFF Positions: Clearly marked, lockable in "OFF" position.

E. Cover Interlock:
1. Prevents switch from being opened when "on."
2. Prevents closing switch when cover is open.
3. Defeater to permit authorized personnel to open door and inspect switch when "on," or operate with cover open.

F. Motor disconnects shall contain minimum 2 NO/NC control circuit disconnecting contacts interlocked with operating handle.

G. Enclosure for Dry, Indoor Locations: NEMA 1 minimum. Enclosures for outdoor locations: NEMA 3R minimum. Others as required for location installed.

2.2 MANUAL MOTOR CONTROLLER, SINGLE PHASE

A. Acceptable Manufacturer: Square D.

B. General: Manual toggle switch with handle guard and lockoff, thermal overload relay, NEMA 1 surface mounted enclosure. Square D, Class 2510 or equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install motor and circuit disconnects as recommended by manufacturer and as required by Code and UL.

B. Maintain Code clearances.

C. Provide a nameplate on each motor and circuit disconnect identifying the equipment item served. Where disconnect is to be installed in existing motor control center replace existing nameplate with new nameplate identifying new equipment item served.

END OF SECTION

SECTION 263600

TRANSFER SWITCHES

PART 1 - GENERAL

1.1 CONTRACT CONDITIONS

A. Transfer switch is owner furnished; contractor installed. Product data included for reference.

B. Work of this division is bound by the General Conditions and this specification and accompanying drawings.

1.2 GENERAL REQUIREMENTS

A. The short-circuit overcurrent protective device coordination study shall be approved by the Engineer prior to the ordering of switchboards, panelboards, enclosed circuit breakers, disconnect switches, transfer switches, and overcurrent protective devices.

1.3 REFERENCES

A. UL 1008 – Transfer Switches

B. UL 911 – Tests for Safety-Related Controls Employing Solid-State Devices

C. NFPA 70 – National Electrical Code

D. NFPA 110 – Emergency and Standby Power Systems

E. NEMA ICS 10 – AC Transfer Switch Equipment

F. NEMA 250 – Enclosures for Electrical Equipment (1000 volts maximum)

G. IEEE 446 – Recommended Practice for Emergency and Standby Power Systems

1.4 SUBMITTALS

A. Submit product data under provisions of Section 26 01 26.

B. Submit product data for transfer and isolation/bypass switches showing overall dimensions, electrical connections, electrical ratings, and environmental requirements.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Cummings

B. Substitutions: Under provisions of Section 26 0500.

2.2 AUTOMATIC TRANSFER SWITCH

A. Construction: Comply with UL, NEMA, ANSI AND NFPA. Provide 2009 IBC Certification.

B. Shall be electrically operated, mechanically held contactor type, without integral overcurrent protection.

C. Load Inrush Rating: Combination, Tungsten lamp, Electric discharge lamp, inductive and resistive load.

D. Continuous Rating: as indicated on the Drawings.

E. 480 Volts, three-phase, 60 Hz.

F. Interrupting Capacity: 600 percent of continuous rating.

G. 3-Cycle Withstand Current Rating (3-cycle WCR) of transfer switch shall be at least equal to available fault current shown at the transfer switch on the one-line drawing.

H. 4-pole.

I. Closed transition.

2.3 AUTOMATIC TRANSFER WITH BYPASS/ISOLATION SWITCH

A. Construction: Comply with UL, NEMA, ANSI AND NFPA. Provide 2009 IBC Certification.
   1. See Automatic Transfer Switch for all electrical ratings.
   2. Draw-out type.
   3. In bypass mode:
      a. Secondary controls remain connected and transfer switch can be tested in this position.
   4. In Isolation mode:
      a. Secondary controls are disconnected and the entire drawout unit is de-energized without having to open the enclosure door.
      b. Allows transfer switch to be removed from its enclosure.

B. Bypass Switch Ratings: Match automatic transfer switch for all electrical ratings.

2.4 AUTOMATIC SEQUENCE OF OPERATION

A. Transfer Load to Emergency Source:
   1. Upon normal source voltage 80 percent or less.
   2. After adjustable time delay period of 0 to 60 seconds.
   3. Upon emergency source voltage within 90 percent of nominal.
   4. Upon emergency source frequency within 95 percent of nominal.

B. Retransfer Load to Normal Source:
   1. Upon restoration of nominal voltage and frequency of normal source.
   2. After adjustable time delay period of 0 to 1,800 seconds.
   3. Bypass time delay in event of emergency source failure.

2.5 MICROPROCESSOR CONTROLLER

A. Controller functions and capabilities:
   1. Provide all the operational and display functions of the automatic transfer switch.
   2. Password protected menu driven display screens for transfer switch monitoring, control and field changeable functions and settings.
   3. Accessible without opening the enclosure door.
   4. Serial communication port shall use industry standard open architecture communication protocol for high-speed serial communications, compatible with RS 485.

5. Built-in diagnostic display that includes the capturing of historical data, such as number of transfers and time on emergency power source.
6. Provide a real-time clock with battery backup.
7. A load/no load clock exerciser shall be programmable to start the engine generator set and transfer the load (when selected) for exercise purposes on a weekly basis.
8. Test switch with “Test – Load – No Load” position to simulate a normal source failure.
9. Provide all functions listed under “AUTOMATIC SEQUENCE OF OPERATION”
10. In-Phase Monitor: Inhibit transfer until source and load are within 60 electrical degrees, 2 Hz frequency difference and 70% or more of nominal voltage.
11. A contact that closes when normal source fails for initiating engine starting, rated 10 amps, 32 VDC. Contacts to be gold plated for low voltage service.
12. One auxiliary contact that is closed when automatic transfer switch is connected to normal and one auxiliary contact that is closed when automatic transfer switch is connected to emergency. Rated 10 amps, 480 volts, 60 Hz AC.
13. Test switches, status light panel, and control panel shall be mounted on hinged door for accessibility. Flexible wiring harness for control panel to switch connections provided with switch.
14. Provide a set of form "C" contacts for remote monitoring; provide contacts for each of the following: Normal Power Available; Emergency Power Available; ATS on normal source; ATS on emergency source.
15. Provide inhibit transfer to emergency and inhibit transfer to normal.

B. Display:
1. 20-character LCD.
2. Keypad.
3. Include ATS position and source availability.

2.6 ACCESSORIES

A. Relays and control circuits shall be provided to obtain fixed preferential control with transfer switch.

B. Relays for inhibiting transfer from emergency and from normal sources.

C. An override switch shall be provided to bypass the automatic transfer controls.

D. Provide Ethernet connection to campus private network status.

2.7 ENCLOSURE

A. Enclosure: NEMA Type 1.

B. Finish in manufacturer’s standard gray.

PART 3 - EXECUTION

3.1 INSPECTION

A. Verify that surfaces are ready to receive work.

B. Verify field measurements are as shown on Drawings.

C. Verify that required utilities are available, in proper location, and ready for use.

D. Verify transfer switch status and source availability are annunciated properly to the power monitoring network.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Provide seismically engineered mounting supports for switch.

C. Coordinate with Architect for location conflicts of equipment.

D. Provide equipment grounding as required by Code.

E. The following outputs shall be integrated into the electrical metering system:
1. Normal Power Available.
2. Emergency Power Available.
3. ATS on Normal Source.
4. ATS on Emergency Source.

3.3 SYSTEM DEMONSTRATION

A. Demonstrate operation of transfer switch in the presence of the facilities electrical supervisor, CPS electrician, and commissioning agent by operating normal power source under load and verifying transfer switch transfers to alternate source and back to normal source after normal power is restored.

B. The automatic transfer switch manufacturer shall provide factory start-up to ensure proper operation of the individual components and correct overall sequence of operation and to ensure that the operating transfer time, voltage, frequency and time delay settings are in compliance with the specification requirements.

END OF SECTION