# PROJECT MANUAL BANGOR TOWNSHIP SCHOOLS

CENTRAL ELEMENTARY SCHOOL CHRISTA MCAULIFFE MIDDLE SCHOOL EDISON ADMINISTRATION BUILDING JOHN GLENN HIGH SCHOOL LINCOLN ELEMENTARY SCHOOL NORTH PRE-SCHOOL WEST ELEMENTARY SCHOOL

## **ME UPGRADES**

Bay City, MI 48706

MARCH 30, 2023



William A. Kibbe & Associates, Inc. Architects – Engineers – Consultants 1475 S. Washington Ave., Saginaw, Michigan 48601 Ph (989) 752-5000 Fax (989) 752-5002 www.kibbe.com WAK No. 21-1719- 0435

#### SECTION 000200 - INVITATION TO BID

#### 1.1 GENERAL

A. Bangor Township Schools will be receiving sealed proposals for the ME Upgrades at the following (7) District Buildings, all located in Bay City, Michigan 48706.

WAGE RATES: Project will be required to comply with the latest minimum Federal Wage requirements as noted in the attached Davis-Bacon wage rates and document.

B. Owner requests proposals on Work as follows:

1. Project:	Bangor Township Schools ME Upgrades
2. Project Addresses:	John Glenn High School
	3201 Kiesel Road
	Bay City, Michigan 48706
	Christa McAuliffe Middle School
	3281 Kiesel Road
	Bay City, Michigan 48706
	Central Elementary School
	208 State Park Drive
	Bay City, Michigan 48706
	Lincoln Elementary School
	2771 North Euclid Avenue
	Bay City, Michigan 48706
	West Elementary School
	3175 Wilder Road
	Bay City, Michigan 48706
	North Pre-School
	504 Revilo Road
	Bay City, Michigan 48706
	Edison Administration Building
	3359 E. Midland Rd.
	Bay City, Michigan 48706
3. Owner:	Bangor Township Schools
	Kurtis Pake, Finance Director
	Office: 989-684-8121

#### pakek@bangorschools.org

4. Architect/Engineer: William A. Kibbe & Associates, Inc. 1475 S. Washington Avenue Saginaw, MI 48601 Office: 989-752-5000 Russ Meyer, Project Designer/Manager (rmeyer@kibbe.com) Jay C. Wheeler, PE, Project Administrator (jwheeler@kibbe.com) Tyler Mietz, PE, Engineer of Record (tyler@trm-engineering.com)

- 5. Sealed Bids Due: By 2:00 pm Local Time, Tuesday, April 18, 2023
- 6. Place Due:Bangor Township Schools (Edison Building)3359 East Midland RoadBay City, MI 48706
- 7. Type of Bidding: Prime/General Contract, to include All Trades Work

8. Label Sealed Bid:	BANGOR TOWNSHIP SCHOOLS
	ME UPGRADES
	"SEALED BID - DO NOT OPEN"

### 9. Pre-bid Meeting: Thursday, April 6, 2023 @ 10:00 a.m. (Start at Edison Administration Building, then the remaining (6) buildings)

- C. Sealed bid proposals must be on the forms furnished by the Architect/Engineer. Blank forms for bidding are included in the electronic bid documents, which can be obtained at the offices of:
  - William A. Kibbe & Associates
     1475 S. Washington Avenue, Saginaw, MI 48601
     Office 989-752-5000 | Fax 989-752-5002

2. PDF Files will be e-mailed to all bidders at no cost. If a printed set is requested, they can be provided at the cost of printing and postage. Notify the Architect in advance to make sure the printed sets are available prior to pick up.

- D. Bid Opening:
  - 1. Bids will be publically opened & read immediately after the receipt of bids.
- E. Withdrawal:
  - 1. Bids may not be withdrawn prior to 60 calendar days after actual date of opening bids.

- F. Rejection:
  - 1. Owner reserves the right to waive any informality or to reject any or all bids and to accept any bid deemed most advantageous to the Owner.
- G. Bonding & Insurances:
  - 1. 5% Bid Bond (NOT REQUIRED).
  - 2. 100% Labor, Material & Performance Bonds will be required for this project, from the awarded bidder.
  - 3. Certificate of Insurance will be required from the accepted bidder, per bid specification.
- H. All other requirements for bidding are detailed in the Instruction to Bidders.

#### END OF SECTION 000200

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#### SECTION 001000 - INSTRUCTIONS TO BIDDERS

#### 1.1 GENERAL

- A. Bangor Township Schools, Kurtis Pake, Finance Director, (herein called the "Owner"), invites bids for construction of the "Bangor Township Schools – ME Upgrades" at (7) District Buildings, in Bay City, Michigan, per the Invitation to Bid.
- B. Bids will be received at the place and time indicated in Invitation to Bid.
- C. Where any Article of the General Conditions of the Contract is supplemented hereby, provisions of such article shall remain in effect. All supplemental provisions shall be considered as added thereto. Where any such article is amended, voided or superseded, the provisions of such article not so specifically amended, voided or superseded shall remain in effect.
- D. The Contractor shall provide all items, articles, materials, operations, or methods listed, mentioned, or scheduled on the drawings, and/or herein, including all labor, materials, equipment, and incidentals necessary and required for their completion.
- E. For convenience of reference and to facilitate letting of subcontracts, the specifications located in this book specification & on the drawings, are separated into sections. Such separations shall not operate to make the Architect an arbiter or to establish subcontract limits between Contractor and Subcontractor.
- F. Submit a sealed envelope containing bid and address to:

ATTN: Bangor Township Schools 3359 East Midland Road Bay City, MI 48706

#### BANGOR TOWNSHIP SCHOOLS ME UPGRADES "SEALED BID - DO NOT OPEN"

- G. Owner will publically open bids immediately following the receipt of bids.
- H. Owner invites the Bid on the "ME Upgrades" to include the work of all trades included in contract documents. Refer to bid form for specific requirements regarding bids, alternates, unit prices and cost breakdowns.
- I. Examination of Site:
  - 1. It is necessary for bidders to inform themselves of the conditions under which work is to be performed, the sites and buildings for the work, and obstacles which may be encountered and all other relevant matters concerning the work to be performed. The bidder, if awarded the contract, shall not be allowed any

extra compensation by reason of any matter or thing concerning which such bidder might have become fully self-informed because of a failure to have so informed self-prior to the bidding.

- J. Preparation of Bid
  - 1. Submit on forms furnished herein.
  - 2. Fill out in ink or typewritten, without erasure, interlineation or changes.
  - 3. Make Bid in name of principal and if co-partnership, give names of all parties. Give complete address. If bid is submitted by an agent, provide satisfactory evidence of agency authority.
  - 4. Fill in all blank spaces for bid prices in both words and figures. Submit each bid in sealed envelope. Indicate on outside of envelope, name of bidder, bidders address, and name of project for which bid is submitted. If forwarded by mail, enclose sealed envelope containing bid in another envelope addressed indicated.
  - 5. Bid must be received prior to due date and time indicated in Invitation for Bid.
- K. Bid Guaranty / Security: (NOT REQUIRED)
  - 1. Proposal must be accompanied by a five percent (5%) bidder's bond, by an authorized surety company.
  - 2. The bid guaranty of all except the three (3) lowest accepted bidders will be returned within seven (7) days after opening of bids. Bid guaranty of accepted bidders will be returned after executed contract and required bonds have been finally approved by Owner. If no award has been made within sixty (60) days after the opening of bids, the bid security shall be returned upon demand of the bidder, so long as he has not been notified of the acceptance of his bid. If any bidder refuses to enter into a contract, the Owner will retain his bid security as liquidated damages, but not as a penalty.
  - Sureties on all bonds must be acceptable to the Owner. U.S. Treasury Circular No. 570 lists approved sureties, states or licensure and underwriting limits. A copy of this circular may be obtained by writing to Audit Staff, Bureau of Government Financial Operations, U.S. Treasury Department, Washington, D.C. 20226. In addition, approved surety to be listed by A.M. Best as "B" rating or better and be licensed to operate in the State of Michigan.
- L. Requirements for Signing Bids:
  - 1. Bids which are not signed by the individual making them should have attached thereto a power of attorney evidencing authority to sign in the name of the person for whom it is signed.
  - 2. Bids which are signed for a partnership should be signed by one of the partners or by an attorney-in-fact. If signing by an attorney-in-fact, there should be

attached to the bid a power of attorney evidencing authority to sign the bid, executed by the partners.

- Bids which are signed for a corporation should have the correct corporate name thereon and the signature of the president or other authorized officer of the corporation, manually written below the corporate name following the word, "By\_\_\_\_\_\_". Provide a signature authorization certificate.
- M. Substitutions:
  - 1. Proposals shall be based on the various brands, makes and standards of materials specified, and unless substitutions are authorized <u>in writing</u> within seven (7) days prior to the receipt of bids, all contracts will be so awarded. Requests shall clearly describe the product for which approval is requested, including all data necessary to demonstrate acceptability. If the product is acceptable, the Architect will approve it in an addendum issued to all prime bidders on record.
  - 2. Proposed substitutions that are unable to be approved seven (7) days prior to receipt of bids may be bid as a voluntary alternate on the bid/tender form. Under this condition, each bidder shall state on the bid/tender form under voluntary alternate(s) the name(s) of proposed substitution(s) to be used if approved and the amount to be added or deducted from the proposal amount if accepted. Submit all data necessary to demonstrate acceptability to the Architect.
  - 3. NO SUBSTITUTIONS WILL BE PERMITTED AFTER THE AWARD OF CONTRACTS.
- M. Taxes:
  - 1. Each proposal submitted shall include and the successful bidder shall be required to pay all taxes which are levied by Federal, State, or Municipal Governments upon labor, and for materials entering into the work. The Owner reserves the right to require evidence of payment of such taxes prior to final payment.
  - 2. In compliance with the regulations of the Michigan Sales Tax Commission, sales and use tax is to be included in the proposals.
- N. Withdrawal or Revision to Bid:
  - 1. Bid may be withdrawn or revised prior to scheduled time for opening, under following terms:
    - a. Bidders may, without prejudice to themselves, withdraw a bid after it has been deposited, provided request for such withdrawal is received in writing, before time set for opening. Telephonic communications are

not acceptable. After opening, no Bid may be withdrawn for the period indicated.

- b. Bidder may modify his bid by written confirmation prior to scheduled time of bid opening. Bidders must have time & date noted to be valid.
- O. Time for Completion:

- 1. It is hereby understood and mutually agreed, by and between the Contractor and the Owner, that the date of beginning and the time for completion of each phase of the project are ESSENTIAL CONDITIONS of this contract.
- 2. All trades of work as specified in the contract documents shall be completed within the time frames indicated for each phase with only such minor replacements, corrections or adjustment items that do not interfere with the complete operation and utilization of all other parts of the contracted work. The project as completed must be approvable for occupancy by Governing Agencies.
- 3. Completion is as follows:

a. Milestone Schedule:	
March 30, 2023	Bid Documents Completed
March 31, 2023	Documents available for Contractors & Submit for Plan Reviews
April 6, 2023 @ 10:00 am	Site Walk-Thru (required attendance) (Starting at Edison Admin. Building)
April 18, 2023 @ 2:00 pm	Bids Due (at Edison Admin. Building)
April 19 thru April 21, 2023	Bid Reviews (w/ recommendation for award)
April 24, 2023	Bid Award (at regular School Board meeting)
April 25, 2023	Notice to Proceed
May 1, 2023	Start Construction & Order Equipment
TBD	Substantially Complete (as qualified on Bid Form by Contractor)

4. It shall be the Prime Contractor's responsibility to immediately identify and order long lead items that may jeopardize the substantial completion and final occupancy dates as specified.

- 5. Contractor shall be expected to fully man the project on all working days. The only exceptions that will be accepted shall be weather, labor strikes, or unavailability of materials.
- P. Irregular Bids
  - 1. Bids are considered irregular and may be rejected for the following reasons unless otherwise provided by law:
    - a. If form furnished is not used or is altered.
    - b. If there are unauthorized additions, conditional bids, or irregularities of any kind which may tend to make bid incomplete, indefinite, or ambiguous as to its meaning.
    - c. If bidder adds any provisions reserving right to accept or reject any award, or to into contact pursuant to an award.
    - d. If unit or lump sum prices contained in bid schedule are obviously unbalanced either in excess of, or below, reasonable cost analysis values.
    - e. If bidder fails to insert alternate and unit prices for every item indicated.
    - f. If bidder fails to complete bid in any other particulars where information is requested so bid can not be properly evaluated.
  - 2. Owner reserves right to reject any or all bids and to waive irregularities or informalities as may be deemed in Owner's interest.
- Q. Interpretations
  - If bidder for proposed work is in doubt as to the true meaning of any part of the contact documents, submit written request for interpretation (RFI). Bidder submitting request is responsible for its prompt and actual delivery. Interpretations will not be made orally. The architect is not responsible for any other explanations or interpretations which anyone presumes to make.
  - 2. Written request for interpretation shall be made to William A. Kibbe & Associates, Inc., 1475 S. Washington Ave., Saginaw, Michigan 48601, Russ Meyer, <u>rmeyer@kibbe.com</u> or Jay C. Wheeler, PE, <u>jwheeler@kibbe.com</u>. Request must be received AT LEAST 3 DAYS PRIOR to date fixed for opening of bids. All interpretations or supplemental instructions will be in form of written addenda e-mailed or mailed prior to date fixed for opening of bids. Copy of such addenda will be e-mailed or mailed to each individual or entity issued contract documents. Failure to receive such addenda does not relieve bidder from any obligation under his bid as submitted. All addenda are part of the contract documents.
  - 3. Bidder desiring approval of material or equipment not specified must comply with this Section for Substitutions prior to receipt of bids.

- 4. Project Contacts:
  - i) Owner: <u>Kurtis Pake</u>, Finance Director, Bangor Township Schools E-mail: pakek@bangorschools.org
  - ii) Engineers & Project Manager: Phone: 989-752-5000 <u>Russ Meyer</u> E-mail: rmeyer@kibbe.com <u>Jay C. Wheeler, PE</u> E-mail: jwheeler@kibbe.ciom Tyler Mietz, PE E-mail: tyler@trm-engineering.com
- R. Method of Award
  - 1. Upon receiving notice of acceptance of a bid, contractor will enter into a contract with Owner or its agent within four (4) weeks.
- S. Contractor Qualifications
  - All contractors shall be licensed contractors, possessing good labor relations, capable of performing quality workmanship and working in harmony with other contractors on the job. All work shall be coordinated with the general project work. In the event contractor willfully violates the requirements of this paragraph, Owner shall have the right to order contractor to remove itself, its equipment, and its employees from the job.
  - 2. Bidder to whom award is contemplated may be required to furnish the following information:
    - a. Financial statement.
    - b. Performance record, including past & present projects, amount of contracts, present completion, owner, architect.
    - c. List of references and similar projects.
    - d. List of company, key personnel with their background and experience.
- T. Non-Iran Linked Business
  - By signing the proposal bid form, I certify and agree on behalf of myself and the company submitting this proposal the following: (1) that I am duly authorized to legally bind the company submitting this proposal; and (2) that the company submitting this proposal is not an "Iran linked business," as that term is defined in Section 2(e) of the Iran Economic Sanctions Act, being Michigan Public Act No. 517 of 2012; and (3) That I and the company submitting this proposal will immediately comply with any further certifications or information submissions requested by the School District in this regard."
- U. Federal Wage Rates

- This project is subject to the requirements of Davis Bacon and Related Acts. The contractor must comply with the minimum rates for wages for laborers and mechanics as determined by the Secretary of Labor in accordance with the provisions of the Davis-Bacon and related Acts. The Contractor will post at the job site the Davis Bacon and Related Acts poster: "Notice to All Employees Working on Federal or Federally Financed Construction Projects" included in the contract specifications and available at the following website: <u>http://www.dol.gov/esa/whd/regs/compliance/posters/davis.htm</u>.
- 2. Contractor to verify that the attached version of the Wage Rates used is the most current at time of the bid submittal.

END OF SECTION 001000

"General Decision Number: MI20230077 02/24/2023

Superseded General Decision Number: MI20220077

State: Michigan

Construction Type: Building

County: Bay County in Michigan.

BUILDING CONSTRUCTION PROJECTS (does not include single family homes or apartments up to and including 4 stories).

Note: Contracts subject to the Davis-Bacon Act are generally required to pay at least the applicable minimum wage rate required under Executive Order 14026 or Executive Order 13658. Please note that these Executive Orders apply to covered contracts entered into by the federal government that are subject to the Davis-Bacon Act itself, but do not apply to contracts subject only to the Davis-Bacon Related Acts, including those set forth at 29 CFR 5.1(a)(2)-(60).

<pre> If the contract is entered  into on or after January 30,  2022, or the contract is  renewed or extended (e.g., an  option is exercised) on or  after January 30, 2022:        </pre>	<ul> <li>Executive Order 14026</li> <li>generally applies to the contract.</li> <li>The contractor must pay all covered workers at</li> <li>least \$16.20 per hour (or the applicable wage rate</li> <li>listed on this wage</li> <li>determination, if it is</li> <li>higher) for all hours</li> <li>spent performing on the contract in 2023.</li> </ul>
If the contract was awarded on or between January 1, 2015 and January 29, 2022, and the contract is not renewed or extended on or after January 30, 2022:	<ul> <li>Executive Order 13658 generally applies to the contract.</li> <li>The contractor must pay all covered workers at least \$12.15 per hour (or the applicable wage rate listed on this wage determination, if it is higher) for all hours spent performing on that contract in 2023.</li> </ul>

The applicable Executive Order minimum wage rate will be

adjusted annually. If Executive Orders and a performance of work on wage determination, th conformance request.	this contra classifica the contra e contracto	nct is covered b ntion considered nct does not app nr must still su	by one of the I necessary for Dear on this Ubmit a
Additional information protections under the http://www.dol.gov/whd	on contrac Executive C /govcontrac	tor requirement Orders is availa ts.	s and worker able at
Modification Number 0 1 2	Publicati 01/06/20 02/03/20 02/24/20	on Date 23 23 23 23	
ASBE0047-002 07/01/20	22		
		Rates	Fringes
ASBESTOS WORKER/HEAT & INSULATOR	FROST	\$ 34.62	18.58
BOIL0169-001 01/01/20	21		
		Rates	Fringes
BOILERMAKER		\$ 35.95	34.52
BRMI0009-030 08/01/20	20		
		Rates	Fringes
BRICKLAYER TILE FINISHER TILE SETTER		\$ 30.00 \$ 22.80 \$ 29.82	21.24 17.54 15.35
FOOTNOTE:			
Paid Holiday: Fourth the contractor in an said holiday within	of July, i y period of the current	f the worker is seven working calendar year.	s employed by days before
CARP0706-002 06/01/20	20		
		Rates	Fringes
CARPENTER, Includes Acoustical Ceiling			

CARP1045-003 06/01/2013 Rates Fringes LATHER\$ 24.29 13.66 ELEC0692-001 06/01/2022	
Rates         Fringes           LATHER	
LATHER\$ 24.29 13.66 ELEC0692-001 06/01/2022	Fringes
ELEC0692-001 06/01/2022	13.66
Rates Fringes	Fringes
ELECTRICIAN Excludes Low Voltage Wiring.\$ 35.31 38.03%+9.25	38.03%+9.25
ENGI0324-001 06/01/2022	
Rates Fringes	Fringes
OPERATOR:       Power Equipment         GROUP 1	24.85 24.85 24.85 24.85 24.85 24.85 24.85 24.85 24.85
boom and jib 400' or longer: \$3.00 per hour above the group 1 rate.	
PAID HOLIDAYS: New Year's Day, Memorial Day, Fourth of July, Labor Day, Thanksgiving Day and Christmas Day.	
POWER EQUIPMENT OPERATOR CLASSIFICATIONS	
GROUP 1: Crane operator with main boom and jib 400', 300', or 220' or longer.	nd jib 400', 300', or
GROUP 2: Crane operator with main boom and jib 140' or longer, tower crane, gantry crane, whirley derrick	nd jib 140' or ey derrick
GROUP 3: Bulldozer; Concrete Pump; Crane; Grader/Blade; Highlift; Hoist; Roller; Scraper; Stiff Leg derrick;	Grader/Blade; .eg derrick;

Trencher		
GROUP 4: Bobcat/Skid Loader; Br 20' lift)	room/Sweeper; Fo	rk Truck (over
GROUP 5: Boom Truck (non-swinging	g)	
GROUP 6: Fork Truck (20' lift and	d under for maso	nry work)
GROUP 7: Oiler		
IRON0025-019 06/01/2022		
	Rates	Fringes
IRONWORKER		
REINFORCINGSTRUCTURAL	\$ 31.43 \$ 34.50	34.77 38.44
LABO0334-010 06/01/2022		
	Rates	Fringes
LABORER: Landscape and Irrigation		
GROUP 1 GROUP 2	\$ 23.82 \$ 21.60	7.60 7.60
CLASSIFICATIONS		
GROUP 1: Landscape specialist, including air, gas and diesel equipment operator, lawn sprinkler installer and skidsteer (or equivalent)		
GROUP 2: Landscape laborer: small power tool operator, material mover, truck driver and lawn sprinkler installer tender		
LAB01098-009 07/01/2021		
	Rates	Fringes
LABORER Common or General; Grade Checker; Mason Tender - Brick (Comont (Concrete:		
Pipelayer	\$ 22.67 \$ 23.72	12.90 12.90

-----PAIN1803-001 06/01/2022 Rates Fringes PAINTER: Brush, Roller and Spray.....\$ 26.27 20.17 PAINTER: Drywall Finishing/Taping.....\$ 26.27 20.17 -----PLAS0016-012 04/01/2014 Rates Fringes CEMENT MASON/CONCRETE FINISHER...\$ 25.47 12.38 \_\_\_\_\_ \* PLUM0085-003 05/04/2022 Rates Fringes PIPEFITTER, Includes HVAC Pipe and Unit Installation.....\$ 41.00 22.39 PLUMBER, Excludes HVAC Pipe and Unit Installation.....\$ 38.25 21.07 \_\_\_\_\_ ROOF0149-003 06/01/2020 Rates Fringes ROOFER.....\$ 29.58 18.33 \_\_\_\_\_ SFMI0669-001 04/01/2022 Rates Fringes SPRINKLER FITTER (Fire Sprinklers).....\$ 38.69 25.22 \_\_\_\_\_ SHEE0007-009 05/01/2018 Rates Fringes SHEET METAL WORKER (Including HVAC Duct Installation; Excluding HVAC System Installation).....\$ 26.83 23.78 \_\_\_\_\_ \* SUMI2011-002 02/01/2011 Rates Fringes

ELECTRICIAN (Low Voltage Wiring)\$ 17.47	3.10
IRONWORKER, ORNAMENTAL\$ 18.48	7.93
OPERATOR: Backhoe/Excavator/Trackhoe\$ 18.57	6.40
OPERATOR: Tractor\$ 19.10	8.48
OPERATOR: Loader\$ 15.93 **	8.10
TRUCK DRIVER, Includes Dump and Tandem Truck\$ 12.00 **	0.00
TRUCK DRIVER: Tractor Haul Truck\$ 13.57 **	1.18

WELDERS - Receive rate prescribed for craft performing operation to which welding is incidental.

\_\_\_\_\_

\*\* Workers in this classification may be entitled to a higher minimum wage under Executive Order 14026 (\$16.20) or 13658 (\$12.15). Please see the Note at the top of the wage determination for more information.

Note: Executive Order (EO) 13706, Establishing Paid Sick Leave for Federal Contractors applies to all contracts subject to the Davis-Bacon Act for which the contract is awarded (and any solicitation was issued) on or after January 1, 2017. If this contract is covered by the EO, the contractor must provide employees with 1 hour of paid sick leave for every 30 hours they work, up to 56 hours of paid sick leave each year. Employees must be permitted to use paid sick leave for their own illness, injury or other health-related needs, including preventive care; to assist a family member (or person who is like family to the employee) who is ill, injured, or has other health-related needs, including preventive care; or for reasons resulting from, or to assist a family member (or person who is like family to the employee) who is a victim of, domestic violence, sexual assault, or stalking. Additional information on contractor requirements and worker protections under the EO is available at

https://www.dol.gov/agencies/whd/government-contracts.

Unlisted classifications needed for work not included within

the scope of the classifications listed may be added after award only as provided in the labor standards contract clauses (29CFR 5.5 (a) (1) (ii)).

\_\_\_\_\_

The body of each wage determination lists the classification and wage rates that have been found to be prevailing for the cited type(s) of construction in the area covered by the wage determination. The classifications are listed in alphabetical order of ""identifiers"" that indicate whether the particular rate is a union rate (current union negotiated rate for local), a survey rate (weighted average rate) or a union average rate (weighted union average rate).

#### Union Rate Identifiers

A four letter classification abbreviation identifier enclosed in dotted lines beginning with characters other than ""SU"" or ""UAVG"" denotes that the union classification and rate were prevailing for that classification in the survey. Example: PLUM0198-005 07/01/2014. PLUM is an abbreviation identifier of the union which prevailed in the survey for this classification, which in this example would be Plumbers. 0198 indicates the local union number or district council number where applicable, i.e., Plumbers Local 0198. The next number, 005 in the example, is an internal number used in processing the wage determination. 07/01/2014 is the effective date of the most current negotiated rate, which in this example is July 1, 2014.

Union prevailing wage rates are updated to reflect all rate changes in the collective bargaining agreement (CBA) governing this classification and rate.

#### Survey Rate Identifiers

Classifications listed under the ""SU"" identifier indicate that no one rate prevailed for this classification in the survey and the published rate is derived by computing a weighted average rate based on all the rates reported in the survey for that classification. As this weighted average rate includes all rates reported in the survey, it may include both union and non-union rates. Example: SULA2012-007 5/13/2014. SU indicates the rates are survey rates based on a weighted average calculation of rates and are not majority rates. LA indicates the State of Louisiana. 2012 is the year of survey on which these classifications and rates are based. The next number, 007 in the example, is an internal number used in producing the wage determination. 5/13/2014 indicates the survey completion date for the classifications and rates under that identifier.

Survey wage rates are not updated and remain in effect until a new survey is conducted.

Union Average Rate Identifiers

Classification(s) listed under the UAVG identifier indicate that no single majority rate prevailed for those classifications; however, 100% of the data reported for the classifications was union data. EXAMPLE: UAVG-OH-0010 08/29/2014. UAVG indicates that the rate is a weighted union average rate. OH indicates the state. The next number, 0010 in the example, is an internal number used in producing the wage determination. 08/29/2014 indicates the survey completion date for the classifications and rates under that identifier.

A UAVG rate will be updated once a year, usually in January of each year, to reflect a weighted average of the current negotiated/CBA rate of the union locals from which the rate is based.

#### WAGE DETERMINATION APPEALS PROCESS

1.) Has there been an initial decision in the matter? This can be:

- \* an existing published wage determination
- \* a survey underlying a wage determination
- \* a Wage and Hour Division letter setting forth a position on a wage determination matter
- \* a conformance (additional classification and rate) ruling

On survey related matters, initial contact, including requests for summaries of surveys, should be with the Wage and Hour National Office because National Office has responsibility for the Davis-Bacon survey program. If the response from this initial contact is not satisfactory, then the process described in 2.) and 3.) should be followed.

With regard to any other matter not yet ripe for the formal process described here, initial contact should be with the Branch of Construction Wage Determinations. Write to: Branch of Construction Wage Determinations Wage and Hour Division U.S. Department of Labor 200 Constitution Avenue, N.W. Washington, DC 20210

2.) If the answer to the question in 1.) is yes, then an interested party (those affected by the action) can request review and reconsideration from the Wage and Hour Administrator (See 29 CFR Part 1.8 and 29 CFR Part 7). Write to:

Wage and Hour Administrator U.S. Department of Labor 200 Constitution Avenue, N.W. Washington, DC 20210

The request should be accompanied by a full statement of the interested party's position and by any information (wage payment data, project description, area practice material, etc.) that the requestor considers relevant to the issue.

3.) If the decision of the Administrator is not favorable, an interested party may appeal directly to the Administrative Review Board (formerly the Wage Appeals Board). Write to:

Administrative Review Board U.S. Department of Labor 200 Constitution Avenue, N.W. Washington, DC 20210

4.) All decisions by the Administrative Review Board are final.

\_\_\_\_\_

END OF GENERAL DECISIO"

SECTION 003000 - BID FORM

BID FORM - CONSTRUCTION TRADES BANGOR TOWNSHIP SCHOOLS ME UPGRADES

PROJECT:	Bangor Township Schools ME Upgrades
	WAK Project No. 21-1719-0435
TO:	Bangor Township Schools (Edison Building) 3359 East Midland Road Bay City, MI 48706
ARCHITECT/ ENGINEER:	William A. Kibbe & Associates, Inc. 1475 S. Washington Avenue Bay City, MI 48708
BASE PROPOSAL:	"ME" – Mechanical/Electrical Trades

The Undersigned, having visited the sites and familiarized themselves with the local conditions affecting the cost of the work and the contract documents, including plans, project manual, and technical specifications, Invitation to Bid, Instructions to Bidders, General Conditions, Supplementary Conditions, and any addenda issued thereto, hereby proposes to perform and to provide and furnish all the labor, materials, tools, expendable equipment, utility and transportation services, etc., necessary to perform and complete in a workmanlike manner all work required under base bid for the aforementioned project, all in strict accordance with the Contract Documents, as prepared by <u>William A. Kibbe & Associates, Inc., Architects/Engineers.</u>

In consideration of all the above requirements, the undersigned agrees to accept in payment the sum of:

PROPOSAL "ME" – MECHANICAL/ELECTRICAL TRADES (BASE BID):

For quote analysis, the total lump sum quote must be subdivide	ed by building as outlined below:
John Glenn High School	\$
Christa McAuliffe Middle School	\$
Central Elementary School	\$
Lincoln Elementary School	\$
West Elementary School	\$

(\$).

Project No.	21-1719-0435
-------------	--------------

ME Upgrades	
North Pre-School	\$
Edison Administration Building	\$
TOTAL BASE BID <u>(MUST BE EQUAL TO TOTAL LUMP SUM</u> <u>AMOUNT ON PREVIOUS PAGE)</u>	\$
<u>ADD ALTERNATE NO. M-1 -</u> Remove & Replace the (7) RTU's (Christa McAuliffe MS)	\$
ADD ALTERNATE NO. L-1 - Remove & Replace the RTU (Lincoln Elementary)	\$
Exceptions to the specifications:	
If none, please indicate No Exceptions taken to the Pro-	oject Specifications.
Said sum to be subject to all the terms of the contract and to i character or description and all requirements noted in the sp	include Wage Rates and all Taxes of whatever pecifications applicable thereto.

ADDENDA: Addenda issued during bidding period covering clarifications, additions, deletions or changes are acknowledged and are included in the proposal as follows:

Addenda Number:	Dated
Addenda Number:	Dated
Addenda Number:	Dated

**BID FORM - CONSTRUCTION TRADES** 

Bangor Township Schools

#### VOLUNTARY ALTERNATES:

The following voluntary alternates are offered for substituting materials and/or equipment. (Attach product information).

1.	ADD/DEDUCT <u>\$</u>
2.	ADD/DEDUCT <u>\$</u>
3.	ADD/DEDUCT \$

CHANGES IN THE WORK: For authorized changes in the work, involving additions to or deletions from the work, the Undersigned agrees to perform or delete, or to cause to be performed or deleted by the subcontractors, such authorized work at net cost to him plus the following percentages to be added to the cost or credited to the Owner, which percentages shall include all the contractor's cost for on-site superintendent, supervision, overhead and profit.

Work performed by own forces:	15%
Work under subcontract:	10%

COMPLETION TIME: The Undersigned agrees to commence work operations immediately upon formal notice of award of contract and to substantially complete the whole of the work on or before the proposed substantial completion date as provided on this Bid Form.

The Prime Bidder hereby proposes to be **substantially complete** by the following date noted below: This date will be used in the contractual agreement between the Contractor/Owner for this project.

NEGOTIATION: The Undersigned agrees that, should the overall cost exceed the funds available, they will be willing to negotiate with the Owner and Architect/Engineer for the purpose of making further reductions in the contract work, and shall agree to give full credit for all such reductions in the work requested by the Owner, including full value of labor, materials and subcontracted work and reasonable proportionate reductions in overhead and profit, thereby arriving at an agreed upon contract price. Contractor will endeavor to determine the most cost effective method of accomplishing the Owner's objective and report same to Owner and Architect/Engineer.

WITHDRAWAL/PROPOSAL GUARANTY: The Undersigned agrees in submitting this proposal (bid), that the quotation stated will not be withdrawn for a period of sixty (60) consecutive calendar days from bid due date. Further, accompanying this proposal is a proposal guaranty, as required, consisting of:

#### (NOT REQUIRED)

(State Nature of Guarantee & Amount)

CONTRACT EXECUTION: The undersigned agrees to execute a contract for work covered by this proposal provided that notification of its acceptance is within sixty (60) calendar days after the opening of the proposal (bid).

The Undersigned hereby declares that he/she has the legal status checked below:

( ) Individual	
( ) Partnership having the following partners:	
	-
	-
	-
( ) Corporation incorporated under the state laws of	
	-
This proposal is submitted in the name of and notice of a delivered to:	cceptance should be mailed, telegraphed, or
FIRM NAME	
BYTITLE_	
(Signature)	
DATETELEPHONE	
IN PRESENCE OF:	
TITLE_	
END OF SECTION 003000	
NSTRUCTIONS: Submit one copy and retain one copy for	file.

#### Bangor Township Schools FAMILIAL DISCLOSURE AFFIDAVIT

All Bids shall be accompanied by this sworn statement disclosing any familial relationship that exists between the owner(s) or any employee of the bidder and any member of the Board of Education of the District and/or the Superintendent of the District.

The undersigned, owner or authorized officer of \_\_\_\_\_\_(the bidder), pursuant to the familial disclosure requirement provided in the Bangor Township Schools Universal Service Fund Request for Proposals, hereby represent and warrant, except as provided below, that no familial relationships exist between the bidder or any employee of the bidder, and any member of the Bangor Township Schools Board of Education and/or the Superintendent.

□ The following are the bidder's familial relationship(s) with Bangor Township Schools:

Bidder/Employee	Name related to:	Relationship

□ **There is no familial relationship** that exists between the bidder and/or any employee of the bidder and any member of the Bangor Township School's Board of Education and/or the Superintendent.

Bidder:

(Company Name)

SS:

By:

(Signature)

(Title)

This instrument was acknowledged before me, a Notary Public, in and for \_\_\_\_\_

County, \_\_\_\_\_ on this \_\_\_\_ day of \_\_\_\_\_, 20\_\_\_.

(Notary Public Signature)

My commission expires: \_\_\_\_\_

Acting in the County of: \_\_\_\_\_

Bangor Township Schools ME Upgrades

SECTION 005000 - AGREEMENT FORM

1.1 DOCUMENTS:

The "Standard Form of Agreement between Owner and Contractor", A.I.A. Document A101, 2017 Edition, where the basis of payment is a stipulated sum will be the form of agreement utilized for this project.

1.2 RELATED INFORMATION:

Attention is directed to the following divisions of the specifications for additional information relative to the agreement form.

003000	Bid Form - Under "Time of Completion"
007000	General Conditions
008000	Supplementary Conditions

Contractors shall be held responsible for having familiarized themselves with this document and all other documents affecting their contracts in this specification.

This document is on file at the Architect's office or can be obtained from:

Michigan Society of Architects 553 East Jefferson Detroit, Michigan 48226

END OF SECTION 005000

AGREEMENT FORM

Bangor Township Schools ME Upgrades

SECTION 007000 - GENERAL CONDITIONS

#### 1.1 DOCUMENTS:

"The General Conditions of the Contract for Construction", A.I.A. Document A-201, 2017 Edition, forms a part of these specifications and shall have the same effect as if bound herein.

This document is modified as described in Modifications of the General Conditions.

Contractors shall be held responsible for having familiarized themselves with this document and all other documents affecting their contracts in this specification.

This document is on file at the Architect's office or can be obtained from:

Michigan Society of Architects 553 East Jefferson Detroit, Michigan 48226

END OF SECTION 007000

GENERAL CONDITIONS

#### SECTION 008000 - SUPPLEMENTARY CONDITIONS

The following Supplementary Conditions modify, change, delete from or add to the "General Conditions of the Contract for Construction", A.I.A. Document A-201, 2017 Edition, where any article of the General Conditions is modified or any paragraph, subparagraph or clause thereof is modified or deleted by these Supplementary Conditions. The unaltered provisions of the article, paragraph, subparagraph, or clause shall remain in effect.

#### ARTICLE 1 - CONTRACT DOCUMENTS

Modify Article 1.1.3 as follows:

#### 1.1.3 The Work

The work comprises all required demolition and removal work, and completely new construction and renovation as required by the contract documents, including all labor necessary to produce such construction, and all materials, equipment and incidentals incorporated or to be incorporated in such construction to produce the intended results.

#### Modify Article 1.2.3 as follows:

1.2.3 The intent of the Contract Documents is to include all items necessary for the proper execution and completion of the work. The Contract Documents are complimentary, and what is required by one shall be as binding as if required by all. Work not covered in the Contract Documents will not be required unless it is consistent therewith and is reasonably inferable therefrom as being necessary to produce the intended results. Words and abbreviations which have well known technical, or trade meanings are used in the Contract Documents in accordance with such recognized meanings. Where reference is made to specifications of manufacturers, trade associations or the like, such is understood to be made a part of this specification to have the same effect as if fully reproduced herein. Approval or equal, acceptable, and words of similar definition are understood to mean, "in the judgment of the Architect".

#### Add Article 1.2.4 as follows:

1.2.4 Computed dimensions take precedence over scaled dimensions, large scale details over smaller. Should there be conflict(s) between or within drawings and/or specifications, that which requires the highest degree of performance (quality, quantity, strength, finish, completion, complexity, sophistication, etc.), will be required and shall be provided at no increase in contract amount. All such conflicts shall be brought to the attention of the Architect/Engineer for interpretation of the intent of the drawings and/or specifications.

#### ARTICLE 2 - OWNER

Add Article 2.4.2 as follows:

2.4.2 As stated in the contract documents, certain equipment may be pre-purchased by the Owner, the cost of which is not to be included in the contract.

Add Article 2.4.3 as follows:

2.4.3 The Owner and their representative shall at all times have access to the work wherever it is in preparation of progress and the contractor shall provide proper facilities for such access and for review of construction.

ARTICLE 3 - CONTRACTOR

Add Article 3.1.4 as follows:

3.1.4 Term "GENERAL CONTRACTOR" or "PRIME CONTRACTOR" means person, firm or corporation who performs Architectural Trades Work and who is fully responsible to the Owner for all administration, handling and coordination of Work.

Add Article 3.1.5 as follows:

3.1.5 Term "MECHANICAL CONTRACTOR" means person, firm or corporation who performs the Mechanical Work, as a Subcontractor to the General Contractor. Can also be the Prime Contractor.

Add Article 3.1.6 as follows:

3.1.6 Term "PLUMBING CONTRACTOR" means person, firm or corporation who performs the Plumbing Work, as a Subcontractor to the General Contractor.

Add Article 3.1.7 as follows:

3.1.7 Term "ELECTRICAL CONTRACTOR" means person, firm or corporation who performs the Electrical Work, as a Subcontractor to the General Contractor.

Add Article 3.1.8 as follows:

3.1.8 Term "SITE CONTRACTOR" means person, firm or corporation who performs the Site Work (if other than General Contractor) as a Subcontractor to the General Contractor.

Add Article 3.3.4 as follows:

3.3.4 All work shall be furnished and installed in strict accordance with Federal, State & Local laws and codes regarding handicapped requirements as well as the requirements of the governing Health Department, State and Local Mechanical Codes, Plumbing Codes, Electrical Codes, Building Code(s), Office of Fire Safety, testing agencies referenced; i.e. U.L., F.M., etc., and/or all other governing codes.

Add Article 3.4.4 as follows:

3.4.4 The Contractor shall be responsible for all work, equipment and materials to accommodate continuous construction. Responsibility shall include but not be limited to: temporary haul roads, temporary drives, fuel, heat, power, water, air, enclosures, blankets, straw, snow removal, etc. The Owner will not accept claims for additional costs due to site or climatic conditions.

Add Article 3.5.3 as follows:

3.5.3 The Contractor warrants that the contract has been completed in full conformity with the intent of the contract documents and has not made any substitutions of materials except as authorized in writing by the Owner and the Architect. The Contractor agrees to return to the site of the work within fourteen (14) working days of receipt of written notice from the Owner or the Architect and will furnish at contractor's expense all necessary labor and material to make proper repairs or corrections made necessary by defective materials or inferior workmanship furnished or performed under contract, including damage to adjacent materials or equipment caused by the defect, all corrective work shall be without cost to the Owner and shall be completed to the satisfaction of the Owner and Architect. Failure to take action by the contractor on warranted work shall result in notification of the bonding company by the Owner or Architect with the intent to have the defective material or inferior workmanship corrected at the contractor's expense. The warranty of work shall commence upon the substantial completion date of the project and remain in full force and effect for one (1) year from the date thereof.

Add Article 3.5.4 as follows:

3.5.4 Defective material or inferior workmanship corrected by the contractor shall be warranty for an additional year from date of acceptance by the Owner or Architect of the warranty work.

Add Article 3.6.1 as follows:

3.6.1 The Contractor submitting a bid shall include and the successful bidder shall be required to pay all taxes which are levied by Federal, State or Municipal governments upon labor, and for materials entering into the work. The Owner reserves the right to require evidence of payment of such taxes prior to final payment. The above includes taxes which are legally enacted at the time bids are received, whether or not yet effective.

Modify Article 3.7.1 as follows:

3.7.1 The Prime Contractor shall obtain and pay for the building permit and for all other permits and governmental fees, licenses and inspections necessary for the proper execution and completion of the work which are customarily secured after execution of the contract and which are legally required at the time bids are received, excluding the following trades:

- .1 The Mechanical Trades Contractor shall obtain and pay for all required mechanical permits and inspections.
- .2 The Plumbing Trades Contractor shall obtain and pay for all required plumbing permits and inspections.
- .3 The Electrical Trades Contractor shall obtain and pay for all required electrical permits and inspections.
- .4 The Site Work Contractor shall obtain and pay for all required site work permits and inspections.

Add Article 3.9.4 as follows:

3.9.4 The Contractor shall maintain a competent Project Manager and Superintendent approved by the Architect/Engineer and Owner throughout the period of construction. The Project Manager or Superintendent shall be deemed an agent of the contractor and any orders given him by the Architect/Engineer shall be binding upon the contractor. The Project Manager or Superintendent of the Contractor may not be removed from (or replaced on) the job during the period of construction without approval of the Architect/Engineer and Owner.

#### Add to Article 3.12.5 as follows:

3.12.5 The Contractor shall mark corrections, notations, etc., and note his approval on each copy of shop drawings before they are submitted to the Architect. Shop drawings which, in the opinion of the Architect have not been fully checked by the Contractor will not be reviewed by the Architect. The shop drawings will be returned for proper checking by the Contractor. No extension of the contract completion date will be allowed because of such action by the Architect.

Add Article 3.13.1 as follows:

3.13.1 The Contractor shall coordinate with the Owner all arrangements necessary to conduct construction operations, with a minimum of interference to the Owner's operations. Clean-up of areas not within the construction limits shall be daily and complete, and any damage to these areas caused by construction operations shall be repaired to original condition immediately.

Add Article 3.13.2 as follows:

3.13.2 The Contractor shall not disrupt any of the existing utility services without prior approval. The Contractor shall obtain permission to do so from the Owner through the Architect. Requests for permission to disrupt any utility shall be submitted well in advance of the need in order to not delay the work. The refusal by the Owner of such a request which is submitted on short notice, will not be accepted as a basis for time extension.

#### ARTICLE 4 – ARCHITECT/ENGINEER

Add Article 4.2.7.1 as follows:

4.2.7.1 The Architect/Engineer shall make all interpretations concerning the contract documents during bidding and construction phases of the project.

ARTICLE 7 - CHANGES IN THE WORK

Add Article 7.1.4 as follows:

7.1.4 If the Architect/Engineer or Owner needs or wishes to change the scope or character of the work, a bulletin may be issued by the Architect. The Contractor upon receipt of the bulletin shall within ten (10) days, submit to the Architect a completely itemized lump sum quotation in two (2) copies, indicating the cost or credit to the Owner resulting from the change in the work.

Add Article 7.1.5 as follows:

7.1.5 Extra compensation will not be authorized for work which, though not specifically detailed or specified, is reasonably inferable to satisfy the design intent and/or obviously necessary to maintain the quality of construction and finish established by the drawings and specifications. The contractor is expected to examine the drawings, specifications and site of the work carefully before submitting a proposal and to obtain from the Architect in writing, any additional information which would affect its bid.

#### Add Article 7.3.3.1.1 as follows:

7.3.3.1.1 By mutual acceptance of a lump sum properly itemized bulletin quotation indicating; quantities, unit costs, and total costs of materials including applicable sales and use taxes and delivery charges; hours of labor, hourly rates and total labor costs, including direct and indirect payroll taxes and insurance based upon direct cost of labor; copies of detailed subcontractor's quotations; fee as stated in the proposal and the contract, which shall include all costs for on-site superintendence, general supervision, other direct and indirect costs or charges of any nature, overhead and profit; this shall apply to subcontractors as well as the contractor. Charges for direct and indirect taxes on labor, insurance and other payroll loadings, sales and use taxes, premium time (overtime) costs shall be computed separately and shall not be subject to the percentage fee. This shall apply to subcontractors as well as the contractor. Should the change result in both work being added and work being omitted, the applicable fee shall be computed on the net costs of the change even though the change results in different trades being employed.

ARTICLE 8 - TIME

Modify Article 8.1.2 as follows:

8.1.2 The date of commencement of the work shall be the date of the Owner/Contractor Agreement.

Add Article 8.1.5 as follows:

8.1.5 The total project shall be substantially complete and ready for use by the Owner as follows:

<u>Commence</u> Board Award – April 24, 2023 <u>Substantial Completion</u> As Specified by Contractor's Bid

#### ARTICLE 9 - PAYMENTS AND COMPLETION

Modify Article 9.3.1 as follows:

9.3.1 At least ten (10) days before the date for each progress payment established in the Owner/Contractor Agreement, the Contractor shall submit to the Architect an itemized application for payment utilizing AIA Document G702 & Continuation Sheet G703, "Application and Certificate for Payment"; notarized and supported by such data substantiating the contractor's right to payment as the Owner or the Architect may require, reflecting retainage which shall be ten (10%) percent through substantial completion of the entire project. Upon reaching substantial completion, the Architect shall determine such retainages as may be required to finish incomplete work and unsettled claims. In addition,

each Application for Payment shall be accompanied by the following: all in a form and substance satisfactory to the Owner and in compliance with applicable statutes set forth by the State in which the work is being done.

- .1 A current Sworn Statement from the Contractor setting forth all subcontractors and materialmen with whom the Contractor has subcontracted, the amount of each subcontract, the amount requested for any subcontractor or materialman in the application for payment and the amount to be paid to the Contractor from such progress payment, together with a current duly executed waiver of construction, mechanics' and materialmen's liens from the Contractor establishing receipt of payment or satisfaction of the payment requested by the Contractor in the current Application for Payment;
- .2 Commencing with the second (2nd) Application for Payment submitted by the Contractor, duly executed so-called "after the fact" waivers of construction, mechanics' and materialmen's liens from all subcontractors, materialmen and, when appropriate from lower tier subcontractors, establishing receipt of payment or satisfaction of payment of all amounts requested on behalf of such entities and disbursed prior to submittal by the Contractor of the current Application for Payment, plus sworn statements from all subcontractors, materialmen and, where appropriate from lower tier subcontractors, covering all amounts described in previous applications for payment.
- .3 Final waivers of lien must be submitted for all contracts, subcontracts and material for final payments.

Add Article 9.3.1.3 as follows:

9.3.1.3 When the construction contract has been completed to fifty (50%) percent, the Architect and Owner may, upon evaluation reduce retainage. The amount of reduction shall be determined by the Architect/Engineer and will be based upon satisfactory performance relative to percentage of completion and quality of the work in place as well as other determining factors. If in the opinion of the Architect/Engineer and Owner, the Contractor is not performing after reductions have been initiated, the Architect/Engineer reserves the authority to reinstate the ten (10%) percent retainage.

Add Article 9.10.6 as follows:

9.10.6 Upon completion of the project, or portions thereof, the Contractor shall transfer to the Owner all applicable items accumulated throughout construction. Satisfaction of the following requirements shall be considered a part of payment requests. These include but are not limited to the following items:

- .1 Service manuals, installation instructions, special tools and specialties.
- .2 Spare parts ordered as part of this contract.
- .3 Submittal of the Contractors' one year guarantee.
- .4 Submittal of manufacturer's guarantees, bonds, and letters of coverage extending beyond the time limitations of the Contractor's guarantee.

- .5 Delivery of any salvaged or borrowed materials or equipment to the Owner.
- .6 Record documents of completed facilities. See separate section for specific requirements.
- .7 All keys to all doors, gates and equipment.

Add Article 9.11 as follows:

9.11 Liquidated Damages: (NOT USED)

9.11.1 If the Contractor shall neglect, fail, or refuse to complete the work within the timeframes indicated, or any proper extension thereof granted by the Owner, then the Contractor does hereby agree, as a part consideration for the awarding of this contract, to pay to the Owner the sum of **Five Hundred Dollars** (\$500.00) per day, not as a penalty but as liquidated damages for such breach of contract, for each and every calendar day that the Contractor shall be in default after the time stipulated for completing the work or portions of the work as stipulated in Article 8.1.5 of these Supplementary Conditions.

9.11.2 The said amount is fixed and agreed upon by and between the Contractor and the Owner because of the impracticability and extreme difficulty of fixing and ascertaining the actual damages the Owner would in such event sustain, and said amount shall be retained from time to time by Owner from current periodical estimates.

9.11.3 It is further agreed that the Contractor shall not be charged with liquidated damages or any excess cost when the delay in completion of the work is due:

- -.1 To any preference, priority or allocation order duly issued by the Government.
- .2 To unforeseeable cause beyond the control and without the fault or negligence of the Contractor, including but not restricted to, Acts of God, or of the public enemy, acts of the Owner, acts of another contractor in the performance of a contract with the Owner, fires, floods, epidemics, quarantine restrictions, strikes, freight embargoes, and unusually severe weather; and
- -.3 To any delays of subcontractors or suppliers occasioned by any of the causes specified in subsections (.1) and (.2) of this article.

9.11.4 Provided further, that the Contractor shall, within ten (10) days from the beginning of such delay, unless the Owner shall grant a further period of time prior to the date of final settlement of the contract, notify the Owner, in writing, of the causes of the delay. The Owner shall ascertain the facts and extent of the delay and notify the Contractor within a reasonable time of its decision in the matter.

#### ARTICLE 10 - PROTECTION OF PERSONS AND PROPERTY

Add Article 10.5 as follows:

10.5 General construction industry safety rules and regulations for the state in which the work is being prosecuted and the U.S. Department of Labor, Safety and Health Regulations for Construction, known as the
U.S. Construction Safety Act shall be adhered to by all Contractors and Subcontractors on this project. Certification of this coverage shall be submitted along with that required in Article 11.

## ARTICLE 11 - INSURANCE

Add to Article 11.1.1 as follows:

11.1.1 The Contractor shall purchase and maintain such insurance from a company or companies licensed to do business in the state in which the project is located and will protect him from claims set forth below which may arise out of or result from the Contractor's operations under the Contract, whether such operations be by himself or by any subcontractor or by anyone directly or indirectly employed by any of them, or by anyone for whose acts any of them may be liable. Liability insurance shall include all major divisions of coverage on a comprehensive basis including; premises operations (including X, C, U); independent contractor's protective, products and completed operations, contractual liability; owned, non-owned, and hired motor vehicles and broad form property damage including completed operations.

Modify Article 11.1.2 as follows:

11.1.2 The insurance required by subparagraph 11.1.1 shall be written for not less than any limits of liability specified in the Contract Documents, or required by law, whichever is greater, provide minimum limits as follows:

- a. Worker's Compensation:
  - (1) State-statutory.
  - (2) Applicable federal statutory.
  - (3) Employer's liability \$500,000.
  - (4) Benefits required by labor union contracts.
- b. Contractor's liability insurance shall be comprehensive general liability including contractual liability.
  - (1) Bodily Injury:\$1,000,000 Each occurrence.\$2,000,000 Aggregate.
  - Property damage (including completed operations broad form):
     \$1,000,000 Each occurrence.
     \$2,000,000 Aggregate.
  - (3) Broad form completed operations and product liability insurance shall be maintained until final payment is made and Contractor shall continue to provide evidence of such coverage to Owner on an annual basis during the coverage period. (Name: Bangor Township Schools and William A. Kibbe & Associates, Inc. & Consultants as an additional insured).
  - (4) Property damage liability insurance shall include coverage for X (Explosion), C (Collapse), and U (Underground).
  - (5) Contractual Liability (Hold Harmless Coverage):

(a)	Bodily Injury:	\$1,000,000 Each Occurrence.
(b)	Property Damage:	\$1,000,000 Each Occurrence.
		\$2,000,000 Aggregate.

(6) Personal Injury with Employment Exclusion Deleted:
 \$1,000,000 Each Person Aggregate.
 \$2,000,000 General Aggregate.

c. Comprehensive automotive liability (owned, non-owned, hired):

(1)	Bodily injury:	\$1,000,000	Each person.
		\$1,000,000	Each occurrence.
(2)	Property damage:	\$1,000,000	Each occurrence.

- d. An umbrella policy extending all limits to a minimum of an additional \$2,000,000.
  - e. This insurance shall not be intended to cover any responsibility for damages as included herein under heading of "Damages", Articles 7.4 and 8.3.

Add Article 11.1.5 as follows:

11.1.5 The Contractor shall furnish to the Owner and the Architect/Engineer, insurance policies protecting both the Owner and the Architect/Engineer from liability for damages as provided for under the Contractor's liability insurance. Liability limits shall be the same as for the Contractor's liability insurance.

Add to Article 11.2.4 as follows:

11.2.4 The Owner shall secure and maintain property insurance, all risk, completed value, in the amount equal to the contract sum for the work.

Modify Article 11.3.1 as follows:

11.3.1 The Owner and Contractor waive all rights against: (1) each other and the subcontractors, subsubcontractors, agents, and employees each of the other, and (2) the Architect/Engineer, his consultants, and separate contractors, if any, and any of their subcontractors, sub-subcontractors, agents and employees for damages caused by fire or other perils to the extent covered by insurance obtained pursuant to this policy or any other property insurance applicable to the work, except such rights as they may have to the proceeds of such insurance held by the Owner as trustee. The foregoing waiver afforded the Architect, his agents and employees shall not extend to the liability imposed. The Owner or the Contractor, as appropriate, shall require of the Architect/Engineer, separate contractors, subcontractors, subsubcontractors, by appropriate agreements written where legally required for validity, similar waivers each in favor of all parties enumerated in this agreement.

Add Article 11.4.1 as follows:

11.4.1 Performance Bond and Labor and Material Payment Bond shall be from a security company duly approved by the U.S. Department of Treasury and listed in the U.S.T. Circular No. 570, latest edition. Surety company shall be rated A.M. Best as 'B' or better and licensed to operate in the State of Michigan. The total cost of the bonds or any additional costs as may be required by the Prime Contractor's Surety Company shall be borne by the Prime Contractor and included in the Prime Contractor's bid.

Add Article 15 as follows:

ARTICLE 16 - EQUAL OPPORTUNITY

16.1 The Contractor shall maintain policies of employment as follows:

16.1.1 The Contractor and all subcontractors shall not discriminate against any employee or applicant for employment because of race, religion, color, sex, national origin or age. The Contractor shall take affirmative action to insure that applicants are employed, and that employees are treated during employment without regard to their race, religion, color, sex, national origin or age. Such action shall include, but not be limited to the following: employment, upgrading, demotion or transfer, recruitment or recruitment advertising, layoff or termination, rates of pay or other forms of compensation, and selection for training, including apprenticeship. The Contractor agrees to post in conspicuous places, available to employees and applicants for employment, notices setting forth the policies of non-discrimination.

15.1.2 The Contractor and all subcontractors shall, in all solicitations or advertisements for employees placed by them or on their behalf, state that all qualified applicants will receive consideration for employment without regard to race, religion, color, sex, national origin or age."

END OF SECTION 008000

(Revised 06/09)

# EQUAL EMPLOYMENT OPPORTUNITY SECTION

## EQUAL EMPLOYMENT OPPORTUNITY

All contractors, subcontractors and/or vendors doing business with the Bangor Township School District shall comply with all applicable laws relative to equal employment opportunity and shall not discriminate against any employee or applicant for employment because of race, color, religion, creed, sex, height, weight, marital status, or national origin. It is expected that the contractor, subcontractor, and or vendor will carry out that pan of this contract pertaining to equal employment opportunity with the same amount of thought and action as he will in any other part of the contract.

- 1. The contractor or his subcontractor under this contract assumes the obligation to take whatever affirmative action is necessary to assure equal employment opportunity in all aspects of employment irrespective of race, color, religion, creed, sex, height, weight, marital status, or national origin.
  - a. To do this a contractor must have a program of affirmative action. The program must be tailored to the particular set of circumstances which apply to the contractor, the locality, the labor market, and the project or projects in which the contractor is involved.
  - b. The contractor is required. within fifteen (15) days of receiving notice of acceptance of his proposal to submit his affirmative action program to the Superintendent for the Bangor Township School District, for review and approval. The contractor will be required to schedule a meeting with the Superintendent, who will explain and outline the requirements of the contractors affirmative action plan. Upon receipt of the contractors affirmative action plan. the Superintendent will then have fifteen (15) days to review the material and certify approval.
  - c. If the affirmative action plan submitted by the contractor is disapproved by the Superintendent because of noncompliance all attempts will be made through negotiations with the contractor. to effectuate compliance and if compliance is not accomplished within the fifteen (15) day period of review, the contractors deposit shall be returned. and the School District shall award a contract to the next lowest bidder.

## EQUAL EMPLOYMENT OPPORTUNITY

- d. If the contractor does not submit his affirmative action plan within fifteen (15) days of the award, he shall be considered to have abandoned all his rights and interest in the award and his deposit shall be forfeited and shall be retained by the owner, as liquidated damages and not as a penalty.
- e. A pre-construction conference will be held on this project. The Bangor Township School District shall initiate the time and place of subject conference.
- f. The contractor may be required to submit copies of his weekly payrolls throughout the duration of the project to the School District Equal Employment Opportunity Officer.
- g. The prime contractor is also responsible to see that all of his sub-contractors adhere to all EEO and affirmative action regulations.

## SUBMISSION REQUIREMENTS OF ALL BIDDERS

All bidders <u>must</u> submit the following with their proposals:

1. The enclosed Equal Employment Contract Compliance Report (part of bid document) must be filled out in its entirety.

<u>Any questions or assistance needed concerning the EEO Compliance Report may be</u> obtained by contacting the Bangor Township School District Superintendent at 1-989-<u>684-8121</u>

## SPECIAL NOTE TO BIDDERS

All bidders who do not comply with the above submission requirements jeopardize having their bids accepted.

-2-

### **DEFINITION OF TERMS**

- \* "Contractors" is defined to include all contractors, vendors, subcontractors, and suppliers providing goods or services directly or indirectly for the School District or one who has provided same during immediate two years preceding reporting date or who expects to be a contractor, bidder, or potential bidder during the two years immediately following the reporting date.
  - 1. Construction contractors are defined as contractors who are engaged in the erection, demolition, or alteration of physical properties, including but not limited to buildings, bridges, roads, fences, and parking lots.
  - 2. Non-construction contractors are defined as those who are principally engaged in the supplying of goods or services other than construction.
- \*\* The "Bangor Township School District" or "School District" is defined to include all departments or other contracting agencies for the Bangor Township School District or any of its political or civil subdivisions.
- \*\*\* Compliance reports are to be filed with the Bangor Township School District Superintendent as follows:
  - 1. Construction contractors are to complete (Sections A & B) reflecting payrolls of the month or week in which bid proposal is submitted.
  - 2. Non-construction contractors are to complete (Section A <u>Only</u>) reflecting most recent payrolls and submit with bid proposal. This report must be submitted annually, if the contract extends beyond one year or if it is on a renewal basis.
  - 3. <u>Contractors both construction & non construction who do not fill out this contract</u> <u>compliance form in its entirety jeopardize having their bids accepted.</u>

Note: Exceptions

- 1. Contracts for goods and services in an amount of less than \$10,000.
- 2. Contractors who always employ less than three (3) employees.

Note: This report replaces previous reports filed within 30 days of award of contracts. For assistance in filing report, please contact the Superintendent of the Bangor Township School District. Telephone (989) <u>684-8121</u>.

## BANGOR TOWNSHIP SCHOOL DISTRICT EQUAL EMPLOYMENT OPPORTUNITY <u>COMPLIANCE REPORT AND PLAN OF ACTION FOR</u> <u>SCHOOL DISTRICT CONTRACTORS</u>

## SECTION A FOR ALL CONTRACTORS

## PART I IDENTIFICATION

1. a. NAME AND ADDRESS OF CONTRACTOR'S	b. TELEPHONE NUMBER
PRINCIPAL OFFICE (Include County)	

c. NAME AND ADDRESS OF PARENT COMPANY IF AN AFFILIATED CORPORATION

2. a.	COMPANY-WIDE REPORTING STATUS: CONTRACTOR VENDOR SUBCONTRACTOR SUPPLIER	b. CC DI	b. CONTRACTING AGENCY(S) OR CONTRACTOR(S) WITH WHOM SCHOOL DISTRICT BUSINESS IS DONE
C. (	CONTRACT NO. (S) d. EFFEC	IVE	E DATE(S) e. COMPLETION DATE(S)
3.	a. DATE OF MOST RECENT REPORT SUBMITTED	b.	b. GIVE ANY CHANGE OF NAME OR ADDRESS SINCE MOST RECENT REPORT

4. MAJOR ACTIVITY OF CONTRACTOR

## PART II - EMPLOYMENT STATISTICS

### 5. WORK FORCE BREAKDOWN

		MAL	E EMPLO. Min	OYEES orities			FEM	ALE EMP N	LOYEES linorities				
JOB CATEGORIES	Total Males	Black	Asian	Amer- Indian	Hispanic	Total Females	Black	Asian	Amer- Indian	Hispanic	TOTAL AL	L EMPLOYEES	TOTAL MINORITI
OFFICIALS and MANAGERS													
PROFESSIONALS													
TECHNICIANS													
SALES WORKERS													
OFFICE and CLERICAL													
CRAFTSMEN (Skilled)													
Operatives (Semiskilled)													
LABORERS (Unskilled)													
SERVICE WORKERS													
TOTAL													
EMPLOYMENT ONE YEAR AGO (if Available)													
APPRENTICES (also include in appropriate categories above the total line)													
6. THE ABOVE	FIGUF	RES AR	RE										
UNUSUALLY H	IIGH 🗌	]			/	AVERAG	E				BELO	N NORMAL 🗌	
7 ARE ALL EM	PLOYE	ES LIS		NO.5	ABOVE	LOCATE	D IN M	IICHIG	AN?	Y	ES 🗌	NO 🗌	
8 DATE OF PA	YROLL	. USED	)										

9 DESCRIBE BRIEFLY HOW EMPLOYMENT STATISTICS WERE OBTAINED (e.g., visual checks, available employment records, etc.)

PART III SUBCONTRACTORS AND	<b>SUPPLIERS</b>
10. DOES THE COMPANY AGREE TO NOTIFY ALL SUBCONTRACTORS, VENDORS, OR SUPPLIERS OF THEIR RESPONSIBILITIES TO FILE COMPLIANCE REPORTS?	YES 🗌
11. DOES THE COMPANY AGREE TO USE ON SCHOOL DISTRICT CONTRACTS ONLY THOSE SUBCONTRACTORS, VENDORS, OR SUPPLIERS WHO ARE REPORTED TO THE COMPANY TO BE IN COMPLIANCE OR AWARDABLE BY THE CONTRACT COMPLIANCE SECTION OF THE BANGOR TOWNSHIP SCHOOL DISTRICT EQUAL OPPORTUNITY OFFICE?	YES 🗌

#### EQUAL EMPLOYMENT OPPORTUNITY

## BANGOR TOWNSHIP SCHOOL DISTRICT EQUAL EMPLOYMENT OPPORTUNITY COMPLIANCE REPORT AND PLAN OF ACTION FOR SCHOOL DISTRICT **CONTRACTORS**

## SECTION B FOR CONSTRUCTION CONTRACTORS (To Be Filed With Section A)

1. NAME AND ADDRESS OF CONTRACTOR'S PRINCIPAL OFFICE (Include County)

## 2. ANALYSIS OF TRADES AND COMMITMENT TO INCREASE.

	PRESENT WORKFORCE	NORMAL WORK FORCE	Reasonable Representation based on normal work force		C	ammite	aant ta	Inorodo		ofMin	ority Em	nlovmo	nt
CRAFT OR TRADE (Local Numbers)	Total/Minorities	Total/Minorities	Combine foremen, journeymen and apprentices	Differential	1st 6 mo.	2nd 6 mo.	3rd 6 mo.	4th 6 mo.	5th 6 mo.	6th 6 mo.	7th 6 mo.	8th 6 mo.	9th 6 mo
Foremen Journeymen Apprentices Foremen	_	—											
Apprentices Foremen	—	—											
Journeymen Apprentices Foremen	—												
Journeymen Apprentices Foremen													
Journeymen Apprentices Foremen													
Journeymen Apprentices Foremen	—	—											
Apprentices Foremen													
Apprentices Foremen													
Apprentices Foremen Journeymen	_	—											
Appleinices													

3 IF THE COMPANY EMPLOYS MINORITIES IN THE FOLLOWING TRADES, PLEASE FILL OUT NO 5 ON THE FOLLOWING PAGE. ASBESTOS WORKER, BOILERMAKER, BRICKMASON, CARPENTER, ELECTRICIAN, ELEVATOR CONSTRUCTOR, OPERATING ENGINEER. GLAZIER. IRON WORKER, LATHER, PAINTER, PIPEFITTER, PLASTERER, PLUMBER RIGGER. REINFORCED IRONWORKER, ROOFER, SHEET METAL WORKER, SPRINKLER FITTER, TILE TERRAZZO AND MARBLE SETTER.

4 a. DATE

b. TYPE OR PRINT NAME, TITLE, AND c. SIGNATURE OF AUTHORIZED ADDRESS OF AUTHORIZED REPRESENTATIVES

REPRRESENTATIVE

## PART IV. PLAN OF ACTION

YES

12. DOES THE COMPANY HAVE A WRITTEN AFFIRMATIVE ACTION PLAN TO ACHIEVE REASONABLY REPRESENTATIVE INTEGRATION OF ITS WORK FORCE IN EACH JOB CATEGORY AND IN EACH TRADE?

13. THE FOLLOWING CHART, WHEN COMPLETED BY THE COMPANY, COMPRISES AN ANALYSIS OF THE WORK FORCE BY JOB CATEGORY AND A COMMITMENT TO INCREASE MINORITY REPRESENTATION WHERE NEEDED IN ORDER TO ACHIEVE REASONABLY REPRESENTATIVE INTEGRATION (Construction contractors must also fill out Section B, which becomes a part of this Plan of Action):

			Reasonable			Cor	nmitm Levels Emp	ent to of Mi oloym	increa nority ent	ase
JOBCATEGORIES	Total All Employees	Total Minorities	Representation ( Per Cent)	Differ	ential	1st yr.	2nd yr.	3rd yr.	4th yr.	5th yr.
OFFICIALS AND MANAGERS										
PROFESSIONALS										
TECHNICIANS										
SALES WORKERS										
OFFICE AND CLERICAL										
CRAFTSMEN (Skilled)										
OPERATIVES (Semiskilled)										
LABORERS (Unskilled)										
SERVICE WORKERS										
TOTAL										
14. a. DATE		b. TYPE OR I ADDRESS O REPRESENT	PRINT NAME, TITLE, F AUTHORIZED ATIVES	AND	c. SIGN REPRE	ATURI SENT/	E OF AU ATIVE	JTHOR	RIZED	

## LIST OF MINORITY TRADESMEN AND MINORITY APPRENTICES.

		SOCIAL SECURITY		JOURNEYMAN OR	
NAME	RACE	NUMBER	TRADE	APPRENTICE	DATE HIRED

#### SECTION 010100 - SUMMARY OF WORK

- 1.1 GENERAL SUMMARY
  - A. Comply with procedures described in this section relative to construction of the project, and Owner's use of the site.
  - B. Related Documents:
    - 1. Documents affecting work of this section include, but are not necessarily limited to, General Conditions, Supplementary Conditions, and sections in Division 1 of these specifications.
- 1.2 DESCRIPTION OF EXISTING BUILDINGS AND PROPOSED IMPROVEMENTS:
  - A. JOHN GLENN HIGH SCHOOL
    - The existing HVAC system consists of hot water boilers, water cooled chillers, cooling tower, air handlers, packaged rooftop units, classroom unit ventilators, fin tube radiation, and cabinet unit heaters. The source of heating is existing hot water boilers, and the source of cooling is existing chillers located in the mechanical room and cooling tower on grade. One of the existing chillers and the cooling tower has reached its life expectancy and needs to be replaced. The unit ventilators and cabinet unit heaters are reaching their life expectancy and need to be replaced. The existing pool equipment room has no current ventilation and needs to be addressed. The rooftop unit for the pool will not condition the space as required and needs to be replaced. The existing rooftop units are 17-18 years old and are reaching their life expectancy and need to be evaluated.
    - 2. The proposed upgrades will include replacement of one chiller and cooling tower, the rooftop unit for the pool, all classroom unit ventilators, all entry cabinet unit heaters, and adding ventilation to the pool equipment room.
  - B. CHRISTA MCAULIFFE MIDDLE SCHOOL
    - The existing HVAC system consists of hot water boilers, air cooled liquid chiller, air handlers, packaged rooftop units, classroom unit ventilators, and cabinet unit heaters. The source of heating is existing hot water boilers, and the source of cooling is existing chiller located in the mechanical room and chiller on grade. The existing chiller has reached its life expectancy and needs to be replaced. The unit ventilators and cabinet unit heaters are reaching their life expectancy and need to be replaced. The existing rooftop units are 17-18 years old and are reaching their life expectancy and need to be evaluated.

Bangor Township Schools ME Upgrades

- 2. The proposed upgrades will include replacement of the chiller, all classroom unit ventilators, and all entry cabinet unit heaters.
- 3. Alternate #M-1: Remove & Replace (7) RTU's.

## C. WEST ELEMENTARY SCHOOL

- The existing HVAC system consists of hot water boilers, air cooled liquid chiller, packaged rooftop units, classroom unit ventilators, blower coil units, fin tube radiation, split systems, and cabinet unit heaters. The source of heating is existing hot water boilers, and the source of cooling is existing chiller located in the mechanical room and chiller on grade. The existing boilers have reached their life expectancy and need to be replaced. The existing Lab has no current ventilation or exhaust required for the space and needs to be added. The dome area has no ventilation at this time and needs to be addressed. The split system in the IT Room needs to be replaced.
- 2. The proposed upgrades will include replacement of the boilers, addition of ventilation and exhaust to the Lab, adding outside air to the dome area, and replace the split system for the IT Room.

## D. LINCOLN ELEMENTARY SCHOOL

- The existing HVAC system consists of hot water boilers, air cooled liquid chiller, packaged rooftop units, classroom unit ventilators, fin tube radiation, split systems, blower coil unit, and cabinet unit heaters. The source of heating is existing hot water boilers, and the source of cooling is existing chiller located in the mechanical room and chiller on grade. The existing boilers have reached their life expectancy and need to be replaced. The dome area has no ventilation at this time and needs to be addressed. The split system in the IT Room needs to be replaced. The existing rooftop units are reaching their life expectancy and need to be evaluated.
- 2. The proposed upgrades will include replacement of the boilers, adding outside air to the dome area, and replace the split system for the IT Room.
- 3. Alternate #L-1: Remove and Replace Multi-Purpose Room RTU.

## E. CENTRAL ELEMENTARY SCHOOL

1. The existing HVAC system consists of hot water boilers, air cooled liquid chiller, air handling units, classroom unit ventilators, fin tube radiation, split systems, blower coil unit, and cabinet unit heaters. The source of heating is existing hot water boilers, and the source of cooling is existing chiller located in the mechanical room and chiller on grade.

#### SUMMARY OF WORK

The existing boilers have reached their life expectancy and need to be replaced. The kitchen has no make-up air at this time and needs to be addressed. The cabinet unit heaters are reaching their life expectancy and need to be replaced.

- 2. The proposed upgrades will include replacement of the boilers, adding make-up air to the kitchen, and replace the cabinet unit heaters in the entries and restrooms.
- F. NORTH PRE-SCHOOL
  - 1. The proposed upgrades will include adding heat to the kitchen and restrooms, replace split system in Speech.
- G. EDISON ADMINISTRATION BUILDING
  - 1. The proposed upgrades will include replacing the unit ventilators.
- H. ELECTRICAL WORK
  - 1. The electrical design will include extending power to all new HVAC equipment.
  - 2. See Alternate #M-1 & #L-1 for associated electrical work.
- 1.3 OWNER OCCUPANCY

Students may be on campus during the project throughout the summer. Provide barriers around construction areas and all the areas being worked on. This will need to be coordinated with the owner & awarded contractor. Maintain circulation to all required not being used for construction access.

1.4 PRE-ORDERED PRODUCTS (NOT USED)

END OF SECTION 010100

### SUMMARY OF WORK

#### SECTION 010190 - CONTRACT CONSIDERATIONS

PART 1 - GENERAL

- 1.0 RELATED DOCUMENTS
  - A. Attention is directed to Division 0, Bidding and Contract Requirements to Division 1, General Requirements, which are hereby made a part of this specification.
- 1.1 CASH ALLOWANCES
  - A. Construction Testing: (Not Used)
  - B. Construction Staking: (Not Used)
- 1.2 CONTINGENCY ALLOWANCE (NOT USED).
- 1.3 SPECIAL INSPECTIONS AND TESTING ALLOWANCES. (Paid for by the Owner, if required by AHJ)
- 1.4 SCHEDULE OF VALUES
  - A. Within 24 hours after opening of the proposals, the successful bidder shall submit in duplicate to the Architect for his inspection a complete bid breakdown. The schedule of values shall be on AIA Form G703. (Contractor's standard form or electronic media printout will be considered).
  - B. In addition, within 48 hours after the opening of bids, the successful bidder shall submit to the Architect, in duplicate, for his inspection and approval, a list of all subcontractors and major suppliers proposed to be employed on this project.
- 1.5 APPLICATIONS FOR PAYMENT
  - A. Submit three (3) copies of each application on AIA Form G702.
  - B. Content and Format: Utilize Schedule of Values for listing items in Application for Payment.
- 1.6 CHANGE PROCEDURES
  - A. Change Order Forms: Change orders will be processed on forms provided by the Architect.

### 1.7 ALTERNATES

- A. Alternates quoted on Bid Forms will be reviewed and accepted or rejected at the Owner's option.
- B. Coordinate related Work and modify surrounding Work as required.
- C. Schedule of Alternates: (See Bid Form, Section 003000).

### END OF SECTION 010190

### SECTION 010270 - APPLICATIONS FOR PAYMENT

#### 1.1 GENERAL SUMMARY

- A. Comply with procedures described in this Section when applying for progress payment and final payment under the Contract.
- B. Related Work:
  - 1. Documents affecting work of this section include, but are not necessarily limited to, General Conditions, Supplementary Conditions, and sections in Division 1 of these specifications.
  - 2. The Contract Sum and the schedule for payments are described in the Form of Agreement.
  - 3. Payments upon Substantial Completion and Completion of the Work are described in the General Conditions and in Section 001700 of these specifications.
  - 4. The Architect/Engineer's approval of applications for progress payment and final payment may be contingent upon the Architect/Engineer's approval of status of Project Record Documents as described in Section 001700 of these Specifications.

### 1.2 QUALITY ASSURANCE

- A. Prior to start of construction, secure the Architect/Engineer's approval of the schedule of values required to be submitted under Paragraph 9.2 of the General Conditions, and further described in Section 000100 of these Specifications.
- B. During progress of the Work, modify the schedule of values as approved by the Architect to reflect changes in the Contract Sum due to Change Orders or other modifications of the Contract.
- C. Base requests for payment on the approved schedule of values.

### 1.3 PROCEDURES

- A. Informal submittal: Unless otherwise directed by the Architect/Engineer:
  - 1. Make an informal submittal of request for payment by filling in, with erasable pencil or on word processor, pertinent portions of AIA Document G702, "Application and Certificate for Payment," plus continuation sheet or sheets.
  - 2. Make this preliminary submittal to the Architect at least ten days prior to the end of the month or at the last regular job meeting of the month.
  - 3. Revise the informal submittal of request for payment as agreed at the job meeting, initialing all copies.
  - 4. Submit a request/application for payment each calendar month.

- 5. Waivers of Lien: Do not submit copies of partial or full waivers of lien with informal submittal.
- B. Formal submittal: Unless otherwise directed by the Project Manager:
  - 1. Make formal submittal of request for payment by filling in the agreed data, by typewriter or neat lettering in ink, on AIA Document G702, "Application and Certificate for Payment," plus continuation sheet or sheets.
  - 2. Sign and notarize the Application and Certificate for Payment.
  - 3. Submit the original and four copies of the Application and Certificate for Payment, including copies of the continuation sheet or sheets and waivers to the Project Manager.
  - 4. Waivers of Lien: Submit partial waivers on each item for amount requested, prior to deduction for retainage, on each item. When an application shows completion of an item, submit final or full waivers.
  - 5. Submit sworn statement with each request for payment.
  - 6. The Architect/Engineer will compare the formal submittal with the approved informal submittal and, when approved, will sign the Application and Certificate for Payment, will make required copies, and will distribute:
    - a. One copy to Contractor;
    - b. Two copies to Owner;
    - c. One copy to Project Manager's file.
  - 7. The Owner, upon approval, will disburse directly to the Contractor.

### END OF SECTION 010270

#### SECTION 010280 - CHANGE ORDER PROCEDURE

- 1.1 GENERAL SUMMARY
  - A. Make such changes in the Work, in the Contract Sum, in the Contract Time for Completion, or any combination thereof, as are described in written Change Orders signed by the Owner and the Architect/Engineer and issued after execution of the Contract, in accordance with the provisions of this Section.
  - B. Related Work:
    - 1. Documents affecting work of this section include, but are not necessarily limited to, General Conditions, Supplementary Conditions, and sections in Division 1 of these specifications.
    - 2. Changes in the Work are described further in the General Conditions and Supplemental Conditions.
    - 3. Architect/Engineer's supplemental instructions:
      - a. From time to time during progress of the Work, the Architect may issue supplemental instructions which interpret the Contract Documents or order minor changes in the Work without change in Contract Sum or Contract Time.
      - b. Should the Contractor consider that a change in Contract Sum or Contract Time is required, he shall submit an itemized proposal to the Architect immediately and before proceeding with the Work. If the proposal is found to be satisfactory and in proper order, the supplemental instructions in that event will be superseded by a Change Order.
    - 4. Proposal requests:
      - a. From time to time during progress of the Work, the Architect may issue a proposal request (bulletin) for an itemized quotation for changes in the Contract Sum and/or Contract Time incidental to proposed modifications to the Contract Documents.
      - b. This will not be a Change Order and will not be a direction to proceed with the changes described therein.

### 1.2 QUALITY ASSURANCE

- A. Include within the Contractor's quality assurance program such measures as are needed to assure familiarity of the Contractor's staff and employees with these procedures for processing Change Order data.
- 1.3 DELIVERY, STORAGE, AND HANDLING
  - A. Maintain a "Register of proposal requests, supplemental instructions, and Change Orders" at the job site, accurately reflecting current status of all pertinent data.
  - B. Make the Register available to the Architect for review at his request.

### 1.4 PROCESSING PROPOSAL REQUESTS

- A. Make written reply to the Architect in response to each proposal request.
  - 1. State proposed change in the Contract Sum, if any.
  - 2. State proposed change in the Contract Time of Completion, if any.
  - 3. Clearly describe other changes in the Work, if any, required by the proposed change or desirable therewith.
  - 4. Include full backup data such as subcontractor's letter of proposal or similar information.
  - 5. Submit this response in single copy.
- B. When cost or credit for the change has been agreed upon by the Owner and the Contractor, or the Owner has directed that cost or credit be determined in accordance with provisions of the General Conditions, the Architect/Engineer will issue a Change Order to the Contractor.
- 1.5 PROCESSING CHANGE ORDERS
  - A. Change Orders will be numbered in sequence and dated.
    - 1. The Change Order will describe the change(s), will refer to the proposal requests or supplemental instructions involved, and will be signed by the Owner and the Architect/Engineer.
    - 2. The Architect/Engineer will issue three copies of each Change Order to the Owner.
      - a. The Owner will promptly sign all three copies and return two copies to the Architect/Engineer.
      - b. The Architect/Engineer will retain one signed copy in his file, will forward one signed copy to the Contractor.

END OF SECTION 010280

### SECTION 010390 - COORDINATION AND MEETINGS

#### 1.1 GENERAL

A. Attention is directed to Division 0, Bidding and Contract Requirements, and to Division 1, General Requirements, which are hereby made a part of this specification.

#### 1.2 COORDINATION

- A. Coordinate scheduling, submittals, and Work of the various Sections of specifications to assure efficient and orderly sequence of installation of interdependent construction elements.
- B. Verify utility requirement characteristics of operating equipment are compatible with building utilities.
- C. Coordinate space requirements and installation of special equipment, and mechanical and electrical work which are indicated diagrammatically on Drawings. Follow routing shown for pipes, ducts, and conduit, as closely as practicable.
- D. In finished areas, conceal pipes, ducts, and wiring within the construction.

### 1.3 CUTTING AND PATCHING

- A. Employ a skilled and experienced mechanic to perform cutting and patching new or existing Work; restore Work with new Products.
- B. Submit written request in advance of cutting or altering structural or building enclosure elements.
- C. Fit Work tight to adjacent elements. Maintain integrity of wall, ceiling, or floor construction; completely seal voids.
- D. Refinish surfaces to match adjacent finishes.

### 1.4 CONFERENCES

- A. Prime Contractor will schedule a pre-construction conference after Notice of Award has been sent to the Prime Contractor.
- 1.5 PROGRESS MEETINGS
  - A. The Prime Contractor will schedule and administer meetings throughout progress of the Work at maximum monthly intervals.

#### END OF SECTION 010390

#### COORDINATION AND MEETINGS

#### SECTION 013400 - SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES

- 1.1 GENERAL SUMMARY
  - A. Make submittals required by the Contract Documents, and revise and resubmit as necessary to establish compliance with the specified requirements, all as described in this Section. Coordinate all submittals with the Progress Schedule and actual work progress.
  - B. Related Work:
    - 1. Documents affecting work of this Section include, but are not necessarily limited to, General Conditions, Supplementary Conditions, and Sections in Division 1 of these Specifications.
    - 2. Individual requirements for submittals also may be described in pertinent Sections of these Specifications.
  - C. Work not included:
    - 1. Non-required submittals will not be reviewed by the Architect/Engineer.

#### 1.2 SUBMITTALS

- A. Make submittals of Shop Drawings, samples, substitution requests, and other items in accordance with the provisions of this Section. Provide additional copies as may be required for Governing Authorities.
- 1.3 QUALITY ASSURANCE
  - A. Coordination of submittals:
    - 1. Prior to each submittal, carefully review and coordinate all aspects of each item being submitted.
    - 2. Verify that each item and the submittal for it conform in all respects with the specified requirements.
    - 3. By affixing the Contractor's signature to each submittal, certify that this coordination has been performed.
- 2.0 PRODUCTS

#### 2.1 SHOP DRAWINGS

- A. Scale and measurements: Make Shop Drawings accurately to a scale sufficiently large to show all pertinent aspects of the item and its method of connection to the Work.
- B. Types of prints required:
  - 1. Submit (5 total sets) of Shop Drawings in the form of original documents or (1) electronic submittal in PDF format, e-mailed to Architect.
- C. Review comments of the Architect will be shown when it is returned to the Contractor. The Contractor may make and distribute such copies as are required for his purposes.
- 2.2 MANUFACTURERS' LITERATURE

- A. Where contents of submitted literature from manufacturers includes data not pertinent to the submittal, <u>clearly show which portions of the contents are being submitted for review. If</u> <u>actual items are not identified, they will be returned without being reviewed.</u>
- B. Submit the number of copies which are required to be returned, plus two copies which will be retained by the Architect.
- C. Where the product data is required for maintenance manuals and close-out documents, submit two additional copies which will be returned. Maintain one additional copy at the project site for reference purposes.
  - 1. Do not proceed with the installation of manufactured products until a copy of related product data is in the installer's possession at the project site.

#### 2.3 SAMPLES

- A. Provide Sample or Samples identical to the precise article proposed to be provided. Identify as described under "Identification of Submittals" below. Colored scans are not acceptable.
- B. Number of Samples required:
  - 1. Submit three sets of samples; one set will be returned. Provide 3 or more samples in each set where variations in color, pattern or texture are observable; show average condition and extreme range of variations. Submit full documentation with each set. Sample submittals are for Architect/Engineer's review of color, texture, pattern and "kind"; maintain returned samples at project site for purposes of quality control comparisons.
  - 2. By pre-arrangement in specific cases, a single sample may be submitted for review and, when approved, be installed in the Work at a location agreed upon by the Architect.
- 2.4 MISCELLANEOUS SUBMITTALS
  - A. Provide copies of miscellaneous submittals as follows:
    - 1. Warranties: Submit 2 executed copies, plus additional copies as required for maintenance & close-out manuals.
    - 2. Maintenance Manuals: Submit 2 bound copies.
    - 3. Record Drawings: Submit original maintained marked-up prints (2 sets).

## 3.0 EXECUTION

## 3.1 IDENTIFICATION OF SUBMITTALS

- A. Consecutively number all submittals.
  - 1. When material is resubmitted for any reason, transmit under a new letter of transmittal and with a new transmittal number.
  - 2. On re-submittals, cite the original submittal number for reference.
- B. Accompany each submittal with a letter of transmittal showing all information required for identification and checking.
- C. On at least the first page of each submittal, and elsewhere as required for positive identification, show the submittal number in which the item was included.
- D. Submittal Log:

- 1. Maintain an accurate submittal log for the duration of the Work, showing current status of all submittals at all times.
- 2. Make the submittal log available to the Architect for the Architect's review upon request.
- 3.2 GROUPING OF SUBMITTALS
  - A. Unless otherwise specified, make submittals in groups containing all associated items to assure that information is available for checking each item when it is received.
    - 1. Partial submittals may be rejected as not complying with the provisions of the Contract.
    - 2. The Contractor may be held liable for delays so occasioned.
    - 3. Items requiring color selection; i.e. interior finishes shall be submitted as a group to facilitate overall color coordinated selection. Color selections will not be made until the majority of samples are received.
- 3.3 TIMING OF SUBMITTALS
  - A. Make submittals far enough in advance of scheduled dates for installation to provide time required for reviews, for securing necessary approvals, for possible revisions and re-submittals, and for placing orders and securing delivery.
  - B. In scheduling, allow up to ten working days for review by the Architect following the Architect's receipt of the submittal.
- 3.4 ARCHITECT/ENGINEER'S ACTIONS
  - A. Review of the shop drawings by the Architect/Engineer is to determine general conformance with the design concept of the project and with the information given in the contract documents. Neither the receipt nor the review of shop drawings by the Architect/Engineer shall relieve the contractor of his responsibility for performance of the work in accordance with the requirements of the contract documents. Contractor shall be responsible for dimensions to be confirmed and correlated at the site; for information that pertains to fabrication process or to the means, method, techniques, sequences and procedures of construction, and for coordination of the work of all trades.
  - B. Contractor Submittals, Shop Drawings or Product Data from time to time are submitted with errors. If overlooked by the Architect/Engineer review process, it shall not grant the contractor leave to proceed in error, and regardless of any information contained in the Shop Drawing review, the contractor shall be required to meet the requirements of the drawings and specifications. Shop drawings and/or product data review shall not waive or supersede in any way the requirements of the contract documents (drawings and specifications).

#### 3.5 REQUIRED SUBMITTALS

A. Submittals required by the Contract Documents: The General Contractor shall be responsible for review of the following divisions of the specifications and submission of requested shop drawings: Division 00 thru 33. The Mechanical & Plumbing Subcontractor shall be responsible for review of the following divisions of specifications and submission of requested shop drawings: (Division 00 thru 33). The Electrical Subcontractor shall be responsible for review of the following divisions and submission of requested shop drawings: (Division 00 thru 33). The Electrical Subcontractor shall be responsible for review of the following divisions of the specifications and submission of requested shop drawings: (Division 00 thru 33). All shop drawings shall be submitted as detailed under Division 01, Section 013400.

#### END OF SECTION 013400

### SECTION 014000 - QUALITY REQUIREMENTS

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section includes administrative and procedural requirements for quality assurance and quality control.
- B. Testing and inspection services are required to verify compliance with requirements specified or indicated. These services do not relieve Contractor of responsibility for compliance with the Contract Document requirements.
  - 1. Specified tests, inspections, and related actions do not limit Contractor's other qualityassurance and quality-control procedures that facilitate compliance with the Contract Document requirements.
  - 2. Requirements for Contractor to provide quality-assurance and quality-control services required by Architect, Owner or authorities having jurisdiction are not limited by provisions of this Section.

### 1.2 DEFINITIONS

- A. Experienced: When used with an entity or individual, "experienced" unless otherwise further described means having successfully completed a minimum of five previous projects similar in nature, size, and extent to this Project; being familiar with special requirements indicated; and having complied with requirements of authorities having jurisdiction.
- B. Field Quality-Control Tests: Tests and inspections that are performed on-site for installation of the Work and for completed Work.
- C. Installer/Applicator/Erector: Contractor or another entity engaged by Contractor as an employee, Subcontractor, or Sub-subcontractor, to perform a particular construction operation, including installation, erection, application, assembly, and similar operations.
  - 1. Use of trade-specific terminology in referring to a trade or entity does not require that certain construction activities be performed by accredited or unionized individuals, or that requirements specified apply exclusively to specific trade(s).
- D. Mockups: Full-size physical assemblies that are constructed on-site either as freestanding temporary built elements or as part of permanent construction. Mockups are constructed to verify selections made under Sample submittals; to demonstrate aesthetic effects and qualities of materials and execution; to review coordination, testing, or operation; to show interface between dissimilar materials; and to demonstrate compliance with specified installation tolerances. Mockups are not Samples. Unless otherwise indicated, approved mockups establish the standard by which the Work will be judged.

- 1. Integrated Exterior Mockups: Mockups of the exterior envelope constructed on-site as freestanding temporary built elements, consisting of multiple products, assemblies, and subassemblies.
- E. Preconstruction Testing: Tests and inspections performed specifically for Project before products and materials are incorporated into the Work, to verify performance or compliance with specified criteria.
- F. Product Tests: Tests and inspections that are performed by a nationally recognized testing laboratory (NRTL) according to 29 CFR 1910.7, by a testing agency accredited according to NIST's National Voluntary Laboratory Accreditation Program (NVLAP), or by a testing agency qualified to conduct product testing and acceptable to authorities having jurisdiction, to establish product performance and compliance with specified requirements.
- G. Source Quality-Control Tests: Tests and inspections that are performed at the source; for example, plant, mill, factory, or shop.
- H. Testing Agency: An entity engaged to perform specific tests, inspections, or both. Testing laboratory shall mean the same as testing agency.
- I. Quality-Assurance Services: Activities, actions, and procedures performed before and during execution of the Work to guard against defects and deficiencies and substantiate that proposed construction will comply with requirements.
- J. Quality-Control Services: Tests, inspections, procedures, and related actions during and after execution of the Work to evaluate that actual products incorporated into the Work and completed construction comply with requirements. Contractor's quality-control services do not include contract administration activities performed by Architect.

## 1.3 DELEGATED-DESIGN SERVICES

A. 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.

## 1.4 CONFLICTING REQUIREMENTS

- A. Conflicting Standards and Other Requirements: If compliance with two or more standards or requirements are specified and the standards or requirements establish different or conflicting requirements for minimum quantities or quality levels, comply with the most stringent requirement. Refer conflicting requirements that are different, but apparently equal, to Architect for direction before proceeding.
- B. Minimum Quantity or Quality Levels: The quantity or quality level shown or specified shall be the minimum provided or performed. The actual installation may comply exactly with the minimum quantity or quality specified, or it may exceed the minimum within reasonable limits. To comply with these requirements, indicated numeric values are minimum or maximum, as

appropriate, for the context of requirements. Refer uncertainties to Architect for a decision before proceeding.

## 1.5 ACTION SUBMITTALS

A. Delegated-Design Services Submittal: In addition to Shop Drawings, Product Data, and other required submittals, submit a statement 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, indicating that the products and systems are in compliance with performance and design criteria indicated. Include list of codes, loads, and other factors used in performing these services.

## 1.6 INFORMATIONAL SUBMITTALS

- A. Contractor's Statement of Responsibility: When required by authorities having jurisdiction, submit copy of written statement of responsibility submitted to authorities having jurisdiction before starting work on the following systems:
  - 1. Main wind-force-resisting system or a wind-resisting component listed in the Statement of Special Inspections.
- B. Testing Agency Qualifications: For testing agencies specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include proof of qualifications in the form of a recent report on the inspection of the testing agency by a recognized authority.
- C. Permits, Licenses, and Certificates: For Owner's record, submit copies of permits, licenses, certifications, inspection reports, releases, jurisdictional settlements, notices, receipts for fee payments, judgments, correspondence, records, and similar documents established for compliance with standards and regulations bearing on performance of the Work.

### 1.7 REPORTS AND DOCUMENTS

- A. Test and Inspection Reports: Prepare and submit certified written reports specified in other Sections. Include the following:
  - 1. Date of issue.
  - 2. Project title and number.
  - 3. Name, address, telephone number, and email address of testing agency.
  - 4. Dates and locations of samples and tests or inspections.
  - 5. Names of individuals making tests and inspections.
  - 6. Description of the Work and test and inspection method.
  - 7. Identification of product and Specification Section.
  - 8. Complete test or inspection data.
  - 9. Test and inspection results and an interpretation of test results.
  - 10. Record of temperature and weather conditions at time of sample taking and testing and inspection.

- 11. Comments or professional opinion on whether tested or inspected Work complies with the Contract Document requirements.
- 12. Name and signature of laboratory inspector.
- 13. Recommendations on retesting and re-inspecting.
- B. Manufacturer's Technical Representative's Field Reports: Prepare written information documenting manufacturer's technical representative's tests and inspections specified in other Sections. Include the following:
  - 1. Statement on condition of substrates and their acceptability for installation of product.
  - 2. Statement that products at Project site comply with requirements.
  - 3. Summary of installation procedures being followed, whether they comply with requirements and, if not, what corrective action was taken.
  - 4. Results of operational and other tests and a statement of whether observed performance complies with requirements.
  - 5. Other required items indicated in individual Specification Sections.
- C. Factory-Authorized Service Representative's Reports: Prepare written information documenting manufacturer's factory-authorized service representative's tests and inspections specified in other Sections. Include the following:
  - 1. Statement that equipment complies with requirements.
  - 2. Results of operational and other tests and a statement of whether observed performance complies with requirements.
  - 3. Other required items indicated in individual Specification Sections.

### 1.8 QUALITY ASSURANCE

- A. General: Qualifications paragraphs in this article establish the minimum qualification levels required; individual Specification Sections specify additional requirements.
- B. Manufacturer Qualifications: A firm experienced in manufacturing products or systems similar to those indicated for this Project and with a record of successful in-service performance, as well as sufficient production capacity to produce required units. As applicable, procure products from manufacturers able to meet qualification requirements, warranty requirements, and technical or factory-authorized service representative requirements.
- C. Fabricator Qualifications: A firm experienced in producing products similar to those indicated for this Project and with a record of successful in-service performance, as well as sufficient production capacity to produce required units.
- D. Installer Qualifications: A firm or individual experienced in installing, erecting, applying, or assembling work similar in material, design, and extent to that indicated for this Project, whose work has resulted in construction with a record of successful in-service performance.
- E. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those

performed for installations of the system, assembly, or product that are similar in material, design, and extent to those indicated for this Project.

- F. Specialists: Certain Specification Sections require that specific construction activities shall be performed by entities who are recognized experts in those operations. Specialists shall satisfy qualification requirements indicated and shall be engaged for the activities indicated.
  - 1. Requirements of authorities having jurisdiction shall supersede requirements for specialists.
- G. Testing Agency Qualifications: An NRTL, an NVLAP, or an independent agency with the experience and capability to conduct testing and inspection indicated, as documented according to ASTM E 329; and with additional qualifications specified in individual Sections; and, where required by authorities having jurisdiction, that is acceptable to authorities.
- H. Manufacturer's Technical Representative Qualifications: An authorized representative of manufacturer who is trained and approved by manufacturer to observe and inspect installation of manufacturer's products that are similar in material, design, and extent to those indicated for this Project.
- I. Factory-Authorized Service Representative Qualifications: An authorized representative of manufacturer who is trained and approved by manufacturer to inspect installation of manufacturer's products that are similar in material, design, and extent to those indicated for this Project.
- J. Preconstruction Testing: Where testing agency is indicated to perform preconstruction testing for compliance with specified requirements for performance and test methods, comply with the following:
  - 1. Contractor responsibilities include the following:
    - a. Provide test specimens representative of proposed products and construction.
    - b. Submit specimens in a timely manner with sufficient time for testing and analyzing results to prevent delaying the Work.
    - c. Build laboratory mockups at testing facility using personnel, products, and methods of construction indicated for the completed Work.
    - d. When testing is complete, remove test specimens and test assemblies, and mockups; do not reuse products on Project.
  - 2. Testing Agency Responsibilities: Submit a certified written report of each test, inspection, and similar quality-assurance service to Architect, with copy to Contractor. Interpret tests and inspections and state in each report whether tested and inspected work complies with or deviates from the Contract Documents.
- K. Mockups: Before installing portions of the Work requiring mockups, build mockups for each form of construction and finish required to comply with the following requirements, using materials indicated for the completed Work:
  - 1. Build mockups of size indicated.

- 2. Build mockups in location indicated or, if not indicated, as directed by Architect.
- 3. Notify Architect seven days in advance of dates and times when mockups will be constructed.
- 4. Employ supervisory personnel who will oversee mockup construction. Employ workers that will be employed to perform same tasks during the construction at Project.
- 5. Demonstrate the proposed range of aesthetic effects and workmanship.
- 6. Obtain Architect's approval of mockups before starting corresponding work, fabrication, or construction.
  - a. Allow seven days for initial review and each re-review of each mockup.
- 7. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
- 8. Demolish and remove mockups when directed unless otherwise indicated.

## 1.9 QUALITY CONTROL

- A. Owner Responsibilities: Where quality-control services are indicated as Owner's responsibility, Owner will engage a qualified testing agency to perform these services.
  - 1. Owner will furnish Contractor with names, addresses, and telephone numbers of testing agencies engaged and a description of types of testing and inspection they are engaged to perform.
  - 2. Costs for retesting and re-inspecting construction that replaces or is necessitated by work that failed to comply with the Contract Documents will be charged to Contractor.
- B. Contractor Responsibilities: Tests and inspections not explicitly assigned to Owner are Contractor's responsibility. Perform additional quality-control activities, whether specified or not, to verify and document that the Work complies with requirements.
  - 1. Engage a qualified testing agency to perform quality-control services.
    - a. Contractor shall not employ same entity engaged by Owner, unless agreed to in writing by Owner.
  - 2. Notify testing agencies at least 24 hours in advance of time when Work that requires testing or inspection will be performed.
  - 3. Where quality-control services are indicated as Contractor's responsibility, submit a certified written report, in duplicate, of each quality-control service.
  - 4. Testing and inspection requested by Contractor and not required by the Contract Documents are Contractor's responsibility.
  - 5. Submit additional copies of each written report directly to authorities having jurisdiction, when they so direct.
- C. Retesting/Reinspection: Regardless of whether original tests or inspections were Contractor's responsibility, provide quality-control services, including retesting and reinspection, for construction that replaced Work that failed to comply with the Contract Documents.

- D. Testing Agency Responsibilities: Cooperate with Architect and Contractor in performance of duties. Provide qualified personnel to perform required tests and inspections.
  - 1. Notify Architect and Contractor promptly of irregularities or deficiencies observed in the Work during performance of its services.
  - 2. Determine the locations from which test samples will be taken and in which in-situ tests are conducted.
  - 3. Conduct and interpret tests and inspections and state in each report whether tested and inspected work complies with or deviates from requirements.
  - 4. Submit a certified written report, in duplicate, of each test, inspection, and similar quality-control service through Contractor.
  - 5. Do not release, revoke, alter, or increase the Contract Document requirements or approve or accept any portion of the Work.
  - 6. Do not perform duties of Contractor.
- E. Manufacturer's Field Services: Where indicated, engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including service connections. Report results in writing as specified in Section 013300 "Submittal Procedures."
- F. Manufacturer's Technical Services: Where indicated, engage a manufacturer's technical representative to observe and inspect the Work. Manufacturer's technical representative's services include participation in pre-installation conferences, examination of substrates and conditions, verification of materials, observation of Installer activities, inspection of completed portions of the Work, and submittal of written reports.
- G. Associated Contractor Services: Cooperate with agencies and representatives performing required tests, inspections, and similar quality-control services, and provide reasonable auxiliary services as requested. Notify agency sufficiently in advance of operations to permit assignment of personnel. Provide the following:
  - 1. Access to the Work.
  - 2. Incidental labor and facilities necessary to facilitate tests and inspections.
  - 3. Adequate quantities of representative samples of materials that require testing and inspection. Assist agency in obtaining samples.
  - 4. Facilities for storage and field curing of test samples.
  - 5. Preliminary design mix proposed for use for material mixes that require control by testing agency.
  - 6. Security and protection for samples and for testing and inspection equipment at Project site.
- H. Coordination: Coordinate sequence of activities to accommodate required quality-assurance and quality-control services with a minimum of delay and to avoid necessity of removing and replacing construction to accommodate testing and inspection.
  - 1. Schedule times for tests, inspections, obtaining samples, and similar activities.

## 1.10 SPECIAL TESTS AND INSPECTIONS

- A. Special Tests and Inspections: Owner will engage a qualified testing agency/special inspector to conduct special tests and inspections required by (AHJ) authorities having jurisdiction as the responsibility of Owner, as indicated in the Statement of Special Inspections and the schedule of Special Inspections attached to this Section, and as follows:
  - 1. Verifying that manufacturer maintains detailed fabrication and quality-control procedures and reviewing the completeness and adequacy of those procedures to perform the Work.
  - 2. Notifying Architect and Contractor promptly of irregularities and deficiencies observed in the Work during performance of its services.
  - 3. Submitting a certified written report of each test, inspection, and similar quality-control service to Architect with copy to Contractor and to authorities having jurisdiction.
  - 4. Submitting a final report of special tests and inspections at Substantial Completion, which includes a list of unresolved deficiencies.
  - 5. Interpreting tests and inspections and stating in each report whether tested and inspected work complies with or deviates from the Contract Documents.
  - 6. Retesting and reinspection corrected work.

## PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

### 3.1 TEST AND INSPECTION LOG

- A. Test and Inspection Log: Prepare a record of tests and inspections. Include the following:
  - 1. Date test or inspection was conducted.
  - 2. Description of the Work tested or inspected.
  - 3. Date test or inspection results were transmitted to Architect.
  - 4. Identification of testing agency or special inspector conducting test or inspection.
- B. Maintain log at Project site. Post changes and revisions as they occur. Provide access to test and inspection log for Architect's reference during normal working hours.
  - 1. Submit log at Project closeout as part of Project Record Documents.

## 3.2 REPAIR AND PROTECTION

- A. General: On completion of testing, inspection, sample taking, and similar services, repair damaged construction and restore substrates and finishes.
  - 1. Provide materials and comply with installation requirements specified in other Specification Sections or matching existing substrates and finishes. Restore patched

areas and extend restoration into adjoining areas with durable seams that are as invisible as possible. Comply with the Contract Document requirements for cutting and patching in Section 017300 "Execution."

- B. Protect construction exposed by or for quality-control service activities.
- C. Repair and protection are Contractor's responsibility, regardless of the assignment of responsibility for quality-control services.

#### SCHEDULE OF SPECIAL INSPECTION SERVICES PROJECT **APPLICABLE TO THIS PROJECT** DATE Y/N EXTENT **MATERIAL / ACTIVITY** SERVICE AGENT\* COMPLETED 1704.2.5 Inspection of **Fabricators** Verify fabrication/quality control Ν Periodic In-plant review (3) procedures 1705.1.1 Special Cases (work unusual in nature, including but not limited to alternative Submittal review, shop (3) and/or field inspecmaterials and systems, unusual Ν design applications, materials tion and systems with special manufacturer's requirements) 1705.2 Steel Construction 1. Fabricator and erector documents (Verify reports and certificates as listed in AISC 360, Submittal Review Each submittal Ν chapter N, paragraph 3.2 for compliance with construction documents) Shop (3) and field in-2. Material verification of struc-Ν Periodic tural steel spection 3. Embedments (Verify diameter, grade, type, length, em-**Field inspection** Ν Periodic bedment. See 1705.3 for anchors) 4. Verify member locations, braces, stiffeners, and application of joint details at each con-Υ **Field inspection** Periodic nection comply with construction documents 5. Structural steel welding:

a. Inspection tasks Prior to Welding (Observe, or perform for each welded joint or mem- ber, the QA tasks listed in AISC 360, Table N5.4-1)	Shop (3) and field in- spection	N	Observe or Per- form as noted (4)	
b. Inspection tasks During Welding (Observe, or perform for each welded joint or mem- ber, the QA tasks listed in AISC 360, Table N5.4-2)	Shop (3) and field in- spection	N	Observe (4)	
c. Inspection tasks After Welding (Observe, or perform for each welded joint or mem- ber, the QA tasks listed in AISC 360, Table N5.4-3)	Shop (3) and field in- spection	Y	Observe or Per- form as noted (4)	
d. Nondestructive testing (NDT) of welded joints: see Commentary				
1) Complete penetration groove welds 5/16" or greater in <i>risk category</i> III or IV	Shop (3) or field ultra- sonic testing - 100%	N	Periodic	
2) Complete penetration groove welds 5/16" or greater in <i>risk category</i> II	Shop (3) or field ultra- sonic testing - 10% of welds minimum	N	Periodic	
<ul> <li>3) Thermally cut surfaces</li> <li>of access holes when material t</li> <li>&gt; 2"</li> </ul>	Shop (3) or field mag- netic Partical or Pene- trant testing	N	Periodic	
4) Welded joints subject to fatigue when required by AISC 360, Appendix 3, Table A-3.1	Shop (3) or field radio- graphic or Ultrasonic testing	N	Periodic	
5) Fabricator's NDT reports when fabricator performs NDT	Verify reports	N	Each submittal (5)	
6. Structural steel bolting:	Shop (3) and field in- spection			
a. Inspection tasks Prior to Bolting (Observe, or perform tasks for each bolted connec- tion, in accordance with QA tasks listed in AISC 360, Table N5.6-1)		N	Observe or Per- form as noted (4)	
b. Inspection tasks During Bolting (Observe the QA tasks listed in AISC 360, Table N5.6- 2)		N	Observe (4)	
1) Pre-tensioned and slip- critical joints				
a) Turn-of-nut with matching markings		Ν	Periodic	
b) Direct tension indica- tor		Ν	Periodic	

c) Twist-off type tension control bolt		Ν	Periodic	
d) Turn-of-nut without matching markings		N	Continuous	
e) Calibrated wrench		N	Continuous	
2) Snug-tight joints		N	Periodic	
c. Inspection tasks After Bolt- ing (Perform tasks for each bolted connection in accord- ance with QA tasks listed in AISC 360, Table N5.6-3)		N	Perform (4)	
7. Inspection of steel elements of composite construction prior to concrete placement in ac- cordance with QA tasks listed in AISC 360, Table N6.1	Shop (3) and field in- spection and testing	N	Observe or Per- form as noted (4)	
1705.2.2 Steel Construc- tion Other Than Structural Steel				
1. Material verification of cold- formed steel deck:				
a. Identification markings	Field inspection	N	Periodic	
<ul> <li>b. Manufacturer's certified test reports</li> </ul>	Submittal Review	Ν	Each submittal	
2. Connection of cold-formed steel deck to supporting structure:	Shop (3) and field in- spection			
a. Welding		Ν	Periodic	
b. Other fasteners (in accord- ance with AISC 360,Section N6)				
1) Verify fasteners are in conformance with approved submittal		N	Periodic	
2) Verify fastener installa- tion is in conformance with ap- proved submittal and manufac- turer's recommendations		N	Periodic	
3. Reinforcing steel	Shop (3) and field in- spection			
a. Verification of weldability of steel other than ASTM A706		Ν	Periodic	
b. Reinforcing steel resisting flexural and axial forces in in- termediate and special moment frames, boundary elements of special concrete structural walls and shear reinforcement		N	Continuous	
c. Shear reinforcement		N	Continuous	

d. Other reinforcing steel		N	Periodic	
4. Cold-formed steel trusses spanning 60 feet or greater				
a. Verify temporary and per- manent restraint/bracing are installed in accordance with the approved truss submittal pack- age	Field inspection	N	Periodic	
1705.3 Concrete Construc- tion				
1. Inspection of reinforcing steel installation (see 1705.2.2 for welding)	Shop (3) and field in- spection	N	Periodic	
2. Inspection of pre-stressing steel installation	Shop (3) and field in- spection	Ν	Periodic	
3. Inspection of anchors cast in concrete where allowable loads have been increased per sec- tion 1908.5 or where strength design is used	Shop (3) and field in- spection	N	Periodic	
4. Inspection of anchors and reinforcing steel post-installed in hardened concrete: Per re- search reports including verifi- cation of anchor type, anchor dimensions, hole dimensions, hole cleaning procedures, an- chor spacing, edge distances, concrete minimum thickness, anchor embedment and tighten- ing torque	Field inspection	N	Periodic or as required by the research report issued by an approved source	
5. Verify use of approved de- sign mix	Shop (3) and field in- spection	N	Periodic	
6. Fresh concrete sampling, perform slump and air content tests and determine tempera- ture of concrete	Shop (3) and field in- spection	N	Continuous	
7. Inspection of concrete and shotcrete placement for proper application techniques	Shop (3) and field in- spection	N	Continuous	
8. Inspection for maintenance of specified curing temperature and techniques	Shop (3) and field in- spection	N	Periodic	
9. Inspection of pre-stressed concrete:	Shop (3) and field in- spection			
a. Application of pre-stressing force		N	Continuous	
b. Grouting of bonded pre- stressing tendons in the seis- mic-force-resisting system		N	Continuous	
10. Erection of precast concrete members				
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a. Inspect in accordance with construction documents	Field inspection	N	In accordance with construc- tion documents	
b. Perform inspections of welding and bolting in accord- ance with Section 1705.2	Field inspection	Ν	In accordance with Section 1705.2	
11. Verification of in-situ con- crete strength, prior to stressing of tendons in post tensioned concrete and prior to removal of shores and forms from beams and structural slabs	Review field testing and laboratory reports	Ν	Periodic	
12. Inspection of formwork for shape, lines, location and dimensions	Field inspection	N	Periodic	
13. Concrete strength testing and verification of compliance with construction documents	Field testing and review of laboratory reports	Ν	Periodic	
1705.4 Masonry Construc- tion				
(A) Level A, B and C Quality Assurance:				
1. Verify compliance with approved submittals	Field Inspection	N	Periodic	
(B) Level B Quality Assur- ance:				
1. Verification of f'm and f'AAC prior to construction	Testing by unit strength method or prism test method	Ν	Periodic	
(C) Level C Quality Assur- ance:				
1. Verification of f'm and f'AAC prior to construction and for every 5,000 SF during construc- tion	Testing by unit strength method or prism test method	N	Periodic	
2. Verification of propor- tions of materials in premixed or preblended mortar, prestressing grout, and grout other than self- consolidating grout, as deliv- ered to the project site	Field inspection	N	Continuous	
3. Verify placement of ma- sonry units	Field Inspection	N	Periodic	

(D) Levels B and C Quality Assurance:				
1. Verification of Slump Flow and Visual Stability Index (VSI) of self-consolidating grout as delivered to the project	Field testing	N	Continuous	
2. Verify compliance with approved submittals	Field inspection	N	Periodic	
3. Verify proportions of site- mixed mortar, grout and pre- stressing grout for bonded ten- dons	Field Inspection	Ν	Periodic	
4. Verify grade, type, and size of reinforcement and an- chor bolts, and prestressing tendons and anchorages	Field Inspection	N	Periodic	
5. Verify construction of mortar joints	Field Inspection	N	Periodic	
6. Verify placement of rein- forcement, connectors, and prestressing tendons and an- chorages	Field Inspection	Ν	Level B – Periodic	
		N	Level C – Continuous	
7. Verify grout space prior to grouting	Field Inspection	N	Level B – Periodic	
		Ν	Continuous	
8. Verify placement of grout and prestressing grout for bonded tendons	Field Inspection	N	Continuous	
9. Verify size and location of structural masonry elements	Field Inspection	Ν	Periodic	
10. Verify type, size, and location of anchors, including details of anchorage of masonry to structural members, frames, or other construction.	Field inspection	N	Level B – Periodic	
		N	Level C – Continuous	
11. Verify welding of rein- forcement (see 1705.2.2)	Field inspection	N	Continuous	

12. Verify preparation, con- struction, and protection of ma- sonry during cold weather (tem- perature below 40°F) or hot weather (temperature above 90°F)	Field inspection	N	Periodic	
13. Verify application and measurement of prestressing force	Field Inspection	N	Continuous	
14. Verify placement of AAC masonry units and con- struction of thin-bed mortar joints (first 5000 SF of AAC ma- sonry)	Field inspection	N	Continuous	
15. Verify placement of AAC masonry units and con- struction of thin-bed mortar joints (after the first 5000 SF of AAC masonry)	Field inspection	N	Level B – Periodic	
		N	Level C – Continuous	
16. Verify properties of thin- bed mortar for AAC masonry (first 5000 SF of AAC masonry)	Field inspection	N	Continuous	
17. Verify properties of thin- bed mortar forAAC masonry (after the first 5000 SF of AAC masonry)	Field inspection	N	Level B – Periodic	
		N	Level C – Continuous	
18. Prepare grout and mortar specimens	Field testing	N	Level B – Periodic	
		Ν	Level C – Continuous	
19. Observe preparation of prisms	Field inspection	N	Level B – Periodic	
		Ν	Level C – Continuous	
1705.5 Wood Construction				
1. Inspection of the fabrication process of wood structural ele- ments and assemblies in ac- cordance with Section 1704.2.5	In-plant review (3)	N	Periodic	
2. For high-load diaphragms, verify grade and thickness of structural panel sheathing agree with approved building plans	Field inspection	N	Periodic	

3. For high-load diaphragms, verify nominal size of framing members at adjoining panel edges, nail or staple diameter and length, number of fastener lines, and that spacing between fasteners in each line and at edge margins agree with ap- proved building plans	Field inspection	Ζ	Periodic	
4. Metal-plate-connected wood trusses spanning 60 feet or greater: verify temporary and permanent restraint/bracing are installed in accordance with the approved truss submittal pack- age	Field inspection	Ν	Periodic	
1705.6 Soils				
1. Verify materials below shal- low foundations are adequate to achieve the design bearing ca- pacity.	Field inspection	Ν	Periodic	
2. Verify excavations are ex- tended to proper depth and have reached proper material.	Field inspection	Ν	Periodic	
3. Perform classification and testing of controlled fill materials.	Field inspection	Ν	Periodic	
4. Verify use of proper materi- als, densities, and lift thickness- es during placement and com- paction of controlled fill	Field inspection	Ν	Continuous	
<ol> <li>Prior to placement of con- trolled fill, observe subgrade and verify that site has been prepared properly</li> </ol>	Field inspection	Ν	Periodic	
1705.7 Driven Deep Foun- dations				
1. Verify element materials, siz- es and lengths comply with re- quirements	Field inspection	Ν	Continuous	
2. Determine capacities of test elements and conduct addition- al load tests, as required	Field inspection	Ν	Continuous	
3. Observe driving operations and maintain complete and ac- curate records for each element	Field inspection	Ν	Continuous	

4. Verify placement locations and plumbness, confirm type and size of hammer, record number of blows per foot of penetration, determine required penetrations to achieve design capacity, record tip and butt elevations and document any damage to foundation element	Field inspection	Ζ	Continuous	
5. For steel elements, perform additional inspections per Section 1705.2	See Section 1705.2	Ν	See Section 1705.2	
6. For concrete elements and concrete-filled elements, per- form additional inspections per Section 1705.3	See Section 1705.3	Z	See Section 1705.3	
7. For specialty elements, per- form additional inspections as determined by the registered design professional in responsi- ble charge	Field inspection	Ν	In accordance with construc- tion documents	
8. Perform additional inspec- tions and tests in accordance with the construction documents	Field Inspection and testing	Ν	In accordance with construc- tion documents	
1705.8 Cast-in-Place Deep Foundations				
1.Observe drilling operations and maintain complete and ac- curate records for each element	Field inspection	Ν	Continuous	
2. Verify placement locations and plumbness, confirm ele- ment diameters, bell diameters (if applicable), lengths, embed- ment into bedrock (if applicable) and adequate end-bearing stra- ta capacity. Record concrete or grout volumes	Field inspection	Ν	Continuous	
3. For concrete elements, per- form additional inspections in accordance with Section 1705.3	See Section 1705.3	Ν	See Section 1705.3	
4. Perform additional inspec- tions and tests in accordance with the construction documents	Field Inspection and testing	Ν	In accordance with construc- tion documents	
1705.9 Helical Pile Founda- tions				
1. Verify installation equipment, pile dimensions, tip elevations, final depth, final installation torque and other data as re- quired.	Field inspection	Ν	Continuous	

2. Perform additional inspec- tions and tests in accordance with the construction documents	Field Inspection and testing	N	In accordance with construc- tion documents	
1705.10.1 Structural Wood Special Inspections For Wind Resistance				
1. Inspection of field gluing op- erations of elements of the main windforce-resisting system	Field inspection	N	Continuous	
2. Inspection of nailing, bolting, anchoring and other fastening of components within the main windforce-resisting system	Shop (3) and field in- spection	N	Periodic	
1705.10.2 Cold-formed Steel Special Inspections For Wind Resistance				
1.Inspection during welding op- erations of elements of the main windforce-resisting system	Shop (3) and field in- spection	N	Periodic	
2.Inspections for screw attach- ment, bolting, anchoring and other fastening of components within the main windforce- resisting system	Shop (3) and field in- spection	N	Periodic	
1705.10.3 Wind-resisting Components				
1. Roof cladding	Shop (3) and field in- spection	N	Periodic	
2. Wall cladding	Shop (3) and field in- spection	Ν	Periodic	
1705.11.1 Structural Steel Special Inspections for Seismic Resistance				
Inspection of structural steel in accordance with AISC 341	Shop (3) and field in- spection	N	In accordance with AISC 341	
1705.11.2 Structural Wood Special Inspections for Seismic Resistance				
1. Inspection of field gluing op- erations of elements of the seismic-force resisting system	Field inspection	N	Continuous	
<ol> <li>Inspection of nailing, bolting, anchoring and other fastening of components within the seis- mic-force-resisting system</li> </ol>	Shop (3) and field in- spection	N	Periodic	

1705.11.3 Cold-formed Steel Light-Frame Con- struction Special Inspec- tions for Seismic Re- sistance				
1. Inspection during welding operations of elements of the seismic-force-resisting system	Shop (3) and field in- spection	Ν	Periodic	
2. Inspections for screw at- tachment, bolting, anchoring and other fastening of compo- nents within the seismic-force- resisting system	Shop (3) and field in- spection	Ν	Periodic	
1705.11.4 Designated Seismic Systems Verifica- tion				
Inspect and verify that that the component label, anchorage or mounting conforms to the certificate of compliance in accordance with Section 1705.12.3	Field inspection	Ζ	Periodic	
1705.11.5 Architectural Components Special In- spections for Seismic Re- sistance				
1. Inspection during the erection and fastening of exterior clad- ding and interior and exterior veneer	Field inspection	Ν	Periodic	
2. Inspection during the erection and fastening of interior and exterior nonbearing walls	Field inspection	N	Periodic	
3. Inspection during anchorage of access floors	Field inspection	Ν	Periodic	
1705.11.6 Mechanical and Electrical Components Special Inspections for Seismic Resistance				
1. Inspection during the anchor- age of electrical equipment for emergency or standby power systems	Field inspection	N	Periodic	
2. Inspection during the anchor- age of other electrical equip- ment	Field inspection	Ν	Periodic	

		-		 
3. Inspection during installation and anchorage of piping sys- tems designed to carry hazard- ous materials, and their associ- ated mechanical units	Field inspection	N	Periodic	
4. Inspection during the installa- tion and anchorage of HVAC ductwork that will contain haz- ardous materials	Field inspection	N	Periodic	
5. Inspection during the installa- tion and anchorage of vibration isolation systems	Field inspection	Ν	Periodic	
1705.11.7 Storage Racks Special Inspections for Seismic Resistance				
Inspection during the anchorage of storage racks 8 feet or greater in height	Field inspection	N	Periodic	
1705.11.8 Seismic Isolation Systems				
Inspection during the fabrication and installation of isolator units and energy dissipation devices used as part of the seismic iso- lation system	Shop and field inspec- tion	N	Periodic	
1705.12.1 Concrete Rein- forcement Testing and Qualification for Seismic Resistance				
1. Review certified mill test re- ports for each shipment of rein- forcement used to resist earth- quake-induced flexural and axi- al forces in reinforced concrete special moment frames, special structural walls, and coupling beams connecting special struc- tural walls	Review certified mill test reports	Ν	Each shipment	
2. Verify reinforcement weldabil- ity of ASTM A615 reinforcement used to resist earthquake- induced flexural and axial forces in reinforced concrete special moment frames, special struc- tural walls, and coupling beams connecting special structural walls	Review test reports	N	Each shipment	

1705.12.2 Structural Steel Testing and Qualification for Seismic Resistance				
Test in accordance with the quality assurance requirements of AISC 341	Shop (3) and field test- ing	N	Per AISC 341	
1705.12.3 Seismic Certifi- cation of Nonstructural Components				
Review certificate of compliance for designated seismic system components.	Certificate of compli- ance review	Ν	Each submittal	
1705.12.4 Seismic Isolation Systems				
Test seismic isolation system in accordance with ASCE 7 Section 17.8	Prototype testing	Ν	Per ASCE 7	
1705.13 Sprayed Fire- resistant Materials				
1. Verify surface condition preparation of structural mem- bers	Field inspection	Ν	Periodic	
2. Verify application of sprayed fire-resistant materials	Field inspection	Ν	Periodic	
3. Verify average thickness of sprayed fire-resistant materials applied to structural members	Field inspection	N	Periodic	
4. Verify density of the sprayed fire-resistant material complies with approved fire-resistant de- sign	Field inspection and testing	Ν	Per IBC Section 1705.13.5	
<ol> <li>Verify the cohesive/adhesive bond strength of the cured sprayed fire-resistant material</li> </ol>	Field inspection and testing	Ν	Per IBC Section 1705.13.6	
1705.14 Mastic and Intu- mescent Fire-Resistant Coatings				
Inspect mastic and intumescent fire-resistant coatings applied to structural elements and decks	Field inspection	Ν	Periodic	
1705.15 Exterior Insulation and Finish Systems (EIFS)				

1. Verify materials, details and installations are per the approved construction documents	Field inspection	N	Periodic		
2. Inspection of water-resistive barrier over sheathing substrate	Field inspection	Ν	Periodic		
1705.16 Fire-Resistant Penetrations and Joints					
1. Inspect penetration firestop systems	Field testing	N	Per ASTM E2174		
2. Inspect fire-resistant joint systems	Field testing	Ν	Per ASTM E2393		
1705.17 Smoke Control Systems					
1. Leakage testing and record- ing of device locations prior to concealment	Field testing	N	Periodic		
2. Prior to occupancy and after sufficient completion, pressure difference testing, flow meas- urements, and detection and control verification	Field testing	N	Periodic		
* INSPECTION AGENTS				TF	
FIRM			ADDRESS		NO.
2					
3.					
4.					
Notes: 1. The inspection and testing agent(s) shall be engaged by the Owner or the Owner's Agent, and not by the Contractor or Subcontractor whose work is to be inspected or tested. Any conflict of interest must be disclosed to the Building Official prior to commencing work. The qualifications of the Special In- spector(s) and/or					
testing agencies may be subject	to the approval of the Building C	Official and/	or the Design Profession	nal.	
<ol> <li>The list of Special Inspectors may be submitted as a separate document, if noted so above.</li> <li>Special Inspections as required by Section 1704.2.5 are not required where the fabricator is approved in accordance with IBC Section 1704.2.5.2</li> </ol>					
<ol> <li>Observe on a random basis, operations need not be delayed pending these inspections. Perform these tasks for each welded joint, bolted connection, or steel element.</li> <li>NDT of welds completed in an approved fabricator's shop may be performed by that fabricator when approved by the AHJ. Refer to AISC 360, N7.</li> </ol>					
Are Requirements for Seismic Resist	ance included in the Stateme	nt of Sner	cial Inspections?	Yes	No
Are Requirements for Wind Resistance	ce included in the Statement	of Special	Inspections?	Yes	No
DATE:					

#### SECTION 017000 - CONTRACT CLOSEOUT

- 1.0 GENERAL
  - A. Attention is directed to Division 0, Bidding and Contract Requirements, and to Division 1, General Requirements, which are hereby made a part of this specification. Also see Mechanical, Plumbing & Electrical specifications for any additional requirements.

#### 1.1 CONTRACT CLOSEOUT PROCEDURES

- A. Submit written certification that Contract Documents have been reviewed, Work has been inspected, and Work is substantially complete in accordance with Contract Documents and ready for Architect/Engineer's inspection. Identify any and all items that remain to be completed or corrected.
- B. After inspection by Owner and Architect, and if the Architect concurs that work is substantially completed, he shall prepare a Certification of Substantial Completion on A.I.A. Form G704, accompanied by Contractor's list of items to be completed or corrected, as verified and amended by the Architect, Owner and General Contractor.
- C. When the Contractor considers the work to be complete, he shall submit a final request for inspection. The Architect, Owner, and General Contractor shall inspect the work and if found to be acceptable, the Architect shall request the Contractor to make closeout submittals.
- D. If the Contractor does not have work completed in accordance with the contract documents and ready for final inspection, and the Architect must make an additional final inspection trip, the cost of this final inspection(s) shall be deducted from the contract.
- E. When Architect and Owner complete final inspection and approve the project, the Contractor shall submit final Application for Payment identifying total adjusted Contract Sum/Price, previous payments, and amount remaining due. If required, the Architect will prepare a final change order reflecting approved adjustments to the contract sum which were not previously made by change orders.

#### 1.2 FINAL CLEANING

- A. Execute final cleaning prior to final inspection.
- B. If the Contractor fails to clean up at the completion of the work, the Owner may do so and the cost thereof shall be charged to the Contractor(s) as the Architect so determines.
- C. Clean debris from site, roofs, gutters, downspouts, and drainage systems.
- D. Remove waste and surplus materials, rubbish, demolition materials, and construction facilities from the site. Burning of rubbish and debris on the premises will not be permitted at any time.
- E. Contractor shall repair all damaged site work as a result of demolition or construction.

## 1.3 ADJUSTING

- A. Adjust operating Products and equipment to ensure smooth and unhindered operation.
- 1.4 PROJECT RECORD DOCUMENTS (For each Building)
  - A. Maintain on site, one set of Contract Documents to be utilized for record documents. This requirement is for all trades, architectural, mechanical, and electrical.

- B. Record actual revisions to the Work. Record information concurrent with construction progress.
- C. Specifications: Legibly mark and record at each Product Section a description of actual Products installed.
- D. Record Documents and Shop Drawings: Legibly mark each item to record actual construction.
- E. Submit documents to Architect/Engineer with claim for final Application for Payment.
- 1.5 OPERATION AND MAINTENANCE DATA (For each Building)
  - A. Submit to the Architect two (2) sets prior to final inspection, bound in 8-1/2 x 11 inch text pages, three D size ring binders with durable plastic covers. One flash drive with all documents (PDF) scanned. (Separate Binder for each Building)
  - B. Prepare binder cover with printed title "OPERATION AND MAINTENANCE INSTRUCTIONS", and title of project.
  - C. Internally subdivide the binder contents with permanent page dividers, logically organized, with tab titling clearly printed under reinforced laminated plastic tabs.
  - D. Contents:
    - 1. Directory, listing names, addresses, and telephone numbers of Architect/Engineer, Contractor, Subcontractors, and major equipment suppliers.
    - 2. Operation and maintenance instructions, arranged by system.
    - 3. Project documents and certificates.
- 1.6 WARRANTIES (for each Building)
  - A. Provide duplicate notarized copies.
  - B. Execute and assemble documents from Subcontractors, suppliers, and manufacturers.
  - C. Submit to Architect prior to final Application for Payment. (can be combined but must separate by each building)
- 1.7 SPARE PARTS AND MAINTENANCE MATERIALS: See individual Specifications.

## SECTION 05 1200 - STRUCTURAL STEEL FRAMING

#### PART 1 - GENERAL

#### 1.01 SUMMARY

- A. Section Includes:
  - 1. Structural steel.
  - 2. Grout.

## **1.02 DEFINITIONS**

A. Structural Steel: Elements of the structural frame indicated on Drawings and as described in AISC 303, "Code of Standard Practice for Steel Buildings and Bridges."

#### **1.03 PREINSTALLATION MEETINGS**

A. Preinstallation Conference: Conduct conference at Project site.

#### 1.04 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: Show fabrication of structural-steel components.
- C. Delegated-Design Submittal: For structural-steel connections indicated to comply with design loads, include analysis data.

### 1.05 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer and fabricator.
- B. Welding certificates.
- C. Mill test reports for structural steel, including chemical and physical properties.
- D. Source quality-control reports.
- E. Field quality-control and special inspection reports.

### 1.06 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Comply with applicable provisions of the following specifications and documents:
  - 1. AISC 303.
  - 2. AISC 360.
  - 3. RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts."

## 1.07 DELIVERY, STORAGE, AND HANDLING

- A. Store materials to permit easy access for inspection and identification. Keep steel members off ground and spaced by using pallets, dunnage, or other supports and spacers. Protect steel members and packaged materials from corrosion and deterioration.
  - 1. Do not store materials on structure in a manner that might cause distortion, damage, or overload to members or supporting structures. Repair or replace damaged materials or structures as directed.
- B. Store fasteners in a protected place in sealed containers with manufacturer's labels intact.
  - 1. Fasteners may be repackaged provided Owner's testing and inspecting agency observes repackaging and seals containers.
  - 2. Clean and relubricate bolts and nuts that become dry or rusty before use.
  - 3. Comply with manufacturers' written recommendations for cleaning and lubricating ASTM F 1852 fasteners and for retesting fasteners after lubrication.

# PART 2 PRODUCTS

# 2.01 PERFORMANCE REQUIREMENTS

- A. Connections: Provide details of simple shear connections required by the Contract Documents to be selected or completed by structural-steel fabricator to withstand loads indicated and comply with other information and restrictions indicated.
  - 1. Select and complete connections using schematic details indicated and AISC 360.
- B. Moment Connections: Fully restrained.
- C. Construction: Combined system of moment frame, braced frame, and shear walls.

# 2.02 STRUCTURAL-STEEL MATERIALS

- A. W-Shapes: ASTM A 992/A 992M.
- B. Channels, Angles-Shapes: ASTM A 36/A 36M.
- C. Plate and Bar: ASTM A 36/A 36M.
- D. Cold-Formed Hollow Structural Sections: ASTM A 500/A 500M, Grade C, structural tubing.
- E. Welding Electrodes: Comply with AWS requirements.

# 2.03 BOLTS, CONNECTORS, AND ANCHORS

- A. High-Strength Bolts, Nuts, and Washers: ASTM A 325, Type 1, heavy-hex steel structural bolts; ASTM A 563, Grade C, heavy-hex carbon-steel nuts; and ASTM F 436, Type 1, hardened carbonsteel washers; all with plain finish.
  - 1. Direct-Tension Indicators: ASTM F 959, Type 325, compressible-washer type with plain finish.
- B. Tension-Control, High-Strength Bolt-Nut-Washer Assemblies: ASTM F 1852, Type 1, heavy-hex round head assemblies consisting of steel structural bolts with splined ends, heavy-hex carbon-steel nuts, and hardened carbon-steel washers.

- 1. Finish: Plain.
- C. Shear Connectors: ASTM A 108, Grades 1015 through 1020, headed-stud type, cold-finished carbon steel; AWS D1.1/D1.1M, Type B.
- D. Headed Anchor Rods: ASTM F 1554, Grade 36, straight.
  - 1. Finish: Plain.
- E. Threaded Rods: ASTM A 36/A 36M.
  - 1. Finish: Plain.

# 2.04 PRIMER

A. Primer: Fabricator's standard lead- and chromate-free, nonasphaltic, rust-inhibiting primer complying with MPI#79 and compatible with topcoat.

# 2.05 GROUT

A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107/C 1107M, factory-packaged, nonmetallic aggregate grout, noncorrosive and nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

## 2.06 FABRICATION

- A. Structural Steel: Fabricate and assemble in shop to greatest extent possible. Fabricate according to AISC 303, "Code of Standard Practice for Steel Buildings and Bridges," and to AISC 360.
- B. Shear Connectors: Prepare steel surfaces as recommended by manufacturer of shear connectors. Use automatic end welding of headed-stud shear connectors according to AWS D1.1/D1.1M and manufacturer's written instructions.

# 2.07 SHOP CONNECTIONS

- A. High-Strength Bolts: Shop install high-strength bolts according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts" for type of bolt and type of joint specified.
  - 1. Joint Type: Snug tightened.
- B. Weld Connections: Comply with AWS D1.1/D1.1M for tolerances, appearances, welding procedure specifications, weld quality, and methods used in correcting welding work.

# 2.08 GALVANIZING

- A. Hot-Dip Galvanized Finish: Apply zinc coating by the hot-dip process to structural steel in accordance with ASTM A123/A123M.
  - 1. Fill vent and drain holes that are exposed in the finished Work unless they function as weep holes, by plugging with zinc solder and filing off smooth.
  - 2. Galvanize lintels and shelf angles attached to structural-steel frame and located in exterior walls.

# 2.09 SHOP PRIMING

- A. Shop prime steel surfaces except the following:
  - 1. Surfaces embedded in concrete or mortar. Extend priming of partially embedded members to a depth of 2 inches.
  - 2. Surfaces to be field welded.
  - 3. Surfaces of high-strength bolted, slip-critical connections.
  - 4. Galvanized surfaces.
- B. Surface Preparation: Clean surfaces to be painted. Remove loose rust and mill scale and spatter, slag, or flux deposits. Prepare surfaces according to the following specifications and standards:
  - 1. SSPC-SP 2, "Hand Tool Cleaning."
  - 2. SSPC-SP 3, "Power Tool Cleaning."
  - 3. SSPC-SP 7/NACE No. 4, "Brush-off Blast Cleaning."
- C. Priming: Immediately after surface preparation, apply primer according to manufacturer's written instructions and at rate recommended by SSPC to provide a minimum dry film thickness of 1.5 mils. Use priming methods that result in full coverage of joints, corners, edges, and exposed surfaces.

## 2.10 SOURCE QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform shop tests and inspections.
  - 1. Provide testing agency with access to places where structural-steel work is being fabricated or produced to perform tests and inspections.
- B. Bolted Connections: Inspect shop-bolted connections according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts."
- C. Welded Connections: Visually inspect shop-welded connections according to AWS D1.1/D1.1M and the following inspection procedures, at testing agency's option:
  - 1. Liquid Penetrant Inspection: ASTM E 165.
  - 2. Magnetic Particle Inspection: ASTM E 709; performed on root pass and on finished weld. Cracks or zones of incomplete fusion or penetration are not accepted.
  - 3. Ultrasonic Inspection: ASTM E 164.
  - 4. Radiographic Inspection: ASTM E 94.
- D. Prepare test and inspection reports.

# PART 3 EXECUTION

# 3.01 EXAMINATION

# Bangor Township Schools ME Upgrades

- A. Verify, with certified steel erector present, elevations of concrete- and masonry-bearing surfaces and locations of anchor rods, bearing plates, and other embedments for compliance with requirements.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

# 3.02 ERECTION

- A. Set structural steel accurately in locations and to elevations indicated and according to AISC 303 and AISC 360.
- B. Baseplates Bearing Plates and Leveling Plates: Clean concrete- and masonry-bearing surfaces of bond-reducing materials, and roughen surfaces prior to setting plates. Clean bottom surface of plates.
  - 1. Set plates for structural members on wedges, shims, or setting nuts as required.
  - 2. Weld plate washers to top of baseplate.
  - 3. Snug-tighten anchor rods after supported members have been positioned and plumbed. Do not remove wedges or shims but, if protruding, cut off flush with edge of plate before packing with grout.
  - 4. Promptly pack grout solidly between bearing surfaces and plates so no voids remain. Neatly finish exposed surfaces; protect grout and allow to cure. Comply with manufacturer's written installation instructions for shrinkage-resistant grouts.
- C. Maintain erection tolerances of structural steel within AISC 303, "Code of Standard Practice for Steel Buildings and Bridges."

# 3.03 FIELD CONNECTIONS

- A. High-Strength Bolts: Install high-strength bolts according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts" for type of bolt and type of joint specified.
  - 1. Joint Type: Snug tightened.
- B. Weld Connections: Comply with AWS D1.1/D1.1M for tolerances, appearances, welding procedure specifications, weld quality, and methods used in correcting welding work.
  - 1. Comply with AISC 303 and AISC 360 for bearing, alignment, adequacy of temporary connections, and removal of paint on surfaces adjacent to field welds.
  - 2. Remove backing bars or runoff tabs where indicated, back gouge, and grind steel smooth.
  - 3. Assemble and weld built-up sections by methods that maintain true alignment of axes without exceeding tolerances in AISC 303, "Code of Standard Practice for Steel Buildings and Bridges," for mill material.

# 3.04 FIELD QUALITY CONTROL

- A. Special Inspections: Owner will engage a qualified special inspector to perform the following special inspections:
  - 1. Verify structural-steel materials and inspect steel frame joint details.
  - 2. Verify weld materials and inspect welds.

- 3. Verify connection materials and inspect high-strength bolted connections.
- B. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- C. Bolted Connections: Inspect bolted connections according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts."
- D. Welded Connections: Visually inspect field welds according to AWS D1.1/D1.1M.
  - 1. In addition to visual inspection, test and inspect field welds according to AWS D1.1/D1.1M and the following inspection procedures, at testing agency's option:
    - a. Liquid Penetrant Inspection: ASTM E 165.
    - b. Magnetic Particle Inspection: ASTM E 709; performed on root pass and on finished weld. Cracks or zones of incomplete fusion or penetration are not accepted.
    - c. Ultrasonic Inspection: ASTM E 164.
    - d. Radiographic Inspection: ASTM E 94.

# SECTION 230130.52 - EXISTING HVAC AIR DISTRIBUTION SYSTEM CLEANING

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section includes cleaning existing HVAC air-distribution equipment, ducts, plenums, and system components.

## 1.2 DEFINITIONS

- A. ACAC: American Council for Accredited Certification.
- B. AIHA-LAP: American Industrial Hygiene Association Lab Accreditation Program
- C. ASCS: Air systems cleaning specialist.
- D. CESB: Council of Engineering and Scientific Specialty Boards.
- E. CMI: Certified Microbial Investigator.
- F. CMC: Certified Microbial Consultant.
- G. CMR: Certified Microbial Remediator.
- H. CMRS: Certified Microbial Remediation Supervisor.
- I. EMLAP: Environmental Microbiology Laboratory Accreditation Program.
- J. IEP: Indoor Environmental Professional.
- K. IICRC: Institute of Inspection, Cleaning, and Restoration Certification.
- L. NADCA: National Air Duct Cleaners Association.

## 1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

#### 1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

#### 1.5 QUALITY ASSURANCE

- A. ASCS Qualifications: A certified member of NADCA.
  - 1. Certification: Employ an ASCS certified by NADCA on a full-time basis.
  - 2. Supervisor Qualifications: Certified as an ASCS by NADCA.
- B. IEP Qualifications: CMI who is certified by ACAC and accredited by CESB.
- C. IEP Qualifications: CMC who is certified by ACAC and accredited by CESB.
- D. CMR Qualifications: Certified by ACAC and accredited by CESB.
- E. CMRS Qualifications: Certified by ACAC and accredited by CESB.

### PART 2 - PRODUCTS

### 2.1 HVAC CLEANING AGENTS

- A. Description:
  - 1. Formulated for each specific soiled coil condition that needs remedy.

## 2.2 ANTIMICROBIAL SURFACE TREATMENT

- A. Description: Specific product selected shall be as recommended by the IEP based on the specific antimicrobial needs of the specific Project conditions.
  - 1. Formulated to kill and inhibit growth of microorganisms.
  - 2. EPA-registered for use in HVAC systems and for the specific application in which it will be used.
  - 3. Have no residual action after drying, with zero VOC off-gassing.
  - 4. OSHA compliant.
  - 5. Treatment shall dry clear to allow continued visual observation of the treated surface.

## PART 3 - EXECUTION

### 3.1 PREPARATION

- A. Inspect HVAC air-distribution equipment, ducts, plenums, and system components to determine appropriate methods, tools, and equipment required for performance of the Work.
- B. Cleaning Plan: Prepare a written plan for air-distribution system cleaning that includes strategies and step-by-step procedures.

- C. Proceed with work only after conditions detrimental to performance of the Work have been corrected and cleaning plan has been approved.
- D. Use the existing service openings, as required for proper cleaning, at various points of the HVAC system for physical and mechanical entry and for inspection.
- E. Mark the position of manual volume dampers and air-directional mechanical devices inside the system prior to cleaning.

# 3.2 CLEANING

- A. Comply with NADCA ACR.
- B. Perform electrical lockout and tagout according to Owner's standards or authorities having jurisdiction.
- C. Remove non-adhered substances and deposits from within the HVAC system.
- D. Systems and Components to Be Cleaned: All air-moving and -distribution equipment.
- E. Collect debris removed during cleaning. Ensure that debris is not dispersed outside the HVAC system during the cleaning process.
  - 1. Particulate Collection: For particulate collection equipment, include adequate filtration to contain debris removed. Locate equipment downwind and away from all air intakes and other points of entry into the building.
  - 2. HEPA filtration with 99.97 percent collection efficiency for particles sized 0.3 micrometer or larger shall be used where the particulate collection equipment is exhausting inside the building,
- F. Control odors and mist vapors during the cleaning and restoration process.
- G. Mark the position of manual volume dampers and air-directional mechanical devices inside the system prior to cleaning. Restore them to their marked position on completion of cleaning.
- H. System components shall be cleaned so that all HVAC system components are visibly clean. On completion, all components must be returned to those settings recorded just prior to cleaning operations.
- I. Clean all air-distribution devices, registers, grilles, and diffusers.
- J. Clean non-adhered substance deposits according to NADCA ACR and the following:
  - 1. Clean air-handling units, airstream surfaces, components, condensate collectors, and drains.
  - 2. Ensure that a suitable operative drainage system is in place prior to beginning washdown procedures.
  - 3. Clean evaporator coils, reheat coils, and other airstream components.

- K. Air-Distribution Systems:
  - 1. Create service openings in the HVAC system as necessary to accommodate cleaning.
  - 2. Mechanically clean air-distribution systems specified to remove all visible contaminants, so that the systems are capable of passing the HVAC System Cleanliness Tests (see NADCA ACR).
- L. Debris removed from the HVAC system shall be disposed of according to applicable Federal, state, and local requirements.
- M. Mechanical Cleaning Methodology:
  - 1. Source-Removal Cleaning Methods: The HVAC system shall be cleaned using sourceremoval mechanical cleaning methods designed to extract contaminants from within the HVAC system and to safely remove these contaminants from the facility. No cleaning method, or combination of methods, shall be used that could potentially damage components of the HVAC system or negatively alter the integrity of the system.
    - a. Use continuously operating vacuum-collection devices to keep each section being cleaned under negative pressure.
    - b. Cleaning methods that require mechanical agitation devices to dislodge debris that is adhered to interior surfaces of HVAC system components shall be equipped to safely remove these devices. Cleaning methods shall not damage the integrity of HVAC system components or damage porous surface materials, such as duct and plenum liners.
  - 2. Cleaning Mineral-Fiber Insulation Components:
    - a. Fibrous-glass thermal or acoustical insulation elements present in equipment or ductwork shall be thoroughly cleaned with HEPA vacuuming equipment while the HVAC system is under constant negative pressure and shall not be permitted to get wet according to NADCA ACR.
    - b. Cleaning methods used shall not cause damage to fibrous-glass components and will render the system capable of passing the HVAC System Cleanliness Tests (see NADCA ACR).
    - c. Fibrous materials that become wet shall be discarded and replaced.
- N. Coil Cleaning:
  - 1. See NADCA ACR, "Coil Surface Cleaning" Section. Type 1, or Type 1 and Type 2, cleaning methods shall be used to render the coil visibly clean and capable of passing coil cleaning verification.
  - 2. Coil drain pans shall be subject to NADCA ACR, "Non-Porous Surfaces Cleaning Verification." Ensure that condensate drain pans are operational.
  - 3. Electric-resistance coils shall be de-energized, locked out, and tagged before cleaning.
  - 4. Cleaning methods shall not cause any appreciable damage to, cause displacement of, inhibit heat transfer, or cause erosion of the coil surface or fins, and shall comply with coil manufacturer's written recommendations.
  - 5. Rinse thoroughly with clean water to remove any latent residues.

- O. Application of Antimicrobial Treatment:
  - 1. Apply antimicrobial agents and coatings if active fungal growth is determined by the IEP to be at Condition 2 or Condition 3 status according to IICRC S520, as analyzed by a laboratory accredited by AIHA-LAP with an EMLAP certificate, and with results interpreted by an IEP. Apply antimicrobial agents and coatings according to manufacturer's written recommendations and EPA registration listing after the removal of surface deposits and debris.
  - 2. Apply antimicrobial treatments and coatings after the system is rendered clean.
  - 3. Apply antimicrobial agents and coatings directly onto surfaces of interior ductwork.
  - 4. Microbial remediation shall be performed by a qualified CMR and CMRS.

### 3.3 CLEANLINESS VERIFICATION

- A. Verify cleanliness according to NADCA ACR, "Verification of HVAC System Cleanliness" Section.
- B. Surface-Cleaning Verification: Perform visual inspection for cleanliness. If no contaminants are evident through visual inspection, the HVAC system shall be considered clean. If visible contaminants are evident through visual inspection, those portions of the system where contaminants are visible shall be re-cleaned and subjected to re-inspection for cleanliness.
- C. Verification of Coil Cleaning: Coil will be considered clean if the coil is free of foreign matter and chemical residue, based on a thorough visual inspection.
- D. Prepare a written cleanliness verification report.

### 3.4 RESTORATION

- A. Restore and repair HVAC air-distribution equipment, ducts, plenums, and components according to NADCA ACR, "Restoration and Repair of Mechanical Systems" Section.
- B. Replace fibrous-glass materials that cannot be restored by cleaning or resurfacing.
- C. Replace damaged insulation.
- D. Ensure that closures do not hinder or alter airflow.
- E. New closure materials, including insulation, shall match opened materials and shall have removable closure panels fitted with gaskets and fasteners.
- F. Restore manual volume dampers and air-directional mechanical devices inside the system to their marked position on completion of cleaning.

END OF SECTION 230130.52

## 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, horizontal, small and medium, squirrel-cage induction motors for use on alternating-current 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 104 deg F and at altitude of 3300 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 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.
- D. Multispeed Motors: Variable torque.
  - 1. For motors with 2:1 speed ratio, consequent pole, single winding.
  - 2. For motors with other than 2:1 speed ratio, separate winding for each speed.
- E. Rotor: Random-wound, squirrel cage.
- F. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
- G. Temperature Rise: Match insulation rating.
- H. Insulation: Class F.
- I. Code Letter Designation:
  - 1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
  - 2. Motors Smaller Than 15 HP: Manufacturer's standard starting characteristic.
- J. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

### 2.4 ADDITIONAL REQUIREMENTS FOR POLYPHASE MOTORS

- A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.
- B. Motors Used with Variable-Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
  - 1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width-modulated inverters.
  - 2. Premium-Efficient Motors: Class B temperature rise; Class F insulation.
  - 3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
  - 4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

## 2.5 SINGLE-PHASE MOTORS

- A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:
  - 1. Permanent-split capacitor.
  - 2. Split phase.
  - 3. Capacitor start, inductor run.

- 4. Capacitor start, capacitor run.
- B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.
- C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
- D. Motors 1/20 HP and Smaller: Shaded-pole type.
- E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION (Not Applicable)

## SECTION 230517 - SLEEVES AND SLEEVE SEALS FOR HVAC PIPING

#### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section Includes:
  - 1. Sleeves.
  - 2. Sleeve-seal systems.
  - 3. Grout.
  - 4. Silicone sealants.
- B. Related Requirements:
  - 1. Section 078413 "Penetration Firestopping" for penetration firestopping installed in fireresistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

#### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

#### 1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

#### PART 2 - PRODUCTS

#### 2.1 SLEEVES

- A. Cast-Iron Pipe Sleeves: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop collar.
- B. Steel Pipe Sleeves: ASTM A53/A53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends and integral welded waterstop collar.
- C. Galvanized-Steel Sheet Pipe Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.
- D. PVC Pipe Sleeves: ASTM D1785, Schedule 40.

### 2.2 SLEEVE-SEAL SYSTEMS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Advance Products & Systems, Inc.
  - 2. CALPICO, Inc.
  - 3. Metraflex Company (The).
  - 4. Pipeline Seal and Insulator, Inc.
  - 5. Proco Products, Inc.
- Β.
- C. Description:
  - 1. Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
  - 2. Designed to form a hydrostatic seal of 20-psig.
  - 3. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size.
  - 4. Pressure Plates: Carbon steel or Composite plastic.
  - 5. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, ASTM B633 of length required to secure pressure plates to sealing elements.

# 2.3 GROUT

- A. Description: Nonshrink, recommended for interior and exterior sealing openings in nonfirerated walls or floors.
- B. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- C. Design Mix: 5000-psi, 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

# 2.4 SILICONE SEALANTS

- A. Silicone, S, NS, 25, NT: Single-component, nonsag, plus 25 percent and minus 25 percent movement capability, nontraffic-use, neutral-curing silicone joint sealant, ASTM C920, Type S, Grade NS, Class 25, use NT.
- B. Silicone, S, P, 25, T, NT: Single-component, pourable, plus 25 percent and minus 25 percent movement capability, traffic- and nontraffic-use, neutral-curing silicone joint sealant; ASTM C920, Type S, Grade P, Class 25, Uses T and NT. Grade P Pourable (self-leveling) formulation is for opening in floors and other horizontal surfaces that are not fire rated.

PART 3 - EXECUTION

## 3.1 SLEEVE INSTALLATION

- A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
- B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.
- C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
  - 1. Cut sleeves to length for mounting flush with both surfaces.
    - a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.
  - 2. Using grout or silicone sealant, seal space outside of sleeves in slabs and walls without sleeve-seal system.
- D. Install sleeves for pipes passing through interior partitions.
  - 1. Cut sleeves to length for mounting flush with both surfaces.
  - 2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
  - 3. Seal annular space between sleeve and piping or piping insulation; use sealants appropriate for size, depth, and location of joint.
- E. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke-Barrier Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping and fill materials specified in Section 078413 "Penetration Firestopping."

## 3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.
- B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal-system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

### 3.3 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
  - 1. Leak Test: After allowing for a full cure, test sleeves and sleeve seals for leaks. Repair leaks and retest until no leaks exist.
- B. Sleeves and sleeve seals will be considered defective if they do not pass tests and inspections.

### 3.4 SLEEVE AND SLEEVE-SEAL SCHEDULE

- A. Use sleeves and sleeve seals for the following piping-penetration applications:
  - 1. Exterior Concrete Walls Above Grade:
    - a. Piping Smaller Than NPS 6: Cast-iron pipe sleeves or Steel-pipe sleeves.
    - b. Piping NPS 6 and Larger: Cast-iron pipe sleeves or Steel-pipe sleeves.
  - 2. Exterior Concrete Walls Below Grade:
    - a. Piping Smaller Than NPS 6: Cast-iron pipe sleeves with sleeve-seal system or Steel-pipe sleeves with sleeve-seal system.
      - 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
    - b. Piping NPS 6 and Larger: Cast-iron pipe sleeves with sleeve-seal system or Steelpipe sleeves with sleeve-seal system.
      - 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
  - 3. Concrete Slabs-on-Grade:
    - a. Piping Smaller Than NPS 6: Cast-iron pipe sleeves with sleeve-seal system or Steel-pipe sleeves with sleeve-seal system.
      - 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
    - b. Piping NPS 6 and Larger: Cast-iron pipe sleeves with sleeve-seal system or Steelpipe sleeves with sleeve-seal system.
      - 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
  - 4. Concrete Slabs Above Grade:
    - a. Piping Smaller Than NPS 6: Steel-pipe sleeves or PVC-pipe sleeves.
    - b. Piping NPS 6 and Larger: Steel-pipe sleeves or PVC-pipe sleeves.

- 5. Interior Partitions:
  - a. Piping Smaller Than NPS 6: Galvanized-steel pipe sleeves or PVC-pipe sleeves.
  - b. Piping NPS 6 and Larger: Galvanized-steel sheet sleeves.

# SECTION 230519 - METERS AND GAGES FOR HVAC PIPING

#### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section Includes:
  - 1. Bimetallic-actuated thermometers.
  - 2. Liquid-in-glass thermometers.
  - 3. Duct-thermometer mounting brackets.
  - 4. Thermowells.
  - 5. Dial-type pressure gages.
  - 6. Gage attachments.
- B. Related Requirements:
  - 1. Section 231123 "Facility Natural-Gas Piping" for gas meters.

#### 1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings:
  - 1. Include diagrams for power, signal, and control wiring.

#### 1.3 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of meter and gage.

#### 1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

### PART 2 - PRODUCTS

#### 2.1 BIMETALLIC-ACTUATED THERMOMETERS

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

- 1. Ashcroft Inc.
- 2. Palmer Wahl Instrumentation Group.
- 3. Trerice, H. O. Co.
- 4. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
- 5. Weiss Instruments, Inc.
- B. Standard: ASME B40.200.
- C. Case: Liquid-filled and sealed type(s); stainless steel with 3-inch nominal diameter.
- D. Dial: Nonreflective aluminum with permanently etched scale markings and scales in deg F .
- E. Connector Type(s): Union joint, rigid, back and rigid, bottom, with unified-inch screw threads.
- F. Connector Size: 1/2 inch, with ASME B1.1 screw threads.
- G. Stem: 0.25 or 0.375 inch in diameter; stainless steel.
- H. Window: Plain glass or plastic.
- I. Ring: Stainless steel.
- J. Element: Bimetal coil.
- K. Pointer: Dark-colored metal.
- L. Accuracy: Plus or minus 1 percent of scale range.

# 2.2 LIQUID-IN-GLASS THERMOMETERS

- A. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Flo Fab Inc.
    - b. Palmer Wahl Instrumentation Group.
    - c. Trerice, H. O. Co.
    - d. Weiss Instruments, Inc.
  - 2. Standard: ASME B40.200.
  - 3. Case: Cast aluminum; 7-inch nominal size unless otherwise indicated.
  - 4. Case Form: Adjustable angle unless otherwise indicated.
  - 5. Tube: Glass with magnifying lens and blue or red organic liquid.
  - 6. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
  - 7. Window: Glass or plastic.
  - 8. Stem: Aluminum and of length to suit installation.

- a. Design for Air-Duct Installation: With ventilated shroud.
- b. Design for Thermowell Installation: Bare stem.
- 9. Connector: 1-1/4 inches, with ASME B1.1 screw threads.
- 10. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.
- B. Plastic-Case, Industrial-Style, Liquid-in-Glass Thermometers:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Ernst Flow Industries.
    - b. Palmer Wahl Instrumentation Group.
    - c. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
    - d. Weiss Instruments, Inc.
  - 2. Standard: ASME B40.200.
  - 3. Case: Plastic; 7-inch nominal size unless otherwise indicated.
  - 4. Case Form: Adjustable angle unless otherwise indicated.
  - 5. Tube: Glass with magnifying lens and blue or red organic liquid.
  - 6. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
  - 7. Window: Glass or plastic.
  - 8. Stem: Aluminum or Brass and of length to suit installation.
    - a. Design for Air-Duct Installation: With ventilated shroud.
    - b. Design for Thermowell Installation: Bare stem.
  - 9. Connector: 1-1/4 inches, with ASME B1.1 screw threads.
  - 10. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

# 2.3 DUCT-THERMOMETER MOUNTING BRACKETS

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

### 2.4 THERMOWELLS

- A. Thermowells:
  - 1. Standard: ASME B40.200.
  - 2. Description: Pressure-tight, socket-type fitting made for insertion in piping tee fitting.
  - 3. Material for Use with Copper Tubing: CNR or CUNI.
  - 4. Material for Use with Steel Piping: CRES or CSA.
  - 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.
- B. Heat-Transfer Medium: Mixture of graphite and glycerin.
- 2.5 DIAL-TYPE PRESSURE GAGES
  - A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:
    - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      - a. AMETEK, Inc.; U.S. Gauge.
      - b. Ashcroft Inc.
      - c. Ernst Flow Industries.
      - d. Flo Fab Inc.
      - e. Noshok.
      - f. Palmer Wahl Instrumentation Group.
      - g. Trerice, H. O. Co.
      - h. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
      - i. Weiss Instruments, Inc.
    - 2. Standard: ASME B40.100.
    - 3. Case: Sealed 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 bottomoutlet type unless back-outlet type is indicated.
    - 6. Movement: Mechanical, with link to pressure element and connection to pointer.
    - 7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi.
    - 8. Pointer: Dark-colored metal.
    - 9. Window: Glass or plastic.
    - 10. Ring: Metal.
    - 11. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.
  - B. Direct-Mounted, Plastic-Case, Dial-Type Pressure Gages:
    - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      - a. AMETEK, Inc.; U.S. Gauge.
      - b. Ashcroft Inc.
      - c. Flo Fab Inc.
      - d. Noshok.
      - e. Palmer Wahl Instrumentation Group.

- f. Weiss Instruments, Inc.
- g. WIKA Instrument Corporation USA.
- h. Winters Instruments U.S.
- 2. Standard: ASME B40.100.
- 3. Case: Sealed type; plastic; 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 bottomoutlet type unless back-outlet type is indicated.
- 6. Movement: Mechanical, with link to pressure element and connection to pointer.
- 7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi.
- 8. Pointer: Dark-colored metal.
- 9. Window: Glass or plastic.
- 10. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

## 2.6 GAGE ATTACHMENTS

- A. Snubbers: ASME B40.100, brass; with NPS 1/4, ASME B1.20.1 pipe threads and porous-metaltype surge-dampening device. Include extension for use on insulated piping.
- B. Siphons: Loop-shaped section of brass pipe with NPS 1/4 pipe threads.
- C. Valves: Brass ball, with NPS 1/4, ASME B1.20.1 pipe threads.

# PART 3 - EXECUTION

## 3.1 INSTALLATION

- A. Install thermowells with socket extending one-third of pipe diameter and in vertical position in piping tees.
- B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.
- C. Install thermowells with extension on insulated piping.
- D. Fill thermowells with heat-transfer medium.
- E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.
- F. Install remote-mounted thermometer bulbs in thermowells and install cases on panels; connect cases with tubing and support tubing to prevent kinks. Use minimum tubing length.
- G. Install duct-thermometer mounting brackets in walls of ducts. Attach to duct with screws.
- H. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.
- I. Install remote-mounted pressure gages on panel.
- J. Install valve and snubber in piping for each pressure gage for fluids (except steam).
- K. Install valve and syphon fitting in piping for each pressure gage for steam.
- L. Install test plugs in piping tees.
- M. Install flow indicators in piping systems in accessible positions for easy viewing.
- N. Install wafer-orifice flowmeter elements between pipe flanges.
- O. Install permanent indicators on walls or brackets in accessible and readable positions.
- P. Install connection fittings in accessible locations for attachment to portable indicators.
- Q. Mount thermal-energy meters on wall if accessible; if not, provide brackets to support meters.
- R. Install thermometers in the following locations:
  - 1. Inlet and outlet of each hydronic zone.
  - 2. Inlet and outlet of each hydronic boiler.
  - 3. Two inlets and two outlets of each chiller.
  - 4. Inlet and outlet of each hydronic coil in air-handling units.
  - 5. Two inlets and two outlets of each hydronic heat exchanger.
  - 6. Inlet and outlet of each thermal-storage tank.
  - 7. Outside-, return-, supply-, and mixed-air ducts.
- S. Install pressure gages in the following locations:
  - 1. Discharge of each pressure-reducing valve.
  - 2. Inlet and outlet of each chiller chilled-water and condenser-water connection.
  - 3. Suction and discharge of each pump.

### 3.2 CONNECTIONS

- A. Install meters and gages adjacent to machines and equipment to allow space for service and maintenance of meters, gages, machines, and equipment.
- B. Connect flowmeter-system elements to meters.
- C. Connect flowmeter transmitters to meters.
- D. Connect thermal-energy meter transmitters to meters.

### 3.3 ADJUSTING

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

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

### 3.4 THERMOMETER SCHEDULE

- A. Thermometers at inlet and outlet of each hydronic zone shall be the following:
  - 1. Liquid-filled, bimetallic-actuated type.
- B. Thermometers at inlet and outlet of each hydronic boiler shall be the following:
  - 1. Liquid-filled, bimetallic-actuated type.
- C. Thermometers at inlets and outlets of each chiller shall be the following:
  - 1. Liquid-filled, bimetallic-actuated type.
- D. Thermometers at inlet and outlet of each hydronic coil in air-handling units and built-up central systems shall be the following:
  - 1. Liquid-filled, bimetallic-actuated type.
- E. Thermometers at inlets and outlets of each hydronic heat exchanger shall be the following:
  - 1. [Liquid-filled, bimetallic-actuated type.
- F. Thermometers at inlet and outlet of each hydronic heat-recovery unit shall be the following:
  - 1. Liquid-filled, bimetallic-actuated type.
- G. Thermometers at inlet and outlet of each thermal-storage tank shall be the following:
  - 1. Liquid-filled, bimetallic-actuated type.
- H. Thermometers at outside-, return-, supply-, and mixed-air ducts shall be the following:
  - 1. Liquid-filled, bimetallic-actuated type.
- I. Thermometer stems shall be of length to match thermowell insertion length.

### 3.5 THERMOMETER SCALE-RANGE SCHEDULE

- A. Scale Range for Chilled-Water Piping: Minus 40 to plus 160 deg F.
- B. Scale Range for Chilled-Water Piping: 0 to 100 deg F.
- C. Scale Range for Chilled-Water Piping: 0 to 150 deg F.
- D. Scale Range for Condenser-Water Piping: 0 to 100 deg F.

- E. Scale Range for Condenser-Water Piping: 0 to 150 deg F.
- F. Scale Range for Condenser-Water Piping: 0 to 250 deg F.
- G. Scale Range for Heating, Hot-Water Piping: 0 to 250 deg F.
- H. Scale Range for Heating, Hot-Water Piping: 20 to 240 deg F.
- I. Scale Range for Heating, Hot-Water Piping: 50 to 400 deg F.
- J. Scale Range for Air Ducts: Minus 40 to plus 160 deg F.
- K. Scale Range for Air Ducts: 0 to 100 deg F.
- L. Scale Range for Air Ducts: 0 to 150 deg F.
- M. Scale Range for Air Ducts: 20 to 240 deg F.

## 3.6 PRESSURE-GAGE SCHEDULE

- A. Pressure gages at discharge of each pressure-reducing valve shall be the following:
  - 1. Sealed, direct-mounted, metal case.
- B. Pressure gages at inlet and outlet of each chiller chilled-water and condenser-water connection shall be the following:
  - 1. Sealed, direct-mounted, metal case.
- C. Pressure gages at suction and discharge of each pump shall be the following:
  - 1. Sealed, direct-mounted, metal case.

### END OF SECTION 230519

## SECTION 230523.12 - BALL VALVES FOR HVAC PIPING

### PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:1. Bronze ball valves.

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of valve.

#### PART 2 - PRODUCTS

## 2.1 GENERAL REQUIREMENTS FOR VALVES

- A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
- B. ASME Compliance:
  - 1. ASME B1.20.1 for threads for threaded-end valves.
  - 2. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
  - 3. ASME B16.18 for solder-joint connections.
  - 4. ASME B31.1 for power piping valves.
  - 5. ASME B31.9 for building services piping valves.
- C. 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.
- D. To assure uniformity and compatibility of piping components in grooved end piping systems, all grooved products utilized shall be supplied by Victaulic. Grooving tools shall be supplied by the same manufacturer as the grooved components.
- E. Refer to HVAC valve schedule articles for applications of valves.
- F. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- G. Valve Sizes: Same as upstream piping unless otherwise indicated.
- H. Valve Actuator Types:

- 1. Gear Actuator: For quarter-turn valves NPS 4 and larger.
- 2. Handlever: For quarter-turn valves smaller than NPS 4.
- I. Valves in Insulated Piping:
  - 1. Include 2-inch stem extensions.
  - 2. Extended operating handle of nonthermal-conductive material, and protective sleeves that allow operation of valves without breaking the vapor seals or disturbing insulation.
  - 3. Memory stops that are fully adjustable after insulation is applied.
- J. Valve Bypass and Drain Connections: MSS SP-45.

### 2.2 BRONZE BALL VALVES

- A. Bronze Ball Valves, Two-Piece with Full Port and Bronze or Brass Trim, Threaded Ends:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Apollo Valves #77C-100.
    - b. Milwaukee Valve Company.
    - c. NIBCO INC.
  - 2. Description:
    - 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: Bronze.
    - i. Ball: Chrome-plated brass.
    - j. Port: Full.
- B. Bronze Ball Valves, Two-Piece with Full Port and Stainless-Steel Trim:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Apollo Valves #77C-140.
    - b. Milwaukee Valve Company.
    - c. NIBCO INC.
  - 2. Description:
    - 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, vented.
- j. Port: Full.

### PART 3 - EXECUTION

### 3.1 VALVE INSTALLATION

- A. Install valves with unions or flanges at 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.

### 3.2 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

- A. 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.
- B. Select valves with the following end connections:
  - 1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valveend option or press-end option is indicated in valve schedules below.
  - 2. For Steel Piping, NPS 2 and Smaller: Threaded ends.

## 3.3 CHILLED-WATER VALVE SCHEDULE

- A. Pipe NPS 2 and Smaller: Bronze ball valves, two piece, with bronze trim, full port, threaded or solder-joint ends.
  - 1. Valves may be provided with solder-joint ends instead of threaded ends.

### 3.4 CONDENSER-WATER VALVE SCHEDULE

- A. Pipe NPS 2 and Smaller: Bronze ball valves, two piece, with bronze trim, full port, threaded or solder-joint ends.
  - 1. Valves may be provided with solder-joint ends instead of threaded ends.

# 3.5 HEATING-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller: Bronze ball valves, two piece, with bronze trim, full port, threaded or solder-joint ends.

END OF SECTION 230523.12

## SECTION 230523.13 - BUTTERFLY VALVES FOR HVAC PIPING

#### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section Includes:
  - 1. Iron, single-flange butterfly valves.
  - 2. Bronze, grooved-end butterfly valves.
  - 3. High-performance butterfly valves.
  - 4. Chainwheels.

#### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of valve.

### PART 2 - PRODUCTS

- 2.1 GENERAL REQUIREMENTS FOR VALVES
  - A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
  - B. ASME Compliance:
    - 1. ASME B16.1 for flanges on iron valves.
    - 2. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
    - 3. ASME B31.1 for power piping valves.
    - 4. ASME B31.9 for building services piping valves.
  - C. To assure uniformity and compatibility of piping components in grooved end piping systems, all grooved products utilized shall be supplied by Victaulic. Grooving tools shall be supplied by the same manufacturer as the grooved components.
  - D. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
  - E. Valve Sizes: Same as upstream piping unless otherwise indicated.
  - F. Valve Actuator Types:
    - 1. Gear Actuator: For valves NPS 8 and larger.
    - 2. Handlever: For valves NPS 6 and smaller.

- 3. Chainwheel: Device for attachment to gear, stem, or other actuator of size and with chain for mounting height, according to "Valve Installation" Article.
- G. Valves in Insulated Piping: With 2-inch stem extensions with extended necks.

## 2.2 IRON, SINGLE-FLANGE BUTTERFLY VALVES

- A. Iron, Single-Flange Butterfly Valves with Aluminum-Bronze Disc:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.
    - b. Apollo Valves #143.
    - c. DeZurik Water Controls.
    - d. Milwaukee Valve Company.
    - e. NIBCO INC.
  - 2. Description:
    - 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 A126, cast iron or ASTM A536, ductile iron.
    - e. Seat: EPDM.
    - f. Stem: One- or two-piece stainless steel.
    - g. Disc: Aluminum bronze.
- B. Iron, Single-Flange Butterfly Valves with Ductile-Iron Disc:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.
    - b. Apollo Valves #143.
    - c. DeZurik Water Controls.
    - d. Milwaukee Valve Company.
    - e. NIBCO INC.
  - 2. Description:
    - 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 A126, cast iron or ASTM A536, ductile iron.
    - e. Seat: EPDM.

- f. Stem: One- or two-piece stainless steel.
- g. Disc: Nickel-plated or -coated ductile iron.
- C. Iron, Single-Flange Butterfly Valves with Stainless-Steel Disc:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.
    - b. Apollo Valves #143.
    - c. DeZurik Water Controls.
    - d. Milwaukee Valve Company.
    - e. NIBCO INC.
  - 2. Description:
    - 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 A126, cast iron or ASTM A536, ductile iron.
    - e. Seat: EPDM.
    - f. Stem: One- or two-piece stainless steel.
    - g. Disc: Stainless steel.

### 2.3 IRON, GROOVED-END BUTTERFLY VALVES:

- A. 175 CWP, Iron, Grooved-End Butterfly Valves:
  - 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. Victaulic Company Vic<sup>®</sup>-300 MasterSeal<sup>™</sup> and Vic<sup>®</sup>-300 AGS.
  - 2. Description:
    - a. Standard: MSS SP-67, Type I.
    - b. CWP Rating: 175 psig.
    - c. Body Material: Coated, ductile iron.
    - d. Stem: Two-piece stainless steel.
      - 1) Stem shall be offset from the disc centerline to provide complete 360degree circumferential seating.
    - e. Disc: Coated, ductile iron.
    - f. Seal: EPDM.
      - 1) Pressure responsive in sizes though NPS 12.
- B. 300 CWP, Iron, Grooved-End Butterfly Valves:

- 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. Victaulic Company Vic<sup>®</sup>-300 MasterSeal<sup>™</sup> and Vic<sup>®</sup>-300 AGS.
- 2. Description:

f.

- a. Standard: MSS SP-67, Type I.
- b. NPS 8 (DN 50) and Smaller CWP Rating: 300 psig.
- c. NPS 10 (DN 250) and Larger CWP Rating: 300 psig.
- d. Body Material: Coated, ductile iron.
- e. Stem: Two-piece stainless steel.
  - 1) Stem shall be offset from the disc centerline to provide complete 360degree circumferential seating.
  - Disc: Coated, ductile iron, Offset.
- g. Seal: EPDM.
  - 1) Pressure responsive in szies though NPS 12.

### 2.4 BRONZE, GROOVED END BUTTERFLY VALVES

- A. 300 CWP, Bronze, Grooved-End Butterfly Valves
  - 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. Victaulic Company ; Series 608.
  - 2. Description:
    - a. Standard: MSS SP-67.
    - b. NPS 2-1/2 thru NPS 6 CWP Rating: 300 psig.
    - c. Body Material: Bronze.
    - d. Stem: Integrally cast with disc.
    - e. Disc: Coated, ductile iron.
    - f. Seal / Disc Coating: EPDM

## 2.5 CHAINWHEELS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Babbitt Steam Specialty Co.
  - 2. Roto Hammer Industries.
  - 3. Trumbull Industries.

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- B. Description: Valve actuation assembly with sprocket rim, chain guides, chain, and attachment brackets for mounting chainwheels directly to hand wheels.
  - 1. Sprocket Rim with Chain Guides: Ductile iron, of type and size required for valve.
  - 2. Chain: Hot-dip, galvanized steel, of size required to fit sprocket rim.

### PART 3 - EXECUTION

### 3.1 VALVE INSTALLATION

- A. Install valves with unions or flanges at 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 chainwheels on operators for butterfly valves NPS 4 and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor.

### 3.2 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.

## 3.3 CHILLED-WATER VALVE SCHEDULE

- A. Pipe NPS 2-1/2 and Larger:
  - 1. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12: Aluminum-bronze or Ductileiron disc, 200 CWP, and EPDM seat.
  - 2. Bronze, Grooved-End Butterfly Valves, NPS 2-1/2 to NPS 6: 300 CWP.

### 3.4 CONDENSER-WATER VALVE SCHEDULE

- A. Pipe NPS 2-1/2 and Larger:
  - 1. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12: Aluminum-bronze or Ductileiron disc, 200 CWP, and EPDM seat.
  - 2. Bronze, Grooved-End Butterfly Valves, NPS 2-1/2 to NPS 6: 300 CWP.

# 3.5 HEATING-WATER VALVE SCHEDULE

- A. Pipe NPS 2-1/2 and Larger:
  - 1. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12: Aluminum-bronze or Ductileiron disc, 200 CWP, and EPDM seat.
  - 2. Bronze, Grooved-End Butterfly Valves, NPS 2-1/2 to NPS 6: 300 CWP.

END OF SECTION 230523.13

## SECTION 230523.14 - CHECK VALVES FOR HVAC PIPING

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section Includes:
  - 1. Bronze lift check valves.
  - 2. Bronze swing check valves.
  - 3. Iron swing check valves.
  - 4. Iron grooved-end swing check valves.

#### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of valve.

### PART 2 - PRODUCTS

#### 2.1 GENERAL REQUIREMENTS FOR VALVES

- A. Source Limitations for Valves: Obtain each type of valve from single source 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 B16.18 for solder joint.
  - 5. ASME B31.1 for power piping valves.
  - 6. ASME B31.9 for building services piping valves.
- C. To assure uniformity and compatibility of piping components in grooved end piping systems, all grooved products utilized shall be supplied by Victaulic. Grooving tools shall be supplied by the same manufacturer as the grooved components.
- 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-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- F. Valve Sizes: Same as upstream piping unless otherwise indicated.

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

# 2.2 BRONZE SWING CHECK VALVES

- A. Bronze Swing Check Valves with Bronze Disc, Class 125:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. American Valve, Inc.
    - b. Apollo Valves #161T.
    - c. Crane Co.; Crane Valve Group; Stockham Division.
    - d. Milwaukee Valve Company.
    - e. NIBCO INC.
  - 2. Description:
    - a. Standard: MSS SP-80, Type 3.
    - b. CWP Rating: 200 psig.
    - c. Body Design: Horizontal flow.
    - d. Body Material: ASTM B62, bronze.
    - e. Ends: Threaded.
    - f. Disc: Bronze.
- B. Bronze Swing Check Valves with Nonmetallic Disc, Class 125:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Apollo Valves #163T.
    - b. Milwaukee Valve Company.
    - c. NIBCO INC.
  - 2. Description:
    - a. Standard: MSS SP-80, Type 4.
    - b. CWP Rating: 200 psig.
    - c. Body Design: Horizontal flow.
    - d. Body Material: ASTM B62, bronze.
    - e. Ends: Threaded.
    - f. Disc: PTFE.

### 2.3 IRON SWING CHECK VALVES

A. Iron Swing Check Valves with Metal Seats, Class 125:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Apollo Valves #910F.
  - b. Milwaukee Valve Company.
  - c. NIBCO INC.
- 2. Description:
  - a. Standard: MSS SP-71, Type I.
  - b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
  - c. NPS 14 to NPS 24, CWP Rating: 150 psig.
  - d. Body Design: Clear or full waterway.
  - e. Body Material: ASTM A126, gray iron with bolted bonnet.
  - f. Ends: Flanged.
  - g. Trim: Bronze.
  - h. Gasket: Asbestos free.
- B. Iron Swing Check Valves with Nonmetallic-to-Metal Seats, Class 125:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Crane Co.; Crane Valve Group; Crane Valves.
    - b. Crane Co.; Crane Valve Group; Stockham Division.
  - 2. Description:
    - a. Standard: MSS SP-71, Type I.
    - b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
    - c. NPS 14 to NPS 24, CWP Rating: 150 psig.
    - d. Body Design: Clear or full waterway.
    - e. Body Material: ASTM A126, gray iron with bolted bonnet.
    - f. Ends: Flanged.
    - g. Trim: Composition.
    - h. Seat Ring: Bronze.
    - i. Disc Holder: Bronze.
    - j. Disc: PTFE.
    - k. Gasket: Asbestos free.

### 2.4 IRON SWING CHECK VALVES WITH CLOSURE CONTROL

- A. Iron Swing Check Valves with Lever- and Spring-Closure Control, Class 125:
  - 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. NIBCO INC.
- 2. Description:
  - a. Standard: MSS SP-71, Type I.
  - b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
  - c. NPS 14 to NPS 24, CWP Rating: 150 psig.
  - d. Body Design: Clear or full waterway.
  - e. Body Material: ASTM A126, gray iron with bolted bonnet.
  - f. Ends: Flanged.
  - g. Trim: Bronze.
  - h. Gasket: Asbestos free.
  - i. Closure Control: Factory-installed, exterior lever and spring.
- B. Iron Swing Check Valves with Lever and Weight-Closure Control, Class 125:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Apollo Valves #910FLW.
    - b. Milwaukee Valve Company.
    - c. NIBCO INC.
  - 2. Description:
    - a. Standard: MSS SP-71, Type I.
    - b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
    - c. NPS 14 to NPS 24, CWP Rating: 150 psig.
    - d. Body Design: Clear or full waterway.
    - e. Body Material: ASTM A126, gray iron with bolted bonnet.
    - f. Ends: Flanged.
    - g. Trim: Bronze.
    - h. Gasket: Asbestos free.
    - i. Closure Control: Factory-installed, exterior lever and weight.

## 2.5 IRON, GROOVED-END SWING CHECK VALVES

- A. 300/365 CWP, Iron, Grooved-End Swing Check Valves:
  - 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. Victaulic Company Series 712, 716H/716, or 779.
  - 2. Description:

- a. CWP Rating: 300 psig.
- b. Body Material: ASTM A 536, ductile iron.
- c. Seal: EPDM.
- d. Disc: Swing type, or Spring operated, ductile iron or stainless steel, for installation in the vertical or horizontal position.

### PART 3 - EXECUTION

### 3.1 VALVE INSTALLATION

- A. Install valves with unions or flanges at 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 swing check valves for proper direction of flow in horizontal position with hinge pin level.

### 3.2 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.

## 3.3 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

- A. If valve applications are not indicated, use the following:
  - 1. Pump-Discharge Check Valves:
    - a. NPS 2 and Smaller: Bronze swing check valves with bronze or nonmetallic disc.
    - b. NPS 2-1/2 and Larger: Iron swing check valves with lever and weight or with spring.
- B. 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.
- C. Select valves, except wafer types, with the following end connections:
  - 1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valveend option is indicated in valve schedules.
  - 2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules.

- 3. For Copper Tubing, NPS 5 and Larger: Flanged ends.
- 4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
- 5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules.
- 6. For Steel Piping, NPS 5 and Larger: Flanged ends.

## 3.4 CHILLED-WATER VALVE SCHEDULE

- A. Pipe NPS 2 and Smaller:
  - 1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
  - 2. Bronze swing check valves with bronze disc, Class 125.
- B. Pipe NPS 2-1/2 and Larger:
  - 1. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.
  - 2. NPS 2-1/2 to NPS 12: Iron swing check valves with lever and spring or weight closure control, Class 125.
  - 3. Iron swing check valves with metal or nonmetallic-to-metal seats, Class 125.

## 3.5 CONDENSER-WATER VALVE SCHEDULE

- A. Pipe NPS 2 and Smaller:
  - 1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
  - 2. Bronze swing check valves with bronze disc, Class 125.
- B. Pipe NPS 2-1/2 and Larger:
  - 1. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.
  - 2. NPS 2-1/2 to NPS 12: Iron swing check valves with lever and spring or weight closure control, Class 125.
  - 3. Iron swing check valves with metal or nonmetallic-to-metal seats, Class 125.

## 3.6 HEATING-WATER VALVE SCHEDULE

- A. Pipe NPS 2 and Smaller:
  - 1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
  - 2. Bronze swing check valves with bronze disc, Class 125.
- B. Pipe NPS 2-1/2 and Larger:
  - 1. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.
  - 2. NPS 2-1/2 to NPS 12: Iron swing check valves with lever and spring or weight closure control, Class 125.
  - 3. Iron swing check valves with metal or nonmetallic-to-metal seats, Class 125.

END OF SECTION 230523.14

## SECTION 230523.15 - GATE VALVES FOR HVAC PIPING

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section Includes:
  - 1. Bronze gate valves.
  - 2. Iron gate valves.
  - 3. Chainwheels.

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of valve.

#### PART 2 - PRODUCTS

### 2.1 GENERAL REQUIREMENTS FOR VALVES

- A. Source Limitations for Valves: Obtain each type of valve from single source 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 B16.18 for solder joint.
  - 5. ASME B31.1 for power piping valves.
  - 6. ASME B31.9 for building services piping valves.
- C. 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.
- D. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- E. Valve Sizes: Same as upstream piping unless otherwise indicated.
- F. RS Valves in Insulated Piping: With 2-inch stem extensions.
- G. Valve Bypass and Drain Connections: MSS SP-45.

### 2.2 BRONZE GATE VALVES

- A. Bronze Gate Valves, NRS, Class 125:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Apollo Valves #102S/102T.
    - b. Milwaukee Valve Company.
    - c. NIBCO INC.
    - d. Red-White Valve Corporation.
  - 2. Description:
    - a. Standard: MSS SP-80, Type 1.
    - b. CWP Rating: 200 psig.
    - c. Body Material: ASTM B62, bronze with integral seat and screw-in bonnet.
    - d. Ends: Threaded or solder joint.
    - e. Stem: Bronze.
    - f. Disc: Solid wedge; bronze.
    - g. Packing: Asbestos free.
    - h. Handwheel: Malleable iron.
- B. Bronze Gate Valves, RS, Class 125:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Apollo Valves #101S/101T.
    - b. Milwaukee Valve Company.
    - c. NIBCO INC.
  - 2. Description:
    - a. Standard: MSS SP-80, Type 2.
    - b. CWP Rating: 200 psig.
    - c. Body Material: ASTM B62, bronze with integral seat and screw-in bonnet.
    - d. Ends: Threaded or solder joint.
    - e. Stem: Bronze.
    - f. Disc: Solid wedge; bronze.
    - g. Packing: Asbestos free.
    - h. Handwheel: Malleable iron.
- C. Bronze Gate Valves, NRS, Class 150:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Apollo Valves #106T.

- b. Milwaukee Valve Company.
- c. NIBCO INC.
- 2. Description:
  - a. Standard: MSS SP-80, Type 1.
  - b. CWP Rating: 300 psig.
  - c. Body Material: ASTM B62, 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.
- D. Bronze Gate Valves, RS, Class 150:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Apollo Valves #107T.
    - b. Milwaukee Valve Company.
    - c. NIBCO INC.
  - 2. Description:
    - a. Standard: MSS SP-80, Type 2.
    - b. CWP Rating: 300 psig.
    - c. Body Material: ASTM B62, 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.

## 2.3 IRON GATE VALVES

- A. Iron Gate Valves, NRS, Class 125:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Apollo Valves #610F.
    - b. Milwaukee Valve Company.
    - c. NIBCO INC.
  - 2. Description:
    - a. Standard: MSS SP-70, Type I.

- 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 A126, gray iron with bolted bonnet.
- e. Ends: Flanged.
- f. Trim: Bronze.
- g. Disc: Solid wedge.
- h. Packing and Gasket: Asbestos free.
- B. Iron Gate Valves, OS&Y, Class 125:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Apollo Valves #611F.
    - b. Milwaukee Valve Company.
    - c. NIBCO INC.
  - 2. Description:
    - a. Standard: MSS SP-70, Type I.
    - 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 A126, gray iron with bolted bonnet.
    - e. Ends: Flanged.
    - f. Trim: Bronze.
    - g. Disc: Solid wedge.
    - h. Packing and Gasket: Asbestos free.

### 2.4 CHAINWHEELS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Babbitt Steam Specialty Co.
  - 2. Roto Hammer Industries.
  - 3. Trumbull Industries.
- B. Description: Valve actuation assembly with sprocket rim, chain guides, chain, and attachment brackets for mounting chainwheels directly to hand wheels.
  - 1. Sprocket Rim with Chain Guides: Ductile iron, of type and size required for valve.
  - 2. Chain: Hot-dip-galvanized steel, of size required to fit sprocket rim.

### PART 3 - EXECUTION

### 3.1 VALVE INSTALLATION

- A. Install valves with unions or flanges at 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 chainwheels on operators for gate valves NPS 4 and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor.

### 3.2 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.

#### 3.3 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

- A. If valve applications are not indicated, use the following:
  - 1. Shutoff Service: Gate valves.
- B. 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.
- C. Select valves, except wafer types, with the following end connections:
  - 1. For Copper Tubing, NPS 2 and Smaller: Threaded ends, except where solder-joint valveend option is indicated in valve schedules below.
  - 2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends, except where threaded valve-end option is indicated in valve schedules below.
  - 3. For Copper Tubing, NPS 5 and Larger: Flanged ends.
  - 4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
  - 5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends, except where threaded valve-end option is indicated in valve schedules below.
  - 6. For Steel Piping, NPS 5 and Larger: Flanged ends.

### 3.4 CHILLED-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller: Bronze valves, NRS, Class 125, with soldered or threaded ends.

B. Pipe NPS 2-1/2 and Larger: Iron gate valves, NRS OS&Y, Class 125.

# 3.5 CONDENSER-WATER VALVE SCHEDULE

- A. Pipe NPS 2 and Smaller: Bronze valves, NRS, Class 125, with soldered or threaded ends.
- B. Pipe NPS 2-1/2 and Larger: Iron gate valves, NRS OS&Y, Class 125.

## 3.6 HEATING-WATER VALVE SCHEDULE

- A. Pipe NPS 2 and Smaller: Bronze valves, NRS, Class 125, with soldered or threaded ends.
- B. Pipe NPS 2-1/2 and Larger: Iron gate valves, NRS OS&Y, Class 125.

END OF SECTION 230523.15

### SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

### PART 1 - GENERAL

#### 1.1 SUMMARY

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

#### B. Related Requirements:

1. Section 233113 "Metal Ducts" for duct hangers and supports.

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

### 1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

### 1.4 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, Section IX.

### PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design trapeze pipe hangers and equipment supports.

- B. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.
  - 1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
  - 2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
  - 3. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

## 2.2 METAL PIPE HANGERS AND SUPPORTS

- A. Carbon-Steel Pipe Hangers and Supports:
  - 1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
  - 2. Galvanized Metallic Coatings: Pregalvanized, hot-dip galvanized, or electro-galvanized.
  - 3. Nonmetallic Coatings: Plastic coated, or epoxy powder-coated.
  - 4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
  - 5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.
- B. Stainless-Steel Pipe Hangers and Supports:
  - 1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
  - 2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
  - 3. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.
- C. Copper Pipe and Tube Hangers:
  - 1. Description: MSS SP-58, Types 1 through 58, copper-plated steel, factory-fabricated components.
  - 2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-plated steel.

## 2.3 TRAPEZE PIPE HANGERS

A. Description: MSS SP-58, 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.

## 2.4 THERMAL-HANGER SHIELD INSERTS

A. Insulation-Insert Material for Cold Piping: ASTM C552, Type II cellular glass with 100-psi or ASTM C591, Type VI, Grade 1 polyisocyanurate with 125-psi minimum compressive strength and vapor barrier.

- B. Insulation-Insert Material for Hot Piping: Water-repellent-treated, ASTM C533, Type I calcium silicate with 100-psi, ASTM C552, Type II cellular glass with 100-psi or ASTM C591, Type VI, Grade 1 polyisocyanurate with 125-psi minimum compressive strength.
- C. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.
- D. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
- E. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

### 2.5 FASTENER SYSTEMS

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

### 2.6 EQUIPMENT SUPPORTS

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

## 2.7 MATERIALS

- A. Aluminum: ASTM B221.
- B. Carbon Steel: ASTM A1011/A1011M.
- C. Structural Steel: ASTM A36/A36M, carbon-steel plates, shapes, and bars; black and galvanized.
- D. Stainless Steel: ASTM A240/A240M.
- E. Grout: ASTM C1107/C1107M, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
  - 1. Properties: Nonstaining, noncorrosive, and nongaseous.
  - 2. Design Mix: 5000-psi, 28-day compressive strength.

### PART 3 - EXECUTION

### 3.1 APPLICATION

- A. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.
- B. 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.

## 3.2 HANGER AND SUPPORT INSTALLATION

- A. Metal Pipe-Hanger Installation: Comply with MSS SP-58. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.
- B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-58. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.
  - 1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
  - 2. Field fabricate from ASTM A36/A36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.
- C. Fiberglass Pipe-Hanger Installation: Comply with applicable portions of MSS SP-58. Install hangers and attachments as required to properly support piping from building structure.
- D. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled strut systems.
- E. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
- F. Fastener System Installation:
  - 1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches (100 mm) thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
  - 2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
- G. Pipe Stand Installation:

- 1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
- 2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 077200 "Roof Accessories" for curbs.
- H. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- I. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
- J. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- K. Install lateral bracing with pipe hangers and supports to prevent swaying.
- L. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 (DN 65) and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.
- M. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- N. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.
- O. Insulated Piping:
  - 1. Attach clamps and spacers to piping.
    - a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
    - b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
    - c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
  - 2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
    - a. Option: Thermal-hanger shield inserts may be used. Include steel weightdistribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
  - 3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.

- a. Option: Thermal-hanger shield inserts may be used. Include steel weightdistribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
- 4. Shield Dimensions for Pipe: Not less than the following:
  - a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
  - b. NPS 4: 12 inches long and 0.06 inch thick.
  - c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
  - d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
  - e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.
- 5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
- 6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

## 3.3 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.

### 3.4 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.

### 3.5 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.

## 3.6 PAINTING

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
  - 1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.
- B. Touchup: Comply with requirements in Section 099123 "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 A780/A780M.

### 3.7 HANGER AND SUPPORT SCHEDULE

- A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.
- B. Comply with MSS SP-58 for pipe-hanger selections and applications that are not specified in piping system Sections.
- C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.
- D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- E. Use carbon-steel pipe hangers and supports, metal trapeze pipe hangers, and metal framing systems and attachments for general service applications.
- F. Use stainless-steel pipe hangers and corrosion-resistant attachments for hostile environment applications.
- G. Use copper-plated pipe hangers and copper attachments for copper piping and tubing.
- H. Use padded hangers for piping that is subject to scratching.
- I. Use thermal-hanger shield inserts for insulated piping and tubing.
- J. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
  - 1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.

- 2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F, pipes NPS 4 to NPS 24, requiring up to 4 inches of insulation.
- 3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.
- 4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.
- 5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow offcenter closure for hanger installation before pipe erection.
- 6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8.
- 7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
- 8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
- 9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
- 10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8.
- 11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3.
- 12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
- 13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
- 14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steelpipe base stanchion support and cast-iron floor flange or carbon-steel plate.
- 15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steelpipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with Ubolt to retain pipe.
- 16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
- 17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.
- 18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction might occur.
- 19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is unnecessary.
- 20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is unnecessary.
- 21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.
- K. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

- 1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
- 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.
- L. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
  - 1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
  - 2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
  - 3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
  - 4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
  - 5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.
- M. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
  - 1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
  - 2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
  - 3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
  - 4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
  - 5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
  - 6. C-Clamps (MSS Type 23): For structural shapes.
  - 7. 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 Ibeams for heavy loads.
  - 10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel Ibeams 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.

- N. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
  - 1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
  - 2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
  - 3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.
- O. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
  - 1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
  - 2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
  - 3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
  - 4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
  - 5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
  - 6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
  - 7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
  - 8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
    - a. Horizontal (MSS Type 54): Mounted horizontally.
    - b. Vertical (MSS Type 55): Mounted vertically.
    - c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.
- P. Comply with MSS SP-58 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.
- Q. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION 230529
# SECTION 230553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

### PART 1 - GENERAL

### 1.1 SUMMARY

- A. Section Includes:
  - 1. Equipment labels.
  - 2. Warning signs and labels.
  - 3. Pipe labels.
  - 4. Duct labels.

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

### PART 2 - PRODUCTS

### 2.1 EQUIPMENT LABELS

- A. Metal Labels for Equipment:
  - 1. Material and Thickness: Brass, 0.032-inch or aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
  - 2. Letter Color: Black.
  - 3. Background Color: White.
  - 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.
  - 6. Fasteners: Stainless-steel rivets.
  - 7. 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, 1/16 inch thick, and having predrilled holes for attachment hardware.
  - 2. Letter Color: Black.
  - 3. Background Color: White.
  - 4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
  - 5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

- 6. 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.
- 7. Fasteners: Stainless-steel rivets.
- 8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- C. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.
- D. Equipment Label Schedule: For each item of equipment to be labeled, 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.

### 2.2 WARNING SIGNS AND LABELS

- A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.
- B. Letter Color: Black.
- C. Background Color: White.
- 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.
- H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- I. Label Content: Include caution and warning information plus emergency notification instructions.
- 2.3 PIPE LABELS

Α.

- B. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction according to ASME A13.1.
- C. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.
- D. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
- E. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include pipe size and 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: At least 1/2 inch for viewing distances up to 72 inches.

# 2.4 DUCT LABELS

- A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.
- B. Letter Color: Black.
- C. Background Color: White.
- 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 duct size and 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.

### 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 EQUIPMENT LABEL INSTALLATION

- A. Install or permanently fasten labels on each major item of mechanical equipment.
- B. Locate equipment labels where accessible and visible.

### 3.3 PIPE LABEL INSTALLATION

- A. Piping Color-Coding: Painting of piping is specified in Section 099123 "Interior Painting."
- B. 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 branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
  - 3. Near penetrations and on both sides of through walls, floors, ceilings, and inaccessible enclosures.
  - 4. At access doors, manholes, and similar access points that permit view of concealed piping.
  - 5. Near major equipment items and other points of origination and termination.
  - 6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
  - 7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.
- C. Pipe Label Color Schedule:
  - 1. Chilled-Water Piping: White letters on a safety-green background.
  - 2. Condenser-Water Piping: White letters on a safety-green background.
  - 3. Heating Water Piping: White letters on a safety-green background.
  - 4. Refrigerant Piping: Black letters on a safety-white background.
  - 5. Low-Pressure Steam Piping: Black letters on a safety-white background.
  - 6. High-Pressure Steam Piping: Black letters on a safety-white background.
  - 7. Steam Condensate Piping: Black letters on a safety-white background.

# 3.4 DUCT LABEL INSTALLATION

- A. Install plastic-laminated or self-adhesive duct labels with permanent adhesive on air ducts in the following color codes:
  - 1. Blue: For cold-air supply ducts.
  - 2. Yellow: For hot-air supply ducts.
  - 3. Green: For exhaust-, outside-, relief-, return-, and mixed-air ducts.
- B. 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.

END OF SECTION 230553

# SECTION 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

### PART 1 - GENERAL

### 1.1 SUMMARY

- A. Section Includes:
  - 1. Balancing Air Systems:
    - a. Constant-volume air systems.

#### 1.2 DEFINITIONS

- A. AABC: Associated Air Balance Council.
- B. NEBB: National Environmental Balancing Bureau.
- C. TAB: Testing, adjusting, and balancing.
- D. TABB: Testing, Adjusting, and Balancing Bureau.
- E. TAB Specialist: An independent entity meeting qualifications to perform TAB work.
- F. TDH: Total dynamic head.

### 1.3 ACTION SUBMITTALS

A. TAB Report: Documentation indicating that Work complies with ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."

### 1.4 INFORMATIONAL SUBMITTALS

- A. Strategies and Procedures Plan: Within 90 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.
- B. Certified TAB reports.

### 1.5 QUALITY ASSURANCE

- A. TAB Specialists Qualifications: Certified by AABC.
  - 1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC.

- 2. TAB Technician: Employee of the TAB specialist and certified by AABC as a TAB technician.
- B. TAB Specialists Qualifications: Certified by NEBB or TABB.
  - 1. TAB Field Supervisor: Employee of the TAB specialist and certified by NEBB or TABB.
  - 2. TAB Technician: Employee of the TAB specialist and certified by NEBB or TABB as a TAB technician.
- C. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."
- D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.7.2.3 "System Balancing."
- PART 2 PRODUCTS (Not Applicable)

### PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems designs that may preclude proper TAB of systems and equipment.
- B. Examine 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.
- C. Examine the approved submittals for HVAC systems and equipment.
- D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems output, and statements of philosophies and assumptions about HVAC system and equipment controls.
- E. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.
- F. Examine equipment performance data including fan and pump curves.
  - 1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
  - 2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment

performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

- G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.
- H. Examine test reports specified in individual system and equipment Sections.
- I. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.
- J. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.
- K. Examine strainers. Verify that startup screens have been replaced by permanent screens with indicated perforations.
- L. Examine control valves for proper installation for their intended function of throttling, diverting, or mixing fluid flows.
- M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- N. Examine system pumps to ensure absence of entrained air in the suction piping.
- O. Examine operating safety interlocks and controls on HVAC equipment.
- P. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

### 3.2 PREPARATION

- A. Prepare a TAB plan that includes strategies and step-by-step procedures for balancing the systems.
- B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:
  - 1. Airside:
    - a. Duct systems are complete with terminals installed.
    - b. Volume, smoke, and fire dampers are open and functional.
    - c. Clean filters are installed.
    - d. Fans are operating, free of vibration, and rotating in correct direction.
    - e. Variable-frequency controllers' startup is complete and safeties are verified.
    - f. Automatic temperature-control systems are operational.
    - g. Ceilings are installed.

- h. Windows and doors are installed.
- i. 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.

### 3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

- A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance" or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and in this Section.
- B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.
  - 1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
  - 2. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 233300 "Air Duct Accessories."
  - 3. 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.

### 3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

- A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. 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 exhaustair dampers through the supply-fan discharge and mixing dampers.
- F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- G. Verify that motor starters are equipped with properly sized thermal protection.
- H. Check dampers for proper position to achieve desired airflow path.
- I. Check for airflow blockages.
- J. Check condensate drains for proper connections and functioning.
- K. Check for proper sealing of air-handling-unit components.
- L. Verify that air duct system is sealed as specified in Section 233113 "Metal Ducts."

### 3.5 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

- A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.
  - 1. Measure total airflow.
    - a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
    - b. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
    - c. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
    - d. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.
  - 2. Measure fan static pressures as follows:

- a. Measure static pressure directly at the fan outlet or through the flexible connection.
- b. Measure static pressure directly at the fan inlet or through the flexible connection.
- c. Measure static pressure across each component that makes up the air-handling system.
- d. Report artificial loading of filters at the time static pressures are measured.
- 3. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
- 4. Obtain approval from Architect for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
- 5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fanmotor 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 brake horsepower.
- B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.
  - 1. Measure airflow of submain and branch ducts.
  - 2. Adjust submain and branch duct volume dampers for specified airflow.
  - 3. Re-measure each submain and branch duct after all have been adjusted.
- C. Adjust air inlets and outlets for each space to indicated airflows.
  - 1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
  - 2. Measure inlets and outlets airflow.
  - 3. Adjust each inlet and outlet for specified airflow.
  - 4. Re-measure each inlet and outlet after they have been adjusted.

# 3.6 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

- A. Prepare test reports for pumps, coils, and heat exchangers. 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. Prepare schematic diagrams of systems' "as-built" piping layouts.
- C. In addition to requirements in "Preparation" Article, prepare hydronic systems for testing and balancing as follows:
  - 1. Check liquid level in expansion tank.
  - 2. Check highest vent for adequate pressure.

- 3. Check flow-control valves for proper position.
- 4. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- 5. Verify that motor starters are equipped with properly sized thermal protection.
- 6. Check that air has been purged from the system.

# 3.7 PROCEDURES FOR CONSTANT-FLOW HYDRONIC SYSTEMS

- A. Adjust pumps to deliver total design gpm.
  - 1. Measure total water flow.
    - a. Position valves for full flow through coils.
    - b. Measure flow by main flow meter, if installed.
    - c. If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.
  - 2. Measure pump TDH as follows:
    - a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
    - b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
    - c. Convert pressure to head and correct for differences in gage heights.
    - d. 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. With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.
  - 3. Monitor motor performance during procedures and do not operate motor in an overloaded condition.
- B. Adjust flow-measuring devices installed in mains and branches to design water flows.
  - 1. Measure flow in main and branch pipes.
  - 2. Adjust main and branch balance valves for design flow.
  - 3. Re-measure each main and branch after all have been adjusted.
- C. Adjust flow-measuring devices installed at terminals for each space to design water flows.
  - 1. Measure flow at terminals.
  - 2. Adjust each terminal to design flow.
  - 3. Re-measure each terminal after it is adjusted.
  - 4. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
  - 5. Perform temperature tests after flows have been balanced.
- D. For systems with pressure-independent valves at terminals:

- 1. Measure differential pressure and verify that it is within manufacturer's specified range.
- 2. Perform temperature tests after flows have been verified.
- E. For systems without pressure-independent valves or flow-measuring devices at terminals:
  - 1. Measure and balance coils by either coil pressure drop or temperature method.
  - 2. If balanced by coil pressure drop, perform temperature tests after flows have been verified.
- F. Verify final system conditions as follows:
  - 1. Re-measure and confirm that total water flow is within design.
  - 2. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
  - 3. Mark final settings.
- G. Verify that memory stops have been set.

### 3.8 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

- A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals, and proceed as specified above for hydronic systems.
- B. Adjust the variable-flow hydronic system as follows:
  - 1. Verify that the differential-pressure sensor is located as indicated.
  - 2. Determine whether there is diversity in the system.
- C. For systems with no diversity:
  - 1. Adjust pumps to deliver total design gpm.
    - a. Measure total water flow.
      - 1) Position valves for full flow through coils.
      - 2) Measure flow by main flow meter, if installed.
      - 3) If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.
    - b. Measure pump TDH as follows:
      - 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) Convert pressure to head and correct for differences in gage heights.

- 4) 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.
- 5) With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.
- c. Monitor motor performance during procedures and do not operate motor in an overloaded condition.
- 2. Adjust flow-measuring devices installed in mains and branches to design water flows.
  - a. Measure flow in main and branch pipes.
  - b. Adjust main and branch balance valves for design flow.
  - c. Re-measure each main and branch after all have been adjusted.
- 3. Adjust flow-measuring devices installed at terminals for each space to design water flows.
  - a. Measure flow at terminals.
  - b. Adjust each terminal to design flow.
  - c. Re-measure each terminal after it is adjusted.
  - d. Position control valves to bypass the coil and adjust the bypass valve to maintain design flow.
  - e. Perform temperature tests after flows have been balanced.
- 4. For systems with pressure-independent valves at terminals:
  - a. Measure differential pressure and verify that it is within manufacturer's specified range.
  - b. Perform temperature tests after flows have been verified.
- 5. For systems without pressure-independent valves or flow-measuring devices at terminals:
  - a. Measure and balance coils by either coil pressure drop or temperature method.
  - b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.
- 6. Prior to verifying final system conditions, determine the system differential-pressure set point.
- 7. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion open discharge valve 100 percent and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
- 8. Mark final settings and verify that all memory stops have been set.
- 9. Verify final system conditions as follows:
  - a. Re-measure and confirm that total water flow is within design.
  - b. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.

- c. Mark final settings.
- 10. Verify that memory stops have been set.
- D. For systems with diversity:
  - 1. Determine diversity factor.
  - 2. Simulate system diversity by closing required number of control valves, as approved by the design engineer.
  - 3. Adjust pumps to deliver total design gpm.
    - a. Measure total water flow.
      - 1) Position valves for full flow through coils.
      - 2) Measure flow by main flow meter, if installed.
      - 3) If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.
    - b. Measure pump TDH as follows:
      - 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) Convert pressure to head and correct for differences in gage heights.
      - 4) 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.
      - 5) With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.
    - c. Monitor motor performance during procedures and do not operate motor in an overloaded condition.
  - 4. Adjust flow-measuring devices installed in mains and branches to design water flows.
    - a. Measure flow in main and branch pipes.
    - b. Adjust main and branch balance valves for design flow.
    - c. Re-measure each main and branch after all have been adjusted.
  - 5. Adjust flow-measuring devices installed at terminals for each space to design water flows.
    - a. Measure flow at terminals.
    - b. Adjust each terminal to design flow.
    - c. Re-measure each terminal after it is adjusted.
    - d. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
    - e. Perform temperature tests after flows have been balanced.

- 6. For systems with pressure-independent valves at terminals:
  - a. Measure differential pressure, and verify that it is within manufacturer's specified range.
  - b. Perform temperature tests after flows have been verified.
- 7. For systems without pressure-independent valves or flow-measuring devices at terminals:
  - a. Measure and balance coils by either coil pressure drop or temperature method.
  - b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.
- 8. Open control valves that were shut. Close a sufficient number of control valves that were previously open to maintain diversity, and balance terminals that were just opened.
- 9. Prior to verifying final system conditions, determine system differential-pressure set point.
- 10. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion open discharge valve 100 percent and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
- 11. Mark final settings and verify that memory stops have been set.
- 12. Verify final system conditions as follows:
  - a. Re-measure and confirm that total water flow is within design.
  - b. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
  - c. Mark final settings.
- 13. Verify that memory stops have been set.

# 3.9 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 or minus 10 percent.
  - 2. Air Outlets and Inlets: Plus or minus 10 percent.
  - 3. Heating-Water Flow Rate: Plus or minus 10 percent.
  - 4. Cooling-Water Flow Rate: Plus or minus 10 percent.
- B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

### 3.10 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.
  - 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. Inlet vane settings for variable-air-volume systems.
    - g. Settings for supply-air, static-pressure controller.
    - h. Other system operating conditions that affect performance.

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- 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. Terminal units.
  - 6. Balancing stations.
  - 7. Position of balancing devices.
- E. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:
  - 1. Unit Data:
    - a. Unit identification.
    - b. Location.
    - c. Make and type.
    - d. Model number and unit size.
    - e. Manufacturer's serial number.
    - f. Unit arrangement and class.
    - g. Discharge arrangement.
    - h. Sheave make, size in inches, and bore.
    - i. Center-to-center dimensions of sheave and amount of adjustments in inches.
    - j. Number, make, and size of belts.
    - k. Number, type, and size of filters.
  - 2. Motor Data:
    - a. Motor make, and frame type and size.
    - b. Horsepower and rpm.
    - c. Volts, phase, and hertz.
    - d. Full-load amperage and service factor.
    - e. Sheave make, size in inches, and bore.
    - f. Center-to-center dimensions of sheave and amount of adjustments in inches.
  - 3. Test Data (Indicated and Actual Values):
    - a. Total airflow rate in cfm.
    - b. Total system static pressure in inches wg.
    - c. Fan rpm.
    - d. Discharge static pressure in inches wg.
    - e. Filter static-pressure differential in inches wg.
    - f. Cooling-coil static-pressure differential in inches wg.
    - g. Heating-coil static-pressure differential in inches wg.
    - h. Outdoor airflow in cfm.
    - i. Return airflow in cfm.
    - j. Outdoor-air damper position.
    - k. Return-air damper position.

- F. Apparatus-Coil Test Reports:
  - 1. Coil Data:
    - a. System identification.
    - b. Location.
    - c. Coil type.
    - d. Number of rows.
    - e. Fin spacing in fins per inch o.c.
    - f. Make and model number.
    - g. Face area in sq. ft.
    - h. Tube size in NPS.
    - i. Tube and fin materials.
    - j. Circuiting arrangement.
  - 2. Test Data (Indicated and Actual Values):
    - a. Airflow rate in cfm.
    - b. Average face velocity in fpm.
    - c. Air pressure drop in inches wg.
    - d. Outdoor-air, wet- and dry-bulb temperatures in deg F.
    - e. Return-air, wet- and dry-bulb temperatures in deg F.
    - f. Entering-air, wet- and dry-bulb temperatures in deg F.
    - g. Leaving-air, wet- and dry-bulb temperatures in deg F.
    - h. Water flow rate in gpm.
    - i. Water pressure differential in feet of head or psig.
    - j. Entering-water temperature in deg F.
    - k. Leaving-water temperature in deg F.
    - I. Refrigerant expansion valve and refrigerant types.
    - m. Refrigerant suction pressure in psig.
    - n. Refrigerant suction temperature in deg F.
- G. Gas- and Oil-Fired Heat Apparatus Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:
  - 1. Unit Data:
    - a. System identification.
    - b. Location.
    - c. Make and type.
    - d. Model number and unit size.
    - e. Manufacturer's serial number.
    - f. Fuel type in input data.
    - g. Output capacity in Btu/h.
    - h. Ignition type.
    - i. Burner-control types.
    - j. Motor horsepower and rpm.
    - k. Motor volts, phase, and hertz.
    - I. Motor full-load amperage and service factor.

- m. Sheave make, size in inches, and bore.
- n. Center-to-center dimensions of sheave and amount of adjustments in inches (mm).
- 2. Test Data (Indicated and Actual Values):
  - a. Total airflow rate in cfm.
  - b. Entering-air temperature in deg F.
  - c. Leaving-air temperature in deg F.
  - d. Air temperature differential in deg F.
  - e. Entering-air static pressure in inches wg.
  - f. Leaving-air static pressure in inches wg.
  - g. Air static-pressure differential in inches wg.
  - h. Low-fire fuel input in Btu/h.
  - i. High-fire fuel input in Btu/h.
  - j. Manifold pressure in psig.
  - k. High-temperature-limit setting in deg F.
  - I. Operating set point in Btu/h.
  - m. Motor voltage at each connection.
  - n. Motor amperage for each phase.
  - o. Heating value of fuel in Btu/h.
- H. Electric-Coil Test Reports: For electric furnaces, duct coils, and electric coils installed in centralstation air-handling units, include the following:
  - 1. Unit Data:
    - a. System identification.
    - b. Location.
    - c. Coil identification.
    - d. Capacity in Btu/h.
    - e. Number of stages.
    - f. Connected volts, phase, and hertz.
    - g. Rated amperage.
    - h. Airflow rate in cfm.
    - i. Face area in sq. ft..
    - j. Minimum face velocity in fpm.
  - 2. Test Data (Indicated and Actual Values):
    - a. Heat output in Btu/h.
    - b. Airflow rate in cfm.
    - c. Air velocity in fpm.
    - d. Entering-air temperature in deg F.
    - e. Leaving-air temperature in deg F.
    - f. Voltage at each connection.
    - g. Amperage for each phase.
- I. Fan Test Reports: For supply, return, and exhaust fans, include the following:

- 1. Fan Data:
  - a. System identification.
  - b. Location.
  - c. Make and type.
  - d. Model number and size.
  - e. Manufacturer's serial number.
  - f. Arrangement and class.
  - g. Sheave make, size in inches, and bore.
  - h. Center-to-center dimensions of sheave and amount of adjustments in inches.
- 2. Motor Data:
  - a. Motor make, and frame type and size.
  - b. Horsepower and rpm.
  - c. Volts, phase, and hertz.
  - d. Full-load amperage and service factor.
  - e. Sheave make, size in inches, and bore.
  - f. Center-to-center dimensions of sheave, and amount of adjustments in inches .
  - g. Number, make, and size of belts.
- 3. Test Data (Indicated and Actual Values):
  - a. Total airflow rate in cfm.
  - b. Total system static pressure in inches wg.
  - c. Fan rpm.
  - d. Discharge static pressure in inches wg.
  - e. Suction static pressure in inches wg.
- J. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
  - 1. Report Data:
    - a. System and air-handling-unit number.
    - b. Location and zone.
    - c. Traverse air temperature in deg F.
    - d. Duct static pressure in inches wg.
    - e. Duct size in inches.
    - f. Duct area in sq. ft.
    - g. Indicated airflow rate in cfm.
    - h. Indicated velocity in fpm.
    - i. Actual airflow rate in cfm.
    - j. Actual average velocity in fpm.
    - k. Barometric pressure in psig.
- K. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves and include the following:

- 1. Unit Data:
  - a. Unit identification.
  - b. Location.
  - c. Service.
  - d. Make and size.
  - e. Model number and serial number.
  - f. Water flow rate in gpm.
  - g. Water pressure differential in feet of head or psig.
  - h. Required net positive suction head in feet of head or psig.
  - i. Pump rpm.
  - j. Impeller diameter in inches.
  - k. Motor make and frame size.
  - I. Motor horsepower and rpm.
  - m. Voltage at each connection.
  - n. Amperage for each phase.
  - o. Full-load amperage and service factor.
  - p. Seal type.
- 2. Test Data (Indicated and Actual Values):
  - a. Static head in feet of head or psig.
  - b. Pump shutoff pressure in feet of head or psig.
  - c. Actual impeller size in inches.
  - d. Full-open flow rate in gpm.
  - e. Full-open pressure in feet of head or psig.
  - f. Final discharge pressure in feet of head or psig.
  - g. Final suction pressure in feet of head or psig.
  - h. Final total pressure in feet of head or psig.
  - i. Final water flow rate in gpm.
  - j. Voltage at each connection.
  - k. Amperage for each phase.
- L. Instrument Calibration Reports:
  - 1. Report Data:
    - a. Instrument type and make.
    - b. Serial number.
    - c. Application.
    - d. Dates of use.
    - e. Dates of calibration.

### 3.11 VERIFICATION OF TAB REPORT

A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of Construction Manager.

- B. Construction Manager shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.
- C. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
- D. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.
- E. If TAB work fails, proceed as follows:
  - 1. TAB specialists shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
  - 2. If the second final inspection also fails, Owner may contract the services of another TAB specialist to complete TAB work according to the Contract Documents and deduct the cost of the services from the original TAB specialist's final payment.
  - 3. If the second verification also fails, Owner, design professional, or Architect may contact AABC Headquarters regarding the AABC National Performance Guaranty.
- F. Prepare test and inspection reports.
- 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.

END OF SECTION 230593

# SECTION 230713 - DUCT INSULATION

### PART 1 - GENERAL

### 1.1 SUMMARY

- A. Section includes insulating the following duct services:
  - 1. Indoor, concealed supply and outdoor air.
  - 2. Indoor, exposed supply and outdoor air.
  - 3. Indoor, concealed return located in unconditioned space.
  - 4. Indoor, exposed return located in unconditioned space.
  - 5. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
  - 6. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
  - 7. Outdoor, exposed supply and return.

# 1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
  - 1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
  - 2. Detail insulation application at elbows, fittings, dampers, specialties and flanges for each type of insulation.
  - 3. Detail application of field-applied jackets.
  - 4. Detail application at linkages of control devices.
- 1.3 INFORMATIONAL SUBMITTALS
  - A. Field quality-control reports.

#### 1.4 QUALITY ASSURANCE

- A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
  - 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

# PART 2 - PRODUCTS

### 2.1 INSULATION MATERIALS

- A. Comply with requirements in "Duct Insulation Schedule, General," "Indoor Duct and Plenum Insulation Schedule," and "Aboveground, Outdoor Duct and Plenum Insulation Schedule" articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C871.
- D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C795.
- E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- F. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C553, Type II and ASTM C1290, Type III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
  - 1. Products: Subject to compliance with requirements, provide one of the following:
    - a. CertainTeed Corp.; SoftTouch Duct Wrap.
    - b. Johns Manville; Microlite.
    - c. Knauf Insulation; Friendly Feel Duct Wrap.
    - d. Manson Insulation Inc.; Alley Wrap.
    - e. Owens Corning; SOFTR All-Service Duct Wrap.
- G. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C612, 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. Products: Subject to compliance with requirements, provide one of the following:
    - a. CertainTeed Corp.; Commercial Board.
    - b. Fibrex Insulations Inc.; FBX.
    - c. Johns Manville; 800 Series Spin-Glas.
    - d. Knauf Insulation; Insulation Board.
    - e. Manson Insulation Inc.; AK Board.
    - f. Owens Corning; Fiberglas 700 Series.

### 2.2 FIRE-RATED INSULATION SYSTEMS

- A. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is tested and certified to provide a 1-hour fire rating by an NRTL acceptable to authorities having jurisdiction.
  - 1. Products: Subject to compliance with requirements, provide one of the following:
    - a. CertainTeed Corp.; FlameChek.
    - b. Johns Manville; Firetemp Wrap.
    - c. Nelson Fire Stop Products; Nelson FSB Flameshield Blanket.
    - d. Thermal Ceramics; FireMaster Duct Wrap.
    - e. 3M; Fire Barrier Wrap Products.
    - f. Unifrax Corporation; FyreWrap.
    - g. <Insert manufacturer's name; product name or designation>.

### 2.3 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
- B. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
  - 1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.
    - b. Eagle Bridges Marathon Industries; 225.
    - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-03/11-70.
    - d. Mon-Eco Industries, Inc.; 22-25.
  - 2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- C. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
  - 1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82.
    - b. Eagle Bridges Marathon Industries; 225.
    - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-50.
    - d. Mon-Eco Industries, Inc.; 22-25.

- 2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- D. PVC Jacket Adhesive: Compatible with PVC jacket.
  - 1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Dow Corning Corporation; 739, Dow Silicone.
    - b. Johns Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
    - c. P.I.C. Plastics, Inc.; Welding Adhesive.
    - d. Speedline Corporation; Polyco VP Adhesive.
  - 2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
  - 3.

# 2.4 MASTICS AND COATINGS

- A. Materials shall be compatible with insulation materials, jackets, and substrates.
  - 1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- B. Vapor-Retarder Mastic: Water based; suitable for indoor use on below ambient services.
  - 1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-03/11-90.
    - b. Vimasco Corporation; 749.
  - 2. Water-Vapor Permeance: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.
  - 3. Service Temperature Range: Minus 20 to plus 180 deg F.
  - 4. Comply with MIL-PRF-19565C, Type II, for permeance requirements.
  - 5. Color: White.
- C. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.
  - 1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-10.
    - b. Eagle Bridges Marathon Industries; 550.

- c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 46-50.
- d. Mon-Eco Industries, Inc.; 55-50.
- e. Vimasco Corporation; WC-1/WC-5.
- 2. Water-Vapor Permeance: ASTM E96, greater than 1.0 perm at manufacturer's recommended dry film thickness.
- 3. Service Temperature Range: Minus 20 to plus 180 deg F.
- 4. Color: White.

# 2.5 SEALANTS

- A. FSK and Metal Jacket Flashing Sealants:
  - 1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
    - b. Eagle Bridges Marathon Industries; 405.
    - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 95-44.
    - d. Mon-Eco Industries, Inc.; 44-05.
  - 2. Materials shall be compatible with insulation materials, jackets, and substrates.
  - 3. Fire- and water-resistant, flexible, elastomeric sealant.
  - 4. Service Temperature Range: Minus 40 to plus 250 deg F.
  - 5. Color: Aluminum.
  - 6. For indoor applications, use sealants that have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- B. ASJ Flashing Sealants, and Vinyl and PVC Jacket Flashing Sealants:
  - 1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
  - 2. Materials shall be compatible with insulation materials, jackets, and substrates.
  - 3. Fire- and water-resistant, flexible, elastomeric sealant.
  - 4. Service Temperature Range: Minus 40 to plus 250 deg F.
  - 5. Color: White.
  - 6. For indoor applications, use sealants that have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

### 2.6 FACTORY-APPLIED JACKETS

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
  - 1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.
  - 2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.
  - 3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.
  - 4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C1136, Type II.
  - 5. Vinyl Jacket: White vinyl with a permeance of 1.3 perms when tested according to ASTM E96/E96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

### 2.7 FIELD-APPLIED FABRIC-REINFORCING MESH

- A. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in., in a Leno weave, for ducts.
  - 1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Mast-A-Fab.
    - b. Vimasco Corporation; Elastafab 894.

### 2.8 FIELD-APPLIED JACKETS

- A. Field-applied jackets shall comply with ASTM C921, Type I, unless otherwise indicated.
- B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.
- C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
  - 1. Products: Subject to compliance with requirements, [provide one of the following:
    - a. Johns Manville; Zeston.
    - b. P.I.C. Plastics, Inc.; FG Series.
    - c. Proto Corporation; LoSmoke.
    - d. Speedline Corporation; SmokeSafe.
  - 2. Adhesive: As recommended by jacket material manufacturer.
  - 3. Color: White.

- D. Aluminum Jacket: Comply with ASTM B209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.
  - 1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Metal Jacketing Systems.
    - b. ITW Insulation Systems; Aluminum and Stainless Steel Jacketing.
    - c. RPR Products, Inc.; Insul-Mate.
  - 2. Factory cut and rolled to size.
  - 3. Finish and thickness are indicated in field-applied jacket schedules.
  - 4. Moisture Barrier for Indoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper.
  - 5. Moisture Barrier for Outdoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper.
- E. Self-Adhesive Outdoor Jacket: 60-mil- thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a crosslaminated polyethylene film covered with stucco-embossed aluminum-foil facing.
  - 1. Products: Subject to compliance with requirements, provide the following:
    - a. Polyguard Products, Inc.; Alumaguard 60.

# 2.9 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.
  - 1. Products: Subject to compliance with requirements, provide one of the following:
    - a. ABI, Ideal Tape Division; 428 AWF ASJ.
    - b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
    - c. Compac Corporation; 104 and 105.
    - d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.
  - 2. Width: 3 inches.
  - 3. Thickness: 11.5 mils.
  - 4. Adhesion: 90 ounces force/inch in width.
  - 5. Elongation: 2 percent.
  - 6. Tensile Strength: 40 lbf/inch in width.
  - 7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C1136.
  - 1. Products: Subject to compliance with requirements, provide one of the following:

- a. ABI, Ideal Tape Division; 491 AWF FSK.
- b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
- c. Compac Corporation; 110 and 111.
- d. Venture Tape; 1525 CW NT, 1528 CW, and 1528 CW/SQ.
- 2. Width: 3 inches.
- 3. Thickness: 6.5 mils.
- 4. Adhesion: 90 ounces force/inch in width.
- 5. Elongation: 2 percent.
- 6. Tensile Strength: 40 lbf/inch in width.
- 7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
- C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
  - 1. Products: Subject to compliance with requirements, provide one of the following:
    - a. ABI, Ideal Tape Division; 370 White PVC tape.
    - b. Compac Corporation; 130.
    - c. Venture Tape; 1506 CW NS.
  - 2. Width: 2 inches.
  - 3. Thickness: 6 mils.
  - 4. Adhesion: 64 ounces force/inch in width.
  - 5. Elongation: 500 percent.
  - 6. Tensile Strength: 18 lbf/inch in width.
- D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
  - 1. Products: Subject to compliance with requirements, provide one of the following:
    - a. ABI, Ideal Tape Division; 488 AWF.
    - b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
    - c. Compac Corporation; 120.
    - d. Venture Tape; 3520 CW.
  - 2. Width: 2 inches.
  - 3. Thickness: 3.7 mils.
  - 4. Adhesion: 100 ounces force/inch in width.
  - 5. Elongation: 5 percent.
  - 6. Tensile Strength: 34 lbf/inch in width.

# 2.10 SECUREMENTS

- A. Aluminum Bands: ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 3/4 inch wide with wing seal or closed seal.
  - 1. Products: Subject to compliance with requirements, provide one of the following:

- a. ITW Insulation Systems; Gerrard Strapping and Seals.
- b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.
- B. Insulation Pins and Hangers:
  - 1. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
    - a. Products: Subject to compliance with requirements, provide one of the following:
      - 1) AGM Industries, Inc.; Tactoo Perforated Base Insul-Hangers.
      - 2) GEMCO; Perforated Base.
      - 3) Midwest Fasteners, Inc.; Spindle.
    - b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
    - c. Spindle: Aluminum, fully annealed, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
    - d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
  - 2. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
    - a. Products: Subject to compliance with requirements, provide one of the following:
      - 1) GEMCO; Nylon Hangers.
      - 2) Midwest Fasteners, Inc.; Nylon Insulation Hangers.
    - b. Baseplate: Perforated, nylon sheet, 0.030 inch thick by 1-1/2 inches in diameter.
    - c. Spindle: Nylon, 0.106-inch- diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches.
    - d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
  - 3. 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. Products: Subject to compliance with requirements, provide one of the following:
      - 1) AGM Industries, Inc.; Tactoo Self-Adhering Insul-Hangers.
      - 2) GEMCO; Peel & Press.

- 3) Midwest Fasteners, Inc.; Self Stick.
- b. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
- c. Spindle: Aluminum, fully annealed, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
- d. Adhesive-backed base with a peel-off protective cover.
- 4. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick, 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. Products: Subject to compliance with requirements, provide one of the following:
    - 1) AGM Industries, Inc.; RC-150.
    - 2) GEMCO; R-150.
    - 3) Midwest Fasteners, Inc.; WA-150.
    - 4) Nelson Stud Welding; Speed Clips.
  - b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
- 5. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inchthick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
  - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - 1) GEMCO.
    - 2) Midwest Fasteners, Inc.
- C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.
- D. Wire: 0.062-inch soft-annealed, galvanized steel.
  - 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
    - a. C & F Wire.
- 2.11 CORNER ANGLES
  - A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch, PVC according to ASTM D1784, Class 16354-C. White or color-coded to match adjacent surface.
  - B. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14.

### PART 3 - EXECUTION

### 3.1 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

### 3.2 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.
- B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Keep insulation materials dry during application and finishing.
- G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- H. Install insulation with least number of joints practical.
- I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
  - 1. Install insulation continuously through hangers and around anchor attachments.
  - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
  - 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
- J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- K. Install insulation with factory-applied jackets as follows:
  - 1. Draw jacket tight and smooth.

- 2. Cover circumferential joints with 3-inch- 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 at 2 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 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.

### 3.3 PENETRATIONS

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
  - 1. Seal penetrations with flashing sealant.
  - 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
  - 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
  - 4. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
  - 1. Seal penetrations with flashing sealant.
  - 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
  - 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
  - 4. Seal jacket to wall flashing with flashing sealant.

- C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.
  - 1. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.
- E. Insulation Installation at Floor Penetrations:
  - 1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.
  - 2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

# 3.4 INSTALLATION OF MINERAL-FIBER INSULATION

- A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
  - 1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
  - 2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
  - 3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
    - a. On duct sides with dimensions 18 inches 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 overcompress insulation during installation.
    - e. Impale insulation over pins and attach speed washers.
    - f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
  - 4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches 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 vaporbarrier seal.
- b. Install vapor stops for ductwork and plenums operating below 50 deg 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. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.
- 6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
- 7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- 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 100 percent coverage of duct and plenum surfaces.
  - 2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
  - 3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
    - a. On duct sides with dimensions 18 inches 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 overcompress insulation during installation.
    - e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
  - 4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches 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 vaporbarrier seal.
- b. Install vapor stops for ductwork and plenums operating below 50 deg 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.

# 3.5 FIELD-APPLIED JACKET INSTALLATION

- A. Where FSK jackets are indicated, install as follows:
  - 1. Draw jacket material smooth and tight.
  - 2. Install lap or joint strips with same material as jacket.
  - 3. Secure jacket to insulation with manufacturer's recommended adhesive.
  - 4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch- wide joint strips at end joints.
  - 5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.
- B. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.
  - 1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.
- C. Where metal jackets are indicated, install with 2-inch 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.

### 3.6 FIRE-RATED INSULATION SYSTEM INSTALLATION

A. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.

- B. Insulate duct access panels and doors to achieve same fire rating as duct.
- C. Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are specified in Section 078413 "Penetration Firestopping."

# 3.7 FINISHES

- A. Insulation with ASJ or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."
  - 1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
    - a. Finish Coat Material: Interior, flat, latex-emulsion size.
- B. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.
- C. Do not field paint aluminum or stainless-steel jackets.

## 3.8 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
  - 1. Inspect ductwork, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.
- C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

### 3.9 DUCT INSULATION SCHEDULE, GENERAL

- A. Plenums and Ducts Requiring Insulation:
  - 1. Indoor, concealed supply and outdoor air.
  - 2. Indoor, exposed supply and outdoor air.
  - 3. Indoor, concealed return located in unconditioned space.
  - 4. Indoor, exposed return located in unconditioned space.
  - 5. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
  - 6. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
  - 7. Outdoor, exposed supply and return.

- B. Items Not Insulated:
  - 1. Fibrous-glass ducts.
  - 2. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
  - 3. Factory-insulated flexible ducts.
  - 4. Factory-insulated plenums and casings.
  - 5. Flexible connectors.
  - 6. Vibration-control devices.
  - 7. Factory-insulated access panels and doors.

### 3.10 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

- A. Concealed, Supply-Air Duct and Plenum Insulation: Mineral-fiber blanket, 2 inches thick and 1.5-lb/cu. ft. nominal density.
- B. Concealed, Return-Air Duct and Plenum Insulation: Mineral-fiber blanket, 2 inches thick and 1.5-lb/cu. ft. nominal density.
- C. Concealed, Outdoor-Air Duct and Plenum Insulation: Mineral-fiber blanket, 2 inches thick and 1.5-lb/cu. ft. nominal density.
- D. Concealed, Exhaust-Air Duct and Plenum Insulation: Mineral-fiber blanket, 2 inches thick and 1.5-lb/cu. ft. nominal density.
- E. Exposed, Supply-Air Duct and Plenum Insulation: Mineral-fiber board, 1-1/2 inches thick and 3lb/cu. ft. nominal density.
- F. Exposed, Return-Air Duct and Plenum Insulation: Mineral-fiber board, 1-1/2 inches thick and 3lb/cu. ft. nominal density.
- G. Exposed, Outdoor-Air Duct and Plenum Insulation: Mineral-fiber board, 1-1/2 inches thick and 3-lb/cu. ft. nominal density.
- H. Exposed, Exhaust-Air Duct and Plenum Insulation: Mineral-fiber board, 1-1/2 inches thick and 3-lb/cu. ft. nominal density.

### 3.11 ABOVEGROUND, OUTDOOR DUCT AND PLENUM INSULATION SCHEDULE

- A. Insulation materials and thicknesses are identified below. If more than one material is listed for a duct system, selection from materials listed is Contractor's option.
- B. Exposed, Supply-Air Duct and Plenum Insulation: Mineral-fiber board, 2 inches thick and 3lb/cu. ft. nominal density.
- C. Exposed, Return-Air Duct and Plenum Insulation: Mineral-fiber board, 2 inches thick and 3lb/cu. ft. nominal density.

- 3.12 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. Ducts and Plenums, Concealed:
    - 1. None.
    - 2. Aluminum, Stucco Embossed: 0.020 inch thick.
  - D. Ducts and Plenums, Exposed:
    - 1. None.
    - 2. Aluminum, Stucco Embossed: 0.020 inch thick.
- 3.13 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. If more than one material is listed, selection from materials listed is Contractor's option.
  - C. Ducts and Plenums, Exposed, up to 48 Inches in Diameter or with Flat Surfaces up to 72 Inches:
    - 1. Aluminum, Stucco Embossed: 0.020 inch thick.

END OF SECTION 230713

# SECTION 230719 - HVAC PIPING INSULATION

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section includes insulation for HVAC piping systems.
  - 1. Chilled-water and brine piping, indoors and outdoors.
  - 2. Heating hot-water piping, indoors and outdoors.
  - 3. Refrigerant suction and hot-gas piping, indoors and outdoors.

#### B. Related Requirements:

- 1. Section 230713 "Duct Insulation" for duct insulation.
- 2. Section 230716 "HVAC Equipment Insulation" for equipment insulation.

#### 1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
  - 1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
  - 2. Detail attachment and covering of heat tracing inside insulation.
  - 3. Detail insulation application at pipe expansion joints for each type of insulation.
  - 4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
  - 5. Detail removable insulation at piping specialties.
  - 6. Detail application of field-applied jackets.
  - 7. Detail application at linkages of control devices.
- C. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use.

### 1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified Installer.
- B. Material test reports.
- C. Field quality-control reports.

### 1.4 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or craft training program, certified by the Department of Labor, Bureau of Apprenticeship and Training.

### 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 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.

### 1.6 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.

### PART 2 - PRODUCTS

## 2.1 PERFORMANCE REQUIREMENTS

- A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with ASTM E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation, jacket materials, adhesive, mastic, tapes, and cement material containers with appropriate markings of applicable testing agency.
  - 1. All Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
  - 2. All Insulation Installed Indoors; Outdoors-Installed Insulation in Contact with Airstream: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
  - 3. All Insulation Installed Indoors and Outdoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

### 2.2 INSULATION MATERIALS

A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials shall be applied.

- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come into contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested in accordance with ASTM C871.
- D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable in accordance with ASTM C795.
- E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- F. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Comply with ASTM C552.
  - 1. Products: Subject to compliance with requirements, provide the following:
    - a. Pittsburgh Corning Corporation; Foamglas.
  - 2. Preformed Pipe Insulation without Jacket: Type II, Class 1, unfaced.
  - 3. Preformed Pipe Insulation with Jacket: Type II, Class 2, with factory-applied ASJ jacket.
  - 4. Fabricated shapes in accordance with ASTM C450, ASTM C585, and ASTM C1639.
  - 5. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- G. Flexible Elastomeric: Closed-cell, or expanded-rubber materials; suitable for maximum use temperature between minus 70 deg F and 220 deg F. Comply with ASTM C534/C534M, Type I for tubular materials, Type II, for sheet materials.
  - 1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Aeroflex USA, Inc.; Aerocel.
    - b. Armacell LLC; AP Armaflex.
    - c. K-Flex USA; Insul-Lock, Insul-Tube, and K-FLEX LS.
- H. Glass-Fiber, Preformed Pipe: Glass fibers bonded with a thermosetting resin; suitable for maximum use temperature up to 850 deg F in accordance with ASTM C411. Comply with ASTM C547.
  - 1. Products: Subject to compliance with requirements, provide one of the following:
    - a. CertainTeed Corp.; SoftTouch Duct Wrap.
    - b. Johns Manville; Microlite.
    - c. Knauf Insulation; Friendly Feel Duct Wrap.
    - d. Manson Insulation Inc.; Alley Wrap.
    - e. Owens Corning; SOFTR All-Service Duct Wrap.
  - 2. Preformed Pipe Insulation: Type I, Grade A with factory-applied ASJ.
  - 3. Fabricated shapes in accordance with ASTM C450 and ASTM C585.
  - 4. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

- I. Mineral Wool, Preformed Pipe: Mandrel-wound mineral wool fibers bonded with a thermosetting resin, unfaced; suitable for maximum use temperature up to 1200 deg F in accordance with ASTM C447. Comply with ASTM C547.
  - 1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Fibrex Insulations Inc.; Coreplus 1200.
    - b. Johns Manville; Micro-Lok.
    - c. Knauf Insulation; 1000-Degree Pipe Insulation.
    - d. Manson Insulation Inc.; Alley-K.
    - e. Owens Corning; Fiberglas Pipe Insulation.
  - 2. Preformed Pipe Insulation: Type II, Grade A with factory-applied ASJ.
  - 3. Fabricated shapes in accordance with ASTM C450 and ASTM C585.

## 2.3 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
- B. Cellular-Glass Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 deg F.
  - 1. Products: Subject to compliance with requirements, provide the following:
    - a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 81-84.
  - 2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
  - 3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- C. Flexible Elastomeric and Polyolefin Adhesive: Solvent-based adhesive.
  - 1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Aeroflex USA, Inc.; Aeroseal.
    - b. Armacell LLC; Armaflex 520 Adhesive.
    - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-75.
    - d. K-Flex USA; R-373 Contact Adhesive.
  - 2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

- 3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- 4. Flame-spread index shall be 25 or less and smoke-developed index shall be 50 or less as tested in accordance with ASTM E84.
- 5. Wet Flash Point: Below 0 deg F.
- 6. Service Temperature Range: 40 to 200 deg F.
- 7. Color: Black.
- D. Glass-Fiber and Mineral Wool Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
  - 1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.
    - b. Eagle Bridges Marathon Industries; 225.
    - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60/85-70.
    - d. Mon-Eco Industries, Inc.; 22-25.
  - 2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
  - 3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
  - 4.
- E. ASJ Adhesive and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A, for bonding insulation jacket lap seams and joints.
- F. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

See Editing Instruction No. 1 in the Evaluations for cautions about naming manufacturers and products. See Section 016000 "Product Requirements."

- 1. Products: Subject to compliance with requirements, provide one of the following:
  - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82.
  - b. Eagle Bridges Marathon Industries; 225.
  - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-50.
  - d. Mon-Eco Industries, Inc.; 22-25.
- 2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

- 3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- G. PVC Jacket Adhesive: Compatible with PVC jacket.
  - 1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Dow Corning Corporation; 739, Dow Silicone.
    - b. Johns Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
    - c. P.I.C. Plastics, Inc.; Welding Adhesive.
    - d. Speedline Corporation; Polyco VP Adhesive.
  - 2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
  - 3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

## 2.4 MASTICS AND COATINGS

- A. Materials shall be compatible with insulation materials, jackets, and substrates.
  - 1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- B. Vapor-Retarder Mastic, Water Based: Suitable for indoor use on below-ambient services.
  - 1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-80/30-90.
    - b. Vimasco Corporation; 749.
  - 2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
  - 3. Service Temperature Range: Minus 20 to plus 180 deg F.
  - 4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
  - 5. Color: White.
- C. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.
  - 1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-10.
    - b. Eagle Bridges Marathon Industries; 550.

- c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 46-50.
- d. Mon-Eco Industries, Inc.; 55-50.
- e. Vimasco Corporation; WC-1/WC-5.
- 2. Water-Vapor Permeance: ASTM E96/E96M, greater than 1.0 perm at manufacturer's recommended dry film thickness.
- 3. Service Temperature Range: Minus 20 to plus 180 deg F.
- 4. Color: White.

## 2.5 SEALANTS

- A. Materials shall be as recommended by the insulation manufacturer and shall be compatible with insulation materials, jackets, and substrates.
- B. Joint Sealants:
  - 1. Joint Sealants for Cellular-Glass Products: Subject to compliance with requirements, provide one of the following:
    - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
    - b. Eagle Bridges Marathon Industries; 405.
    - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-45.
    - d. Mon-Eco Industries, Inc.; 44-05.
    - e. Pittsburgh Corning Corporation; Pittseal 444.
  - 2. Materials shall be compatible with insulation materials, jackets, and substrates.
  - 3. Permanently flexible, elastomeric sealant.
  - 4. Service Temperature Range: Minus 100 to plus 300 deg F.
  - 5. Color: White or gray.
  - 6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
  - 7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- C. FSK and Metal Jacket Flashing Sealants:
  - 1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
    - b. Eagle Bridges Marathon Industries; 405.
    - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 95-44.
    - d. Mon-Eco Industries, Inc.; 44-05.

- 2. Materials shall be compatible with insulation materials, jackets, and substrates.
- 3. Fire- and water-resistant, flexible, elastomeric sealant.
- 4. Service Temperature Range: Minus 40 to plus 250 deg F.
- 5. Color: Aluminum.
- 6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- 7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- D. ASJ Flashing Sealants and PVDC and PVC Jacket Flashing Sealants:
  - 1. Products: Subject to compliance with requirements, provide the following:
    - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
  - 2. Materials shall be compatible with insulation materials, jackets, and substrates.
  - 3. Fire- and water-resistant, flexible, elastomeric sealant.
  - 4. Service Temperature Range: Minus 40 to plus 250 deg F.
  - 5. Color: White.
  - 6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
  - 7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

### 2.6 FACTORY-APPLIED JACKETS

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
  - 1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.
  - 2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.
  - 3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.
  - 4. ASJ+: Aluminum foil reinforced with glass scrim bonded to a kraft paper interleaving with an outer film leaving no paper exposed; complying with ASTM C1136, Types I, II, III, IV, and VII.
  - 5. PSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C1136, Type II.

### 2.7 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C1136, Type I, unless otherwise indicated.

- B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.
- C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
  - 1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Johns Manville; Zeston.
    - b. P.I.C. Plastics, Inc.; FG Series.
    - c. Proto Corporation; LoSmoke.
    - d. Speedline Corporation; SmokeSafe.
  - 2. Adhesive: As recommended by jacket material manufacturer.
  - 3. Color: 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.
- D. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.
  - 1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Metal Jacketing Systems.
    - b. ITW Insulation Systems; Aluminum and Stainless Steel Jacketing.
    - c. RPR Products, Inc.; Insul-Mate.
  - 2. Factory cut and rolled to size.
  - 3. Finish and thickness are indicated in field-applied jacket schedules.
  - 4. Moisture Barrier for Indoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper.
  - 5. Moisture Barrier for Outdoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper.
  - 6. Factory-Fabricated Fitting Covers:
    - a. Same material, finish, and thickness as jacket.
    - b. Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
    - c. Tee covers.
    - d. Flange and union covers.
    - e. End caps.
    - f. Beveled collars.
    - g. Valve covers.
    - h. Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

- E. Underground Direct-Buried Jacket: 125-mil- thick vapor barrier and waterproofing membrane, consisting of a rubberized bituminous resin reinforced with a woven-glass fiber or polyester scrim and laminated aluminum foil.
- F. Self-Adhesive Outdoor Jacket (Asphaltic): 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.
  - 1. Products: Subject to compliance with requirements, provide the following:
    - a. Polyguard Products, Inc.; Alumaguard 60.
- G. Self-Adhesive Indoor/Outdoor Jacket (Non-Asphaltic): Vapor barrier and waterproofing jacket for installation over insulation located aboveground outdoors or indoors. Specialized jacket has five layers of laminated aluminum and polyester film with low-temperature acrylic pressure-sensitive adhesive. Outer aluminum surface is coated with UV-resistant coating for protection from environmental contaminants.
  - 1. Products: Subject to compliance with requirements, provide the following:
    - a. Polyguard Products, Inc.; Alumaguard 60.
  - 2. Permeance: 0.00 perm as tested in accordance with ASTM F1249.
  - 3. Flamespread/Smoke Developed: 25/50 as tested in accordance with ASTM E84.
  - 4. Aluminum Finish: Embossed.
- H. PVDC Jacket for Indoor Applications: 4-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perm when tested in accordance with ASTM E96/E96M and with a flame-spread index of 10 and a smoke-developed index of 20 when tested in accordance with ASTM E84.
  - 1. Products: Subject to compliance with requirements, provide the following:
    - a. Dow Chemical Company (The); Saran 540 Vapor Retarder Film.
- I. PVDC Jacket for Outdoor Applications: 6-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perm when tested in accordance with ASTM E96/E96M and with a flame-spread index of 25 and a smoke-developed index of 50 when tested in accordance with ASTM E84.
  - 1. Products: Subject to compliance with requirements, provide the following:
    - a. Dow Chemical Company (The); Saran 540 Vapor Retarder Film.
- J. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.

- 1. Products: Subject to compliance with requirements, provide the following:
  - a. Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.
- 2.

## 2.8 FIELD-APPLIED REINFORCING MESH

- A. Woven Polyester Mesh: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in., in a Leno weave, for pipe.
  - 1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Mast-A-Fab.
    - b. Vimasco Corporation; Elastafab 894.

### 2.9 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.
  - 1. Products: Subject to compliance with requirements, provide one of the following:
    - a. ABI, Ideal Tape Division; 428 AWF ASJ.
    - b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
    - c. Compac Corporation; 104 and 105.
    - d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.
  - 2. Width: 3 inches.
  - 3. Thickness: 11.5 mils.
  - 4. Adhesion: 90 ounces force/inch in width.
  - 5. Elongation: 2 percent.
  - 6. Tensile Strength: 40 lbf/inch in width.
  - 7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C1136.
  - 1. Products: Subject to compliance with requirements, provide one of the following:
    - a. ABI, Ideal Tape Division; 491 AWF FSK.
    - b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
    - c. Compac Corporation; 110 and 111.
    - d. Venture Tape; 1525 CW NT, 1528 CW, and 1528 CW/SQ.

- 2. Width: 3 inches.
- 3. Thickness: 6.5 mils.
- 4. Adhesion: 90 ounces force/inch in width.
- 5. Elongation: 2 percent.
- 6. Tensile Strength: 40 lbf/inch in width.
- 7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
- C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
  - 1. Products: Subject to compliance with requirements, provide one of the following:
    - a. ABI, Ideal Tape Division; 370 White PVC tape.
    - b. Compac Corporation; 130.
    - c. Venture Tape; 1506 CW NS.
  - 2. Width: 2 inches.
  - 3. Thickness: 6 mils.
  - 4. Adhesion: 64 ounces force/inch in width.
  - 5. Elongation: 500 percent.
  - 6. Tensile Strength: 18 lbf/inch in width.
- D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
  - 1. Products: Subject to compliance with requirements, provide one of the following:
    - a. ABI, Ideal Tape Division; 488 AWF.
    - b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
    - c. Compac Corporation; 120.
    - d. Venture Tape; 3520 CW.
  - 2. Width: 2 inches.
  - 3. Thickness: 3.7 mils.
  - 4. Adhesion: 100 ounces force/inch in width.
  - 5. Elongation: 5 percent.
  - 6. Tensile Strength: 34 lbf/inch in width.
- E. PVDC Tape for Indoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.
  - 1. Products: Subject to compliance with requirements, provide the following:
    - a. Dow Chemical Company (The); Saran 540 Vapor Retarder Tape.
  - 2. Width: 3 inches.
  - 3. Film Thickness: 4 mils.
  - 4. Adhesive Thickness: 1.5 mils.
  - 5. Elongation at Break: 145 percent.
  - 6. Tensile Strength: 55 lbf/inch in width.

- F. PVDC Tape for Outdoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.
  - 1. Products: Subject to compliance with requirements, provide the following:
    - a. Dow Chemical Company (The); Saran 560 Vapor Retarder Tape.
  - 2. Width: 3 inches.
  - 3. Film Thickness: 6 mils.
  - 4. Adhesive Thickness: 1.5 mils.
  - 5. Elongation at Break: 145 percent.
  - 6. Tensile Strength: 55 lbf/inch in width.

## 2.10 SECUREMENTS

- A. Bands:
  - 1. Products: Subject to compliance with requirements, provide one of the following:
    - a. ITW Insulation Systems; Gerrard Strapping and Seals.
    - b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.
  - 2. Stainless Steel: ASTM A240/A240M, Type 304 or Type 316; 0.015 inch thick, 3/4 inch wide with wing seal or closed seal.
  - 3. Aluminum: ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 3/4 inch wide with wing seal or closed seal.
  - 4. Springs: Twin spring set constructed of stainless steel, with ends flat and slotted to accept metal bands. Spring size is determined by manufacturer for application.
- B. Staples: Outward-clinching insulation staples, nominal 3/4 inch wide, stainless steel or Monel.
- C. Wire: 0.080-inch nickel-copper alloy.
  - 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
    - a. C & F Wire.

### PART 3 - EXECUTION

### 3.1 PREPARATION

- A. Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- B. Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:

- 1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils thick and an epoxy finish 5 mils thick if operating in a temperature range between 140 and 300 deg F. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
- Carbon Steel: Coat carbon steel operating at a service temperature of 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 tradesman 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.

# 3.2 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 insulation materials, forms, vapor barriers or retarders, jackets, and of thicknesses required for each item of pipe 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, compress, or otherwise damage insulation or jacket.
- D. Install insulation with longitudinal seams at top and bottom (12 o'clock and 6 o'clock positions) of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- G. Keep insulation materials dry during storage, application, and finishing. Replace insulation materials that get wet during storage or in the installation process before being properly covered and sealed in accordance with the Contract Documents.
- H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- I. Install insulation with least number of joints practical.
- J. 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 attached to structure with vapor-barrier mastic.

- 3. Install insert materials and 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.
- K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- L. Install insulation with factory-applied jackets as follows:
  - 1. Draw jacket tight and smooth, but not to the extent of creating wrinkles or areas of compression in the insulation.
  - 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 2 inches o.c.
  - 4. For below-ambient services, apply vapor-barrier mastic over staples.
  - 5. Cover joints and seams with tape, in accordance with insulation material manufacturer's written instructions, to maintain vapor seal.
  - 6. 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.
- 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 in similar fashion 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.

### 3.3 PENETRATIONS

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
  - 1. Seal penetrations with flashing sealant.
  - 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor

insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.

- 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
- 4. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.
- C. 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.
- D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- E. 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 078413 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.
- F. Insulation Installation at Floor Penetrations:
  - 1. Pipe: Install insulation continuously through floor penetrations.
  - 2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

# 3.4 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 below.
- B. Insulation Installation on Fittings, Valves, Strainers, Flanges, Mechanical Couplings, and Unions:
  - 1. Install insulation over fittings, valves, strainers, flanges, mechanical couplings, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.

- 2. Insulate pipe elbows using prefabricated fitting insulation or mitered or routed fittings made from same material and density as that of 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 prefabricated fitting insulation or sectional pipe insulation of same material and thickness as that 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 prefabricated fitting insulation or sectional pipe insulation of same material, density, and thickness as that used for adjacent pipe. Overlap adjoining pipe insulation by not less than 2 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 prefabricated fitting insulation or sectional pipe insulation of same material, density, and thickness as that used for adjacent pipe. Overlap adjoining pipe insulation by not less than 2 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 below-ambient services, provide a design that maintains vapor barrier.
- 6. Insulate flanges, mechanical couplings, and unions using a section of oversized preformed pipe insulation to fit. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Stencil or label the outside insulation jacket of each union with the word "union" matching size and color of pipe labels.
- 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 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.
- 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. Install removable insulation covers at locations indicated. 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 that of adjoining pipe insulation.

- 2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union at least 2 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 (50 mm) 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.

# 3.5 INSTALLATION OF CELLULAR-GLASS INSULATION

- A. Insulation Installation on Straight Pipes and Tubes:
  - 1. Secure each layer of insulation to pipe with wire or bands, and tighten bands without deforming insulation materials.
  - 2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
  - 3. For insulation with jackets on above-ambient services, secure laps with outwardclinched staples at 6 inches o.c.
  - 4. For insulation with jackets on below-ambient services, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive, as recommended by insulation material manufacturer, and seal with vapor-barrier mastic and flashing sealant.
- B. Insulation Installation on Pipe Flanges:
  - 1. Install prefabricated pipe insulation to outer diameter of pipe flange.
  - 2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
  - 3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as that of pipe insulation. Where voids are difficult to fill with block insulation, fill the voids with a fibrous insulation material suitable for the specific operating temperature.
  - 4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch (25 mm), and seal joints with flashing sealant.
- C. Insulation Installation on Pipe Fittings and Elbows:
  - 1. Install prefabricated sections of same material as that of straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.

- 2. When preformed sections of insulation are not available, install mitered or routed sections of cellular-glass insulation. Secure insulation materials with wire or bands.
- D. Insulation Installation on Valves and Pipe Specialties:
  - 1. Install prefabricated sections of cellular-glass insulation to valve body.
  - 2. 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.

# 3.6 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. Insulation Installation on Pipe Flanges:
  - 1. Install pipe insulation to outer diameter of pipe flange.
  - 2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
  - 3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as that of pipe insulation.
  - 4. 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.
- C. Insulation Installation on Pipe Fittings and Elbows:
  - 1. Install sections of pipe insulation and miter if required in accordance with manufacturer's written instructions.
  - 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.
- D. Insulation Installation on Valves and Pipe Specialties:
  - 1. Install prefabricated valve covers manufactured of same material as that of pipe insulation when available.
  - 2. When prefabricated 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.

## 3.7 INSTALLATION OF GLASS-FIBER AND MINERAL WOOL INSULATION

- A. Insulation Installation on Straight Pipes and Tubes:
  - 1. Secure each layer of preformed pipe insulation to pipe with wire or bands, and tighten bands without deforming insulation materials.
  - 2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
  - 3. For insulation with jackets on above-ambient surfaces, secure laps with outwardclinched staples at 6 inches o.c.
  - 4. For insulation with jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive, as recommended by insulation material manufacturer, and seal with vapor-barrier mastic and flashing sealant.
- B. Insulation Installation on Pipe Flanges:
  - 1. Install prefabricated pipe insulation to outer diameter of pipe flange.
  - 2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
  - 3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with glass-fiber or mineral-wool blanket insulation.
  - 4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.
- C. Insulation Installation on Pipe Fittings and Elbows:
  - 1. Install prefabricated sections of same material as that of straight segments of pipe insulation when available.
  - 2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.
- D. Insulation Installation on Valves and Pipe Specialties:
  - 1. Install prefabricated sections of same material as that of straight segments of pipe insulation when available.
  - 2. When prefabricated sections are not available, install fabricated sections of pipe insulation to valve body.
  - 3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
  - 4. Install insulation to flanges as specified for flange insulation application.

### 3.8 INSTALLATION OF FIELD-APPLIED JACKETS

- A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.
  - 1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.

- 2. Embed glass cloth between two 0.062-inch- thick coats of lagging adhesive.
- 3. Completely encapsulate insulation with coating, leaving no exposed insulation.
- B. Where FSK jackets are indicated, install as follows:
  - 1. Draw jacket material smooth and tight.
  - 2. Install lap or joint strips with same material as jacket.
  - 3. Secure jacket to insulation with manufacturer's recommended adhesive.
  - 4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch- wide joint strips at end joints.
  - 5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.
- C. Where PVC jackets are indicated and for horizontal applications, install with 1-inch overlap at longitudinal seams and end joints. 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.
- D. 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.
- E. Where PVDC jackets are indicated, install as follows:
  - 1. Apply three separate wraps of filament tape per insulation section to secure pipe insulation to pipe prior to installation of PVDC jacket.
  - 2. Wrap presized jackets around individual pipe insulation sections, with one end overlapping the previously installed sheet. Install presized jacket with an approximate overlap at butt joint of 2 inches over the previous section. Adhere lap seal using adhesive or SSL, and then apply 1-1/4 circumferences of appropriate PVDC tape around overlapped butt joint.
  - 3. Continuous jacket can be spiral-wrapped around a length of pipe insulation. Apply adhesive or PVDC tape at overlapped spiral edge. When electing to use adhesives, refer to manufacturer's written instructions for application of adhesives along this spiral edge to maintain a permanent bond.
  - 4. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of 33-1/2 inches or less. The 33-1/2-inch- circumference limit allows for 2-inch- overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.
  - 5. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.

### 3.9 FINISHES

- A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."
  - 1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
    - a. Finish Coat Material: Interior, flat, latex-emulsion size.
- B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
- C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.
- D. Do not field paint aluminum or stainless steel jackets.
- 3.10 FIELD QUALITY CONTROL
  - A. Engage a qualified testing agency to perform tests and inspections.
  - B. Tests and Inspections: Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.
  - C. All insulation applications will be considered defective if they do not pass tests and inspections.
  - D. Prepare test and inspection reports.

### 3.11 PIPING INSULATION SCHEDULE, GENERAL

- A. Insulation conductivity and thickness per pipe size shall comply with schedules in this Section or with requirements of authorities having jurisdiction, whichever is more stringent.
- B. 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.
- C. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
  - 1. Underground piping.
  - 2. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

- 3.12 INDOOR PIPING INSULATION SCHEDULE
  - A. Condensate and Equipment Drain Water below 60 Deg F:
    - 1. All Pipe Sizes: Insulation shall be one of the following:
      - a. Cellular Glass: 1-1/2 inches thick.
      - b. Flexible Elastomeric: 1 inch thick.
      - c. Glass-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
  - B. Chilled Water and Brine, 40 Deg F and below:
    - 1. NPS 3 and Smaller: Insulation shall be one of the following:
      - a. Cellular Glass: 1-1/2 inches thick.
      - b. Flexible Elastomeric: 1-1/2 inches thick.
      - c. Glass-Fiber, Preformed Pipe Insulation, Type I: 2 inches thick.
    - 2. NPS 4 to NPS 12: Insulation shall be one of the following:
      - a. Cellular Glass: 1-1/2 inches thick.
      - b. Flexible Elastomeric: 1 inch thick.
      - c. Glass-Fiber, Preformed Pipe Insulation, Type I: 2 inches thick.
  - C. Chilled Water and Brine, Above 40 Deg F:
    - 1. NPS 12 and Smaller: Insulation shall be one of the following:
      - a. Cellular Glass: 1-1/2 inches thick.
      - b. Flexible Elastomeric: 1 inch thick.
      - c. Glass-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
  - D. Condenser-Water Supply and Return:
    - 1. NPS 12 and Smaller: Insulation shall be one of the following:
      - a. Cellular Glass: 1-1/2 inches thick.
      - b. Flexible Elastomeric: 1 inch thick.
      - c. Glass-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
  - E. Heating-Hot-Water Supply and Return, 200 Deg F and Below:
    - 1. NPS 12 and Smaller: Insulation shall be one of the following:
      - a. Cellular Glass: 2 inches thick.
      - b. Glass-Fiber, Preformed Pipe, Type I: 2 inches thick.
  - F. Heating-Hot-Water Supply and Return, Above 200 Deg F:
    - 1. NPS 3/4 and Smaller: Insulation shall be one of the following:

- a. Cellular Glass: 2 inches thick.
- b. Glass-Fiber, Preformed Pipe Insulation, Type I: 2 inches thick.
- 2. NPS 1 and Larger: Insulation shall be one of the following:
  - a. Cellular Glass: 3 inches thick.
  - b. Glass-Fiber, Preformed Pipe, Type I: 3 inches thick.
- G. Refrigerant Suction and Hot-Gas Piping:
  - 1. All Pipe Sizes: Insulation shall be the following:
    - a. Flexible Elastomeric: 1 inch thick.
- H. Refrigerant Suction and Hot-Gas Flexible Tubing:
  - 1. All Pipe Sizes: Insulation shall be the following:
    - a. Flexible Elastomeric: 2 inches thick.
- I. Refrigerant Liquid Piping:
  - 1. All Pipe Sizes: Insulation shall be the following:
    - a. Flexible Elastomeric: 1 inch thick.
- 3.13 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE
  - A. Chilled Water and Brine:
    - 1. All Pipe Sizes: Insulation shall be one of the following:
      - a. Cellular Glass: 3 inches thick.
      - b. Glass-Fiber, Preformed Pipe Insulation, Type I: 3 inches thick.
  - B. Condenser-Water Supply and Return:
    - 1. All Pipe Sizes: Insulation shall be one of the following:
      - a. Cellular Glass: 2 inches thick.
      - b. Glass-Fiber, Preformed Pipe Insulation, Type I: 2 inches thick.
  - C. Heating-Hot-Water Supply and Return, 200 Deg F and Below:
    - 1. All Pipe Sizes: Insulation shall be one of the following:
      - a. Cellular Glass: 3 inches thick.
      - b. Glass-Fiber, Preformed Pipe Insulation, Type I: 2 inches thick.
  - D. Refrigerant Suction and Hot-Gas Piping:

- 1. All Pipe Sizes: Insulation shall be one of the following:
  - a. Cellular Glass: 2 inches thick.
  - b. Flexible Elastomeric: 2 inches thick.
- E. Refrigerant Suction and Hot-Gas Flexible Tubing:
  - 1. All Pipe Sizes: Insulation is the following:
    - a. Flexible Elastomeric: 2 inches thick.
- 3.14 OUTDOOR, UNDERGROUND, PIPING INSULATION SCHEDULE
  - A. Insulation, for belowground piping, is specified in Section 232113.13 "Underground Hydronic Piping" and Section 232213.13 "Underground Steam and Condensate Heating Piping."
  - B. Chilled Water, All Sizes: Cellular glass, 2 inches thick.
  - C. Condenser-Water Supply and Return, All Sizes: Cellular glass, 2 inches thick.
  - D. Heating-Hot-Water Supply and Return, All Sizes, 200 Deg F and Below: Cellular glass, 3 inches thick.

### 3.15 INDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the fieldapplied jacket over the factory-applied jacket.
- B. If more than one material is listed, selection from materials listed is Contractor's option.
- C. Piping, Concealed:
  - 1. None.
- D. Piping, Exposed:
  - 1. None.
  - 2. PVC: 30 mils thick.
  - 3. Aluminum, Stucco Embossed: 0.024 inch thick.

### 3.16 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the fieldapplied jacket over the factory-applied jacket.
- B. If more than one material is listed, selection from materials listed is Contractor's option.

- C. Piping, Concealed:
  - 1. None.
- D. Piping, Exposed:
  - 1. PVC: 30 mils thick.

# 3.17 UNDERGROUND, FIELD-APPLIED INSULATION JACKET

A. For underground direct-buried piping applications, install underground direct-buried jacket over insulation material.

END OF SECTION 230719

# SECTION 231123 - FACILITY NATURAL-GAS PIPING

### PART 1 - GENERAL

### 1.1 SUMMARY

- A. Section Includes:
  - 1. Pipes, tubes, and fittings.
  - 2. Piping specialties.
  - 3. Piping and tubing joining materials.
  - 4. Manual gas shutoff valves.
  - 5. Pressure regulators.
  - 6. Dielectric unions.

### 1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: For facility natural-gas piping layout. Include plans, piping layout and elevations, sections, and details for fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to building structure. Detail location of anchors, alignment guides, and expansion joints and loops.
- C. Delegated-Design Submittal: For natural-gas piping and equipment indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
  - 1. Detail fabrication and assembly of seismic restraints.
  - 2. Design Calculations: Calculate requirements for selecting seismic restraints.

### 1.3 INFORMATIONAL SUBMITTALS

- A. Welding certificates.
- B. Field quality-control reports.

## 1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

### 1.5 QUALITY ASSURANCE

- A. Steel Support 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.
- 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.

### PART 2 - PRODUCTS

- 2.1 PERFORMANCE REQUIREMENTS
  - A. Minimum Operating-Pressure Ratings:
    - 1. Piping and Valves: 100 psig minimum unless otherwise indicated.
    - 2. Service Regulators: 65 psig minimum unless otherwise indicated.
  - B. Natural-Gas System Pressure within Buildings: 0.5 psig or less.
  - C. Delegated Design: Design restraints and anchors for natural-gas piping and equipment, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

### 2.2 PIPES, TUBES, AND FITTINGS

- A. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.
  - 1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
  - 2. Wrought-Steel Welding Fittings: ASTM A 234/A 234M for butt welding and socket welding.
  - 3. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
  - 4. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.
    - a. Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.
- B. Corrugated, Stainless-Steel Tubing: Comply with ANSI/IAS LC 1.
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. OmegaFlex, Inc.
    - b. Parker Hannifin Corporation; Parflex Division.

- c. Titeflex.
- d. Tru-Flex Metal Hose Corp.
- 2. Tubing: ASTM A 240/A 240M, corrugated, Series 300 stainless steel.
- 3. Coating: PE with flame retardant.
  - a. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
    - 1) Flame-Spread Index: 25 or less.
    - 2) Smoke-Developed Index: 50 or less.
- 4. Fittings: Copper-alloy mechanical fittings with ends made to fit and listed for use with corrugated stainless-steel tubing and capable of metal-to-metal seal without gaskets. Include brazing socket or threaded ends complying with ASME B1.20.1.
- 5. Striker Plates: Steel, designed to protect tubing from penetrations.
- 6. Manifolds: Malleable iron or steel with factory-applied protective coating. Threaded connections shall comply with ASME B1.20.1 for pipe inlet and corrugated tubing outlets.
- 7. Operating-Pressure Rating: 5 psig.
- C. Annealed-Temper Copper Tube: Comply with ASTM B 88, Type K.
  - 1. Copper Fittings: ASME B16.22, wrought copper, and streamlined pattern.
  - 2. Flare Fittings: Comply with ASME B16.26 and SAE J513.
    - a. Copper fittings with long nuts.
    - b. Metal-to-metal compression seal without gasket.
    - c. Dryseal threads complying with ASME B1.20.3.
  - 3. Protective Coating for Underground Tubing: Factory-applied, extruded PE a minimum of 0.022 inch thick.
- D. PE Pipe: ASTM D 2513, SDR 11.
  - 1. PE Fittings: ASTM D 2683, socket-fusion type or ASTM D 3261, butt-fusion type with dimensions matching PE pipe.
  - 2. PE Transition Fittings: Factory-fabricated fittings with PE pipe complying with ASTM D 2513, SDR 11; and steel pipe complying with ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.
  - 3. Anodeless Service-Line Risers: Factory fabricated and leak tested.
    - a. Underground Portion: PE pipe complying with ASTM D 2513, SDR 11 inlet.
    - b. Casing: Steel pipe complying with ASTM A 53/A 53M, Schedule 40, black steel, Type E or S, Grade B, with corrosion-protective coating covering. Vent casing aboveground.
    - c. Aboveground Portion: PE transition fitting.
    - d. Outlet shall be threaded or suitable for welded connection.

- e. Tracer wire connection.
- f. Ultraviolet shield.
- g. Stake supports with factory finish to match steel pipe casing or carrier pipe.
- 4. Transition Service-Line Risers: Factory fabricated and leak tested.
  - a. Underground Portion: PE pipe complying with ASTM D 2513, SDR 11 inlet connected to steel pipe complying with ASTM A 53/A 53M, Schedule 40, Type E or S, Grade B, with corrosion-protective coating for aboveground outlet.
  - b. Outlet shall be threaded or suitable for welded connection.
  - c. Bridging sleeve over mechanical coupling.
  - d. Factory-connected anode.
  - e. Tracer wire connection.
  - f. Ultraviolet shield.
  - g. Stake supports with factory finish to match steel pipe casing or carrier pipe.

#### 2.3 PIPING SPECIALTIES

- A. Appliance Flexible Connectors:
  - 1. Indoor, Fixed-Appliance Flexible Connectors: Comply with ANSI Z21.24.
  - 2. Indoor, Movable-Appliance Flexible Connectors: Comply with ANSI Z21.69.
  - 3. Outdoor, Appliance Flexible Connectors: Comply with ANSI Z21.75.
  - 4. Corrugated stainless-steel tubing with polymer coating.
  - 5. Operating-Pressure Rating: 0.5 psig.
  - 6. End Fittings: Zinc-coated steel.
  - 7. Threaded Ends: Comply with ASME B1.20.1.
  - 8. Maximum Length: 72 inches.
- B. Y-Pattern Strainers:
  - 1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
  - 2. End Connections: Threaded ends for NPS 2 and smaller.
  - 3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
  - 4. CWP Rating: 125 psig.
- C. Weatherproof Vent Cap: Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.

### 2.4 JOINING MATERIALS

- A. Joint Compound and Tape: Suitable for natural gas.
- B. 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.

C. Brazing Filler Metals: Alloy with melting point greater than 1000 deg F complying with AWS A5.8/A5.8M. Brazing alloys containing more than 0.05 percent phosphorus are prohibited.

## 2.5 MANUAL GAS SHUTOFF VALVES

- A. See "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles for where each valve type is applied in various services.
- B. General Requirements for Metallic Valves, NPS 2 and Smaller: Comply with ASME B16.33.
  - 1. CWP Rating: 125 psig.
  - 2. Threaded Ends: Comply with ASME B1.20.1.
  - 3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
  - 4. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
  - 5. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch and smaller.
  - 6. Service Mark: Valves 1-1/4 inches to NPS 2 shall have initials "WOG" permanently marked on valve body.
- C. One-Piece, Bronze Ball Valve with Bronze Trim: MSS SP-110.
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. BrassCraft Manufacturing Company; a Masco company.
    - b. Conbraco Industries, Inc.; Apollo Div.
    - c. Lyall, R. W. & Company, Inc.
    - d. McDonald, A. Y. Mfg. Co.
    - e. Perfection Corporation; a subsidiary of American Meter Company.
  - 2. Body: Bronze, complying with ASTM B 584.
  - 3. Ball: Chrome-plated brass.
  - 4. Stem: Bronze; blowout proof.
  - 5. Seats: Reinforced TFE; blowout proof.
  - 6. Packing: Separate packnut with adjustable-stem packing threaded ends.
  - 7. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
  - 8. CWP Rating: 600 psig.
  - 9. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
  - 10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.
- D. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. BrassCraft Manufacturing Company; a Masco company.
  - b. Conbraco Industries, Inc.; Apollo Div.
  - c. Lyall, R. W. & Company, Inc.
  - d. McDonald, A. Y. Mfg. Co.
  - e. Perfection Corporation; a subsidiary of American Meter Company.
- 2. Body: Bronze, complying with ASTM B 584.
- 3. Ball: Chrome-plated bronze.
- 4. Stem: Bronze; blowout proof.
- 5. Seats: Reinforced TFE; blowout proof.
- 6. Packing: Threaded-body packnut design with adjustable-stem packing.
- 7. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
- 8. CWP Rating: 600 psig.
- 9. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
- 10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.
- E. Bronze Plug Valves: MSS SP-78.
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Lee Brass Company.
    - b. McDonald, A. Y. Mfg. Co.
  - 2. Body: Bronze, complying with ASTM B 584.
  - 3. Plug: Bronze.
  - 4. Ends: Threaded, socket, as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
  - 5. Operator: Square head or lug type with tamperproof feature where indicated.
  - 6. Pressure Class: 125 psig.
  - 7. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
  - 8. Service: Suitable for natural-gas service with "WOG" indicated on valve body.
- F. PE Ball Valves: Comply with ASME B16.40.
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Kerotest Manufacturing Corp.
    - b. Lyall, R. W. & Company, Inc.
    - c. Perfection Corporation; a subsidiary of American Meter Company.
  - 2. Body: PE.

- 3. Ball: PE.
- 4. Stem: Acetal.
- 5. Seats and Seals: Nitrile.
- 6. Ends: Plain or fusible to match piping.
- 7. CWP Rating: 80 psig.
- 8. Operating Temperature: Minus 20 to plus 140 deg F.
- 9. Operator: Nut or flat head for key operation.
- 10. Include plastic valve extension.
- 11. Include tamperproof locking feature for valves where indicated on Drawings.
- 2.6 PRESSURE REGULATORS
  - A. General Requirements:
    - 1. Single stage and suitable for natural gas.
    - 2. Steel jacket and corrosion-resistant components.
    - 3. Elevation compensator.
    - 4. End Connections: Threaded for regulators NPS 2 (DN 50) and smaller.
  - B. Line Pressure Regulators: Comply with ANSI Z21.80.
    - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      - a. Actaris.
      - b. American Meter Company.
      - c. Eclipse Combustion, Inc.
      - d. Fisher Control Valves and Regulators; Division of Emerson Process Management.
      - e. Invensys.
      - f. Maxitrol Company.
      - g. Richards Industries; Jordan Valve Div.
    - 2. Body and Diaphragm Case: Cast iron or die-cast aluminum.
    - 3. Springs: Zinc-plated steel; interchangeable.
    - 4. Diaphragm Plate: Zinc-plated steel.
    - 5. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
    - 6. Orifice: Aluminum; interchangeable.
    - 7. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
    - 8. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
    - 9. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
    - 10. Overpressure Protection Device: Factory mounted on pressure regulator.
    - 11. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
    - 12. Maximum Inlet Pressure: 2 psig.

- C. Appliance Pressure Regulators: Comply with ANSI Z21.18.
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Canadian Meter Company Inc.
    - b. Eaton Corporation; Controls Div.
    - c. Harper Wyman Co.
    - d. Maxitrol Company.
    - e. SCP, Inc.
  - 2. Body and Diaphragm Case: Die-cast aluminum.
  - 3. Springs: Zinc-plated steel; interchangeable.
  - 4. Diaphragm Plate: Zinc-plated steel.
  - 5. Seat Disc: Nitrile rubber.
  - 6. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
  - 7. Factory-Applied Finish: Minimum three-layer polyester and polyurethane paint finish.
  - 8. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.
  - 9. Maximum Inlet Pressure: 1 psig.

# 2.7 DIELECTRIC UNIONS

- A. Dielectric Unions:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Capitol Manufacturing Company.
    - b. Central Plastics Company.
    - c. Hart Industries International, Inc.
    - d. Jomar International Ltd.
    - e. Matco-Norca, Inc.
    - f. McDonald, A. Y. Mfg. Co.
    - g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
    - h. Wilkins; a Zurn company.
  - 2. Description:
    - a. Standard: ASSE 1079.
    - b. Pressure Rating: 150 psig.
    - c. End Connections: Solder-joint copper alloy and threaded ferrous.

# 2.8 LABELING AND IDENTIFYING

A. Detectable Warning Tape: Acid- and alkali-resistant, PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches wide and 4 mils thick,

continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep; colored yellow.

## PART 3 - EXECUTION

#### 3.1 OUTDOOR PIPING INSTALLATION

- A. Comply with NFPA 54 and the International Fuel Gas Code for installation and purging of natural-gas piping.
- B. Install underground, natural-gas piping buried at least 36 inches below finished grade. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.
  - 1. If natural-gas piping is installed less than 36 inches below finished grade, install it in containment conduit.
- C. Install underground, PE, natural-gas piping according to ASTM D 2774.
- D. Steel Piping with Protective Coating:
  - 1. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.
  - 2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.
  - 3. Replace pipe having damaged PE coating with new pipe.
- E. Copper Tubing with Protective Coating:
  - 1. Apply joint cover kits over tubing to cover, seal, and protect joints.
  - 2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.
- F. Install fittings for changes in direction and branch connections.
- G. Install pressure gage upstream and downstream from each service regulator. Pressure gages are specified in Section 230519 "Meters and Gages for HVAC Piping."

#### 3.2 INDOOR PIPING INSTALLATION

- A. Comply with NFPA 54 and the International Fuel Gas Code for installation and purging of natural-gas piping.
- B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

- C. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.
- 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. Locate valves for easy access.
- H. Install natural-gas piping at uniform grade of 2 percent down toward drip and sediment traps.
- I. Install piping free of sags and bends.
- J. Install fittings for changes in direction and branch connections.
- K. Verify final equipment locations for roughing-in.
- L. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.
- M. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.
  - 1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches (75 mm) long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.
- N. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.
- O. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view.
- P. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.
- Q. Connect branch piping from top or side of horizontal piping.
- R. Install unions in pipes NPS 2 and smaller, adjacent to each valve, at final connection to each piece of equipment.
- S. Do not use natural-gas piping as grounding electrode.

- T. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.
- U. Install pressure gage upstream and downstream from each line regulator. Pressure gages are specified in Section 230519 "Meters and Gages for HVAC Piping."
- V. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."
- W. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."
- X. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

### 3.3 VALVE INSTALLATION

- A. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless-steel tubing or copper connector.
- B. Install underground valves with valve boxes.
- C. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.
- D. Install earthquake valves aboveground outside buildings according to listing.
- E. Install anode for metallic valves in underground PE piping.

#### 3.4 PIPING JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Threaded Joints:
  - 1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
  - 2. Cut threads full and clean using sharp dies.
  - 3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
  - 4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
  - 5. 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.
- D. Welded Joints:

- 1. Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators.
- 2. Bevel plain ends of steel pipe.
- 3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.
- E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.
- F. Flared Joints: Cut tubing with roll cutting tool. Flare tube end with tool to result in flare dimensions complying with SAE J513. Tighten finger tight, then use wrench. Do not overtighten.
- G. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.
  - 1. Plain-End Pipe and Fittings: Use butt fusion.
  - 2. Plain-End Pipe and Socket Fittings: Use socket fusion.

#### 3.5 HANGER AND SUPPORT INSTALLATION

- A. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
- B. Comply with requirements for pipe hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
- C. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:
  - 1. NPS 1 and Smaller: Maximum span, 96 inches; minimum rod size, 3/8 inch.
  - 2. NPS 1-1/4: Maximum span, 108 inches; minimum rod size, 3/8 inch.
  - 3. NPS 1-1/2 and NPS 2: Maximum span, 108 inches; minimum rod size, 3/8 inch.
- D. Install hangers for horizontal, corrugated stainless-steel tubing with the following maximum spacing and minimum rod sizes:
  - 1. NPS 3/8: Maximum span, 48 inches; minimum rod size, 3/8 inch.
  - 2. NPS 1/2: Maximum span, 72 inches; minimum rod size, 3/8 inch.
  - 3. NPS 3/4 and Larger: Maximum span, 96 inches; minimum rod size, 3/8 inch.

#### 3.6 CONNECTIONS

- A. Connect to utility's gas main according to utility's procedures and requirements.
- B. Install natural-gas piping electrically continuous, and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.

- C. Install piping adjacent to appliances to allow service and maintenance of appliances.
- D. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.
- E. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

### 3.7 LABELING AND IDENTIFYING

- A. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for piping and valve identification.
- B. Install detectable warning tape directly above gas piping, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

#### 3.8 FIELD QUALITY CONTROL

- A. Test, inspect, and purge natural gas according to NFPA 54 and the International Fuel Gas Code and authorities having jurisdiction.
- B. Natural-gas piping will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

#### 3.9 OUTDOOR PIPING SCHEDULE

- A. Underground natural-gas piping shall be one of the following:
  - 1. PE pipe and fittings joined by heat fusion; service-line risers with tracer wire terminated in an accessible location.
  - 2. Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.
  - 3. Annealed-temper copper tube with wrought-copper fittings and brazed joints. Coat pipe and fittings with protective coating for copper tubing.
- B. Aboveground natural-gas piping shall be one of the following:
  - 1. Steel pipe with malleable-iron fittings and threaded joints.
  - 2. Steel pipe with wrought-steel fittings and welded joints.
  - 3. Annealed-temper copper tube with wrought-copper fittings and brazed joints.
- C. Branch Piping in Cast-in-Place Concrete to Single Appliance: Annealed-temper copper tube with wrought-copper fittings and flared joints. Install piping embedded in concrete with no joints in concrete.

- D. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.
- 3.10 INDOOR PIPING SCHEDULE
  - A. Aboveground, branch piping NPS 1 and smaller shall be one of the following:
    - 1. Corrugated stainless-steel tubing with mechanical fittings having socket or threaded ends to match adjacent piping.
    - 2. Steel pipe with malleable-iron fittings and threaded joints.
  - B. Aboveground, distribution piping shall be one of the following:
    - 1. Steel pipe with malleable-iron fittings and threaded joints.
    - 2. Steel pipe with wrought-steel fittings and welded joints.
  - C. Underground, below building, piping shall be one of the following:
    - 1. Steel pipe with malleable-iron fittings and threaded joints.
    - 2. Steel pipe with wrought-steel fittings and welded joints.
  - D. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.
  - E. Containment Conduit Vent Piping: Steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints. Coat underground pipe and fittings with protective coating for steel piping.
- 3.11 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE
  - A. Valves for pipe sizes NPS 2 and smaller at service meter shall be one of the following:
    - 1. One-piece, bronze ball valve with bronze trim.
    - 2. Two-piece, full-port, bronze ball valves with bronze trim.
    - 3. Bronze plug valve.
  - B. Distribution piping valves for pipe sizes NPS 2 and smaller shall be one of the following:
    - 1. One-piece, bronze ball valve with bronze trim.
    - 2. Two-piece, full-port, bronze ball valves with bronze trim.
    - 3. Bronze plug valve.
  - C. Valves in branch piping for single appliance shall be one of the following:
    - 1. One-piece, bronze ball valve with bronze trim.
    - 2. Two-piece, full-port, bronze ball valves with bronze trim.
    - 3. Bronze plug valve.

END OF SECTION 231123

### SECTION 232123 - HYDRONIC PUMPS

#### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section Includes:
  - 1. Close-coupled, in-line centrifugal pumps.
  - 2. Separately coupled, horizontally mounted, in-line centrifugal pumps.
  - 3. Separately coupled, vertically mounted, in-line centrifugal pumps.
  - 4. Separately coupled, base-mounted, end-suction centrifugal pumps.
  - 5. Automatic condensate pump units.

#### 1.2 DEFINITIONS

- A. ECM: Electronically commutated motor.
- B. EPDM: Ethylene propylene diene monomer.
- C. FKM: Fluoroelastomer polymer.
- D. HI: Hydraulic Institute.
- E. NBR: Nitrile rubber or Buna-N.
- 1.3 ACTION SUBMITTALS
  - A. Product Data: For each type of pump.
  - B. Shop Drawings: For each pump.
  - C. Delegated-Design Submittal: For each pump.
    - 1. Include design calculations for selecting vibration isolators and for designing vibration isolation bases.

### 1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.
- B. Field quality-control reports.

#### 1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

#### 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.

#### 2.2 CLOSE-COUPLED, IN-LINE CENTRIFUGAL PUMPS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Armstrong Pumps, Inc.
  - 2. Grundfos Pumps Corporation.
  - 3. TACO Comfort Solutions, Inc.
  - 4. Bell and Gossett.
- B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, inline pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally or vertically.
- C. Pump Construction:
  - 1. Casing: Radially split, cast iron, with threaded gauge tappings at inlet and outlet, replaceable bronze wear rings, and threaded companion-flange or union-end connections.
  - 2. Impeller: ASTM B584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For constant-speed pumps, trim impeller to match specified performance.
  - 3. Pump Shaft Sleeve: Bronze.
  - 4. Pump Stub Shaft: Type 304 or Type 316 stainless steel.
  - 5. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless steel spring, and NBR, EPDM, or FKM rubber bellows and gasket. Include water slinger on shaft between motor and seal.
  - 6. Seal Flushing: Flush, cool, and lubricate pump seal by directing pump discharge water to flow over the seal.
- D. Shaft Coupling: Rigid, axially-split spacer coupling to allow service of pump seal without disturbing pump or motor.

# Bangor Township Schools ME Upgrades

- E. Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
  - 1. Enclosure : Totally enclosed, fan cooled.
  - 2. NEMA Premium Efficient motors as defined in NEMA MG 1.
  - 3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
  - 4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
  - 5. Single or Variable-speed motor.
  - 6. Provide integral pump motor variable-speed controller.
- F. Capacities and Characteristics:
  - 1. As indicated on drawings.
    - a.

### 2.3 SEPARATELY COUPLED, HORIZONTALLY MOUNTED, IN-LINE CENTRIFUGAL PUMPS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Armstrong Pumps, Inc.
  - 2. PACO Pumps; Grundfos Pumps Corporation, USA.
  - 3. TACO Comfort Solutions, Inc.
  - 4. Bell and Gossett.
- B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally.
- C. Pump Construction:
  - 1. Casing: Radially split, cast iron, with threaded gauge tappings at inlet and outlet, and threaded companion-flange or union-end connections.
  - 2. Impeller: ASTM B584, cast bronze; statically and dynamically balanced, and keyed to shaft. For pumps that are not frequency-drive controlled, trim impeller to match specified performance.
  - 3. Pump Shaft: Carbon steel, with copper-alloy shaft sleeve.
  - 4. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless steel spring, and NBR, EPDM, or FKM bellows and gasket.
  - 5. Pump Bearings: Permanently lubricated ball bearings or Grease lubricated ball bearings.
- D. Shaft Coupling: Molded-rubber insert with interlocking spider or Interlocking frame with interconnecting springs capable of absorbing vibration.

# Bangor Township Schools ME Upgrades

- E. Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
  - 1. Enclosure Type: Totally enclosed, fan cooled.
  - 2. NEMA Premium Efficient motors as defined in NEMA MG 1.
  - 3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
  - 4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
  - 5. Single or Variable-speed motor.
  - 6. Provide integral pump motor variable-speed controller.
- F. Capacities and Characteristics:
  - 1. As indicated on drawings.

## 2.4 SEPARATELY COUPLED, VERTICALLY MOUNTED, IN-LINE CENTRIFUGAL PUMPS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Armstrong Pumps, Inc.
  - 2. PACO Pumps; Grundfos Pumps Corporation, USA.
  - 3. TACO Comfort Solutions, Inc.
  - 4. Bell and Gossett.
- B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted vertically.
- C. Pump Construction:
  - 1. Casing: Radially split, cast iron, with threaded gauge tappings at inlet and outlet, replaceable bronze wear rings, and threaded companion-flange or union-end connections.
  - 2. Impeller: ASTM B584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For pumps that are not frequency-drive controlled, trim impeller to match specified performance.
  - 3. Pump Shaft: Carbon steel, with copper-alloy shaft sleeve.
  - 4. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless steel spring, and NBR, EPDM, or FKM bellows and gasket.
- D. Shaft Coupling: Molded-rubber insert with interlocking spider or Interlocking frame with interconnecting springs capable of absorbing vibration.

# Bangor Township Schools ME Upgrades

- E. Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
  - 1. Enclosure: Totally enclosed, fan cooled.
  - 2. NEMA Premium Efficient motors as defined in NEMA MG 1.
  - 3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
  - 4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
  - 5. Single or Variable-speed motor.
  - 6. Provide integral pump motor variable-speed controller.
- F. Capacities and Characteristics:
  - 1. As indicated on drawings.

## 2.5 SEPARATELY COUPLED, BASE-MOUNTED, END-SUCTION CENTRIFUGAL PUMPS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Armstrong Pumps, Inc.
  - 2. PACO Pumps; Grundfos Pumps Corporation, USA.
  - 3. TACO Comfort Solutions, Inc.
  - 4. Bell and Gossett.
- B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, end-suction pump with flexible shaft coupling as defined in HI 1.1-1.2 and HI 1.3; designed for base mounting, with pump and motor shafts horizontal.
- C. Pump Construction:
  - 1. Casing: Radially split, cast iron, with replaceable bronze wear rings, threaded gauge tappings at inlet and outlet, drain plug at bottom and air vent at top of volute, and threaded companion-flange or flanged connections. Provide integral mount on volute to support the casing, and provide attached piping to allow removal and replacement of impeller without disconnecting piping or requiring realignment of pump and motor shaft.
  - 2. Impeller: ASTM B584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For pumps that are not frequency-drive controlled, trim impeller to match specified performance.
  - 3. Pump Shaft: Carbon steel, with copper-alloy shaft sleeve.
  - 4. Seal, Mechanical Type: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless steel spring, and NBR, EPDM, or FKM bellows and gasket.

- 5. Seal, Packing Type: Packing seal consisting of stuffing box with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
- 6. Pump Bearings: Grease-lubricated ball bearings in cast-iron housing with grease fittings.
- D. Shaft Coupling: Molded-rubber insert and interlocking spider capable of absorbing vibration. Couplings shall be drop-out type to allow disassembly and removal without removing pump shaft or motor or EPDM coupling sleeve for variable-speed applications.
- E. Coupling Guard: Dual rated; ANSI B15.1, Section 8; OSHA 1910.219 approved; steel; removable; attached to mounting frame.
- F. Mounting Frame: Welded-steel frame and cross members, factory fabricated from ASTM A36/A36M channels and angles. Fabricate to mount pump casing, coupling guard, and motor.
- G. Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
  - 1. Enclosure: Totally enclosed, fan cooled.
  - 2. NEMA Premium Efficient motors as defined in NEMA MG 1.
  - 3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
  - 4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
  - 5. Single or Variable-speed motor.
  - 6. Provide integral pump motor variable-speed controller.
- H. Capacities and Characteristics:
  - 1. As indicated on drawings.

#### 2.6 AUTOMATIC CONDENSATE PUMP UNITS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Little Giant.
  - 2. Diversiteck.
  - 3. Rheem.
  - 4. Beckett.
- B. Description: Packaged units with corrosion-resistant pump, plastic tank with cover, and automatic controls. Collects and removes condensate from fan coil units, air handling units, condensing boilers, and similar components. Include factory- or field-installed check valve and 72-inch-minimum, electrical power cord with plug.

- C. Capacities and Characteristics:
  - 1. Pump Capacity: 80 gph.
  - 2. Maximum Lift: 1 feet.
  - 3. Motor Horsepower: 1/30.
  - 4. Electrical Characteristics:
    - a. Volts: 120 V.
    - b. Phase: Single.
    - c. Hertz: 60 Hz.
    - d. Amperes: 1.5 A.

# 2.7 PUMP SPECIALTY FITTINGS

- A. Suction Diffuser:
  - 1. Angle pattern.
  - 2. 300-psig pressure rating, cast or ductile-iron body and end cap, pump-inlet fitting.
  - 3. Bronze 16-mesh wire startup and bronze permanent strainers with 3/16-inch perforations and 51 percent open area.
  - 4. Bronze. Carbon steel, or Type 304 stainless steel straightening vanes.
  - 5. Drain plug.
  - 6. Factory-fabricated support.
- B. Triple-Duty Valve:
  - 1. Angle or straight pattern.
  - 2. 300-psig pressure rating, cast or ductile-iron body, pump-discharge fitting.
  - 3. Valve with multi-turn stem and memory stop to allow valve to be returned to its original position after shutoff.
  - 4. Brass valve disc with EPDM rubber seat.
  - 5. Type 304 stainless steel valve stem.
  - 6. Drain plug and bronze-fitted shutoff, balancing, and check valve features.
  - 7. Brass gauge ports with integral check valve and orifice for flow measurement.

## 2.8 INTEGRAL PUMP MOTOR VARIABLE-SPEED CONTROLLERS

- A. Where specified or scheduled, provide pumps with an integral pump motor speed controller.
  - 1. Motor: Operates as constant- or variable-speed pump with speed regulated by an integrated variable-speed drive.
  - Integrated Pump Controller: Supports direct communication with the building management system (BMS) with built-in support for the following protocols: BACnet<sup>™</sup> MS/TP.
  - 3. Commissioning and pump set up access to pump controls via the following:
    - a. A web interface (data exchange).

- b. A user interface located on the face of speed controller to adjust modes and mode values.
- c. An electronic display that reads real-time mode set values, flow, head, speed, and power and that locks out unauthorized adjustment of pump.
- 4. Provide electronics with "Auto" as factory default but slope of the proportional curve will automatically match the required system curve, constant pressure control (delta-p/c), variable differential pressure control (delta-p/v), constant curve duty (uncontrolled pump), and rpm regulation. RPM (speed) regulation can be accomplished by the following:
  - a. Manual (via user interface or HTML).
  - b. Remote via 0 to 10 V dc.
  - c. Data protocol communications with the BMS.
- 5. Pump Electronics: Standard with multiple digital inputs and one external digital output to be available for additional mechanical room control and pump status monitoring.
- 6. Controller: Mounted on or adjacent to the motor. Provide enclosure rated to UL Type 12.
- 7. Electronically Protected Pumps: Rated for continuous duty and with built-in startup circuit. Provide overcurrent, line surge and current limit protection, thermal monitoring, heat sink status and over temperature protection.
- 8. Pump capable of being monitored continuously via integrated Internet link.
- 9. Integrated pump controller system to have the following features:
  - a. Controller software shall be capable of sensorless control in variable-volume systems without need for pump-mounted (internal/external) or remotely mounted differential pressure sensor.
  - b. Integrated Pump Controller Sensorless Control: Operates under Quadratic Pressure Control (QPC) to ensure that head reduction with reducing flow conforms to quadratic control curve.
  - c. Controller:
    - 1) Minimum head of 40 percent of design duty head.
    - 2) User-adjustable control mode settings and minimum/maximum head set points using built-in programming interface.
  - d. Controller Integrated Control Software:
    - 1) Capable of controlling pump performance for non-overloading power at every point of operation.
    - 2) Capable of maintaining flow rate data.

## 2.9 ELECTRONICALLY COMMUTATED MOTOR (ECM)

A. Provide pumps so they are specified or scheduled with ECM.

- 1. Synchronous, constant torque, ECM with permanent magnet rotor. Rotor magnets to be time-stable, nontoxic ceramic magnets (Sr-Fe).
- 2. Driven by a frequency converter with an integrated power factor correction filter. Conventional induction motors will not be acceptable.
- 3. Each motor with an integrated variable-frequency drive, tested as one unit by manufacturer.
- 4. Motor speed adjustable over full range from 0 rpm to maximum scheduled speed.
- 5. Variable motor speed to be controlled by a 0- to 10 V-dc or 4- to 20-mA input.
- 6. Integrated motor protection verified by UL to protect the pump against over-/undervoltage, overtemperature of motor and/or electronics, overcurrent, locked rotor, and dry run (no-load condition).

#### PART 3 - EXECUTION

- 3.1 PUMP INSTALLATION
  - A. Comply with HI 1.4.
  - B. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.
  - C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.
  - D. Automatic Condensate Pump Units: Install units for collecting condensate and extend to open drain.
  - E. Equipment Mounting:
    - 1. Install base-mounted pumps on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
  - F. Equipment Mounting: Install in-line pumps with continuous-thread hanger rods and elastomeric hangers or spring hangers with vertical-limit stop of size required to support weight of in-line pumps.
    - 1. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
    - 2. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

#### 3.2 ALIGNMENT

A. Engage a factory-authorized service representative to perform alignment service.

- B. Comply with requirements in HI standards for alignment of pump and motor shaft. Add shims to the motor feet and bolt motor to base frame. Do not use grout between motor feet and base frame.
- C. Comply with pump and coupling manufacturers' written instructions.
- D. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with nonshrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

### 3.3 PIPING CONNECTIONS

- A. Comply with requirements for piping specified in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to pump, allow space for service and maintenance.
- C. Connect piping to pumps. Install valves that are same size as piping connected to pumps.
- D. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.
- E. Install triple-duty valve on discharge side of pumps.
- F. Install suction diffuser and shutoff valve on suction side of pumps.
  - 1. Use startup strainer for initial system startup. Install permanent strainer element before turnover of system to Owner.
- G. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.
- H. Install pressure gauges on pump suction and discharge or at integral pressure-gauge tapping, or install single gauge with multiple-input selector valve.
- I. Install check valve on each condensate pump unit discharge unless unit has a factory-installed check valve.

#### 3.4 ELECTRICAL CONNECTIONS

- A. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- C. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."

#### 3.5 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

#### 3.6 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
  - 1. Complete installation and startup checks in accordance with manufacturer's written instructions.
  - 2. Check piping connections for tightness.
  - 3. Clean strainers on suction piping. Use startup strainer for initial startup.
  - 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 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.

#### 3.7 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Perform tests and inspections.
- C. Hydronic pumps will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

#### 3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain hydronic pumps.

END OF SECTION 232123

### SECTION 232300 - REFRIGERANT PIPING

#### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section Includes:
  - 1. Refrigerant pipes and fittings.
  - 2. Refrigerant piping valves and specialties.
  - 3. Refrigerants.

## 1.2 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

#### 1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

#### 1.4 QUALITY ASSURANCE

- A. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."
- B. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

#### PART 2 - PRODUCTS

#### 2.1 PERFORMANCE REQUIREMENTS

- A. Line Test Pressure for Refrigerant R-134a:
  - 1. Suction Lines for Air-Conditioning Applications: 115 psig.
  - 2. Suction Lines for Heat-Pump Applications: 225 psig.
  - 3. Hot-Gas and Liquid Lines: 225 psig.
- B. Line Test Pressure for Refrigerant R-407C:
  - 1. Suction Lines for Air-Conditioning Applications: 230 psig.
  - 2. Suction Lines for Heat-Pump Applications: 380 psig.
  - 3. Hot-Gas and Liquid Lines: 380 psig.

- C. Line Test Pressure for Refrigerant R-410A:
  - 1. Suction Lines for Air-Conditioning Applications: 300 psig.
  - 2. Suction Lines for Heat-Pump Applications: 535 psig.
  - 3. Hot-Gas and Liquid Lines: 535 psig.

## 2.2 COPPER TUBE AND FITTINGS

- A. Copper Tube: ASTM B 88, Type K or L.
- B. 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-inchlong 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. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
  - 2. Diaphragm: Phosphor bronze and stainless steel with stainless-steel spring.
  - 3. Operator: Rising stem and hand wheel.
  - 4. Seat: Nylon.
  - 5. End Connections: Socket, union, or flanged.
  - 6. Working Pressure Rating: 500 psig.
  - 7. Maximum Operating Temperature: 275 deg F.
- B. Packed-Angle Valves:
  - 1. Body and Bonnet: Forged brass or cast bronze.
  - 2. Packing: Molded stem, back seating, and replaceable under pressure.
  - 3. Operator: Rising stem.
  - 4. Seat: Nonrotating, self-aligning polytetrafluoroethylene.
  - 5. Seal Cap: Forged-brass or valox hex cap.

- 6. End Connections: Socket, union, threaded, or flanged.
- 7. Working Pressure Rating: 500 psig.
- 8. Maximum Operating Temperature: 275 deg F.
- C. Check Valves:
  - 1. Body: Ductile iron, forged brass, or cast bronze; globe pattern.
  - 2. Bonnet: Bolted ductile iron, forged brass, or cast bronze; or brass hex plug.
  - 3. Piston: Removable polytetrafluoroethylene seat.
  - 4. Closing Spring: Stainless steel.
  - 5. Manual Opening Stem: Seal cap, plated-steel stem, and graphite seal.
  - 6. End Connections: Socket, union, threaded, or flanged.
  - 7. Maximum Opening Pressure: 0.50 psig.
  - 8. Working Pressure Rating: 500 psig.
  - 9. Maximum Operating Temperature: 275 deg F.
- D. Service Valves:
  - 1. Body: Forged brass with brass cap including key end to remove core.
  - 2. Core: Removable ball-type check valve with stainless-steel spring.
  - 3. Seat: Polytetrafluoroethylene.
  - 4. End Connections: Copper spring.
  - 5. Working Pressure Rating: 500 psig.
- E. Solenoid Valves: Comply with AHRI 760 and UL 429; listed and labeled by a National Recognized Testing Laboratory (NRTL).
  - 1. Body and Bonnet: Plated steel.
  - 2. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
  - 3. Seat: Polytetrafluoroethylene.
  - 4. End Connections: Threaded.
  - 5. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter, and 24-V ac coil.
  - 6. Working Pressure Rating: 400 psig.
  - 7. Maximum Operating Temperature: 240 deg F.
- F. Safety Relief Valves: Comply with 2010 ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
  - 1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
  - 2. Piston, Closing Spring, and Seat Insert: Stainless steel.
  - 3. Seat: Polytetrafluoroethylene.
  - 4. End Connections: Threaded.
  - 5. Working Pressure Rating: 400 psig.
  - 6. Maximum Operating Temperature: 240 deg F.
- G. Thermostatic Expansion Valves: Comply with AHRI 750.
  - 1. Body, Bonnet, and Seal Cap: Forged brass or steel.
  - 2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
  - 3. Packing and Gaskets: Non-asbestos.
  - 4. Capillary and Bulb: Copper tubing filled with refrigerant charge.
  - 5. Suction Temperature: 40 deg F.

- 6. Superheat: Adjustable.
- 7. Reverse-flow option (for heat-pump applications).
- 8. End Connections: Socket, flare, or threaded union.
- 9. Working Pressure Rating: 700 psig.
- H. Hot-Gas Bypass Valves: Comply with UL 429; listed and labeled by an NRTL.
  - 1. Body, Bonnet, and Seal Cap: Ductile iron or steel.
  - 2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
  - 3. Packing and Gaskets: Non-asbestos.
  - 4. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
  - 5. Seat: Polytetrafluoroethylene.
  - 6. Equalizer: Internal.
  - 7. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter and 24-V ac coil.
  - 8. End Connections: Socket.
  - 9. Throttling Range: Maximum 5 psig.
  - 10. Working Pressure Rating: 500 psig.
  - 11. Maximum Operating Temperature: 240 deg F.
- I. Straight-Type Strainers:
  - 1. Body: Welded steel with corrosion-resistant coating.
  - 2. Screen: 100-mesh stainless steel.
  - 3. End Connections: Socket or flare.
  - 4. Working Pressure Rating: 500 psig.
  - 5. Maximum Operating Temperature: 275 deg F.
- J. Angle-Type Strainers:
  - 1. Body: Forged brass or cast bronze.
  - 2. Drain Plug: Brass hex plug.
  - 3. Screen: 100-mesh monel.
  - 4. End Connections: Socket or flare.
  - 5. Working Pressure Rating: 500 psig.
  - 6. Maximum Operating Temperature: 275 deg F.
- K. Moisture/Liquid Indicators:
  - 1. Body: Forged brass.
  - 2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
  - 3. Indicator: Color coded to show moisture content in parts per million (ppm).
  - 4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
  - 5. End Connections: Socket or flare.
  - 6. Working Pressure Rating: 500 psig.
  - 7. Maximum Operating Temperature: 240 deg F.
- L. Replaceable-Core Filter Dryers: Comply with AHRI 730.
  - 1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
  - 2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.

- 3. Desiccant Media: Activated charcoal.
- 4. Designed for reverse flow (for heat-pump applications).
- 5. End Connections: Socket.
- 6. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
- 7. Maximum Pressure Loss: 2 psig.
- 8. Working Pressure Rating: 500 psig.
- 9. Maximum Operating Temperature: 240 deg F.
- M. Permanent Filter Dryers: Comply with AHRI 730.
  - 1. Body and Cover: Painted-steel shell.
  - 2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
  - 3. Desiccant Media: Activated charcoal.
  - 4. Designed for reverse flow (for heat-pump applications).
  - 5. End Connections: Socket.
  - 6. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
  - 7. Maximum Pressure Loss: 2 psig.
  - 8. Working Pressure Rating: 500 psig.
  - 9. Maximum Operating Temperature: 240 deg F.
- 2.4 REFRIGERANTS
  - A. ASHRAE 34, R-134a: Tetrafluoroethane.
  - B. ASHRAE 34, R-407C: Difluoromethane/Pentafluoroethane/1,1,1,2-Tetrafluoroethane.
  - C. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

#### PART 3 - EXECUTION

#### 3.1 PIPING APPLICATIONS FOR REFRIGERANT R-410A

- A. Suction Lines: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.
- B. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications: Copper, Type L, annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.
- C. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications: Copper, Type K, annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.
- D. Safety-Relief-Valve Discharge Piping: Copper, Type L, annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

E. Safety-Relief-Valve Discharge Piping: Copper, Type K, annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

#### 3.2 VALVE AND SPECIALTY APPLICATIONS

- A. Install diaphragm packless valves in suction and discharge lines of compressor.
- B. Install service valves for gage taps at inlet and outlet of hot-gas bypass valves and strainers if they are not an integral part of valves and strainers.
- C. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.
- D. Except as otherwise indicated, install diaphragm packless valves on inlet and outlet side of filter dryers.
- E. Install a full-size, three-valve bypass around filter dryers.
- F. Install solenoid valves upstream from each expansion valve and hot-gas bypass valve. Install solenoid valves in horizontal lines with coil at top.
- G. Install thermostatic expansion valves as close as possible to distributors on evaporators.
  - 1. Install valve so diaphragm case is warmer than bulb.
  - 2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
  - 3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.
- H. Install safety relief valves where required by 2010 ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.
- I. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.
- J. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for the device being protected:
  - 1. Solenoid valves.
  - 2. Thermostatic expansion valves.
  - 3. Hot-gas bypass valves.
  - 4. Compressor.
- K. Install filter dryers in liquid line between compressor and thermostatic expansion valve.
- L. Install receivers sized to accommodate pump-down charge.
- M. Install flexible connectors at compressors.

#### 3.3 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.
- B. Install refrigerant piping according to ASHRAE 15.
- C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- F. Install piping adjacent to machines to allow service and maintenance.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Select system components with pressure rating equal to or greater than system operating pressure.
- J. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.
- K. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Section 083113 "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.
- L. Install refrigerant piping in protective conduit where installed belowground.
- M. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.
- N. 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.

- O. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.
- P. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.
- Q. Identify refrigerant piping and valves according to Section 230553 "Identification for HVAC Piping and Equipment."
- R. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."
- S. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."
- T. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

#### 3.4 PIPE JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs.
- 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 or steel.

#### 3.5 HANGERS AND SUPPORTS

- A. Comply with requirements for pipe hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
- B. Install the following pipe attachments:
  - 1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet long.
  - 2. Roller hangers and spring hangers for individual horizontal runs 20 feet or longer.
  - 3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
  - 4. Spring hangers to support vertical runs.

- 5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
- C. Install hangers for copper tubing with the following maximum spacing and minimum rod diameters:
  - 1. NPS 1/2: Maximum span, 60 inches; minimum rod, 1/4 inch.
  - 2. NPS 5/8: Maximum span, 60 inches; minimum rod, 1/4 inch.
  - 3. NPS 1: Maximum span, 72 inches; minimum rod, 1/4 inch.
  - 4. NPS 1-1/4: Maximum span, 96 inches; minimum rod, 3/8 inch.
  - 5. NPS 1-1/2: Maximum span, 96 inches; minimum rod, 3/8 inch.
  - 6. NPS 2: Maximum span, 96 inches; minimum rod, 3/8 inch.
  - 7. NPS 2-1/2: Maximum span, 108 inches; minimum rod, 3/8 inch.
  - 8. NPS 3: Maximum span, 10 feet; minimum rod, 3/8 inch.
  - 9. NPS 4: Maximum span, 12 feet; minimum rod, 1/2 inch.
- D. Support multifloor vertical runs at least at each floor.

#### 3.6 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
  - 1. Comply with ASME B31.5, Chapter VI.
  - 2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
  - 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.

#### 3.7 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.

4. Charge system with a new filter-dryer core in charging line.

#### 3.8 ADJUSTING

- A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.
- B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.
- C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.
- D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:
  - 1. Open shutoff valves in condenser water circuit.
  - 2. Verify that compressor oil level is correct.
  - 3. Open compressor suction and discharge valves.
  - 4. Open refrigerant valves except bypass valves that are used for other purposes.
  - 5. Check open compressor-motor alignment and verify lubrication for motors and bearings.
- E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

### END OF SECTION 232300

### SECTION 233113 - METAL DUCTS

#### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section Includes:
  - 1. Rectangular ducts and fittings.
  - 2. Round ducts and fittings.
  - 3. Sheet metal materials.
  - 4. Sealants and gaskets.
  - 5. Hangers and supports.
  - 6. Seismic-restraint devices.
- B. Related Sections:
  - 1. Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
  - 2. Section 233116 "Nonmetal Ducts" for fibrous-glass ducts, thermoset fiber-reinforced plastic ducts, thermoplastic ducts, PVC ducts, and concrete ducts.
  - 3. Section 233119 "HVAC Casings" for factory- and field-fabricated casings for mechanical equipment.
  - 4. Section 233300 "Air Duct Accessories" for dampers, sound-control devices, ductmounting access doors and panels, turning vanes, and flexible ducts.

#### 1.2 PERFORMANCE REQUIREMENTS

- A. Delegated Duct Design: 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 loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and ASCE/SEI 7.
- C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ANSI/ASHRAE 62.1.
- D. 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.

- E. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 "Systems and Equipment" and Section 7 "Construction and System Start-up."
- F. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 "HVAC System Construction and Insulation."

## PART 2 - PRODUCTS

### 2.1 RECTANGULAR DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.
- B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards Metal and Flexible."
- C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards Metal and Flexible."
- D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

#### 2.2 ROUND DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.
  - 1. <u>Manufacturers:</u> Subject to compliance with requirements, provide products by one of the following:
    - a. Lindab Inc.
    - b. <u>McGill AirFlow LLC.</u>
    - c. <u>SEMCO Incorporated.</u>
    - d. <u>Sheet Metal Connectors, Inc.</u>
    - e. <u>Spiral Manufacturing Co., Inc.</u>

- B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards Metal and Flexible."
  - 1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.
- C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards Metal and Flexible."
  - 1. Fabricate round ducts larger Than 90 inches in diameter with butt-welded longitudinal seams.
- D. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

### 2.3 SHEET METAL MATERIALS

- A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards -Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
  - 1. Galvanized Coating Designation: G90.
  - 2. Finishes for Surfaces Exposed to View: Mill phosphatized.
- C. Carbon-Steel Sheets: Comply with ASTM A 1008/A 1008M, with oiled, matte finish for exposed ducts.
- D. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.
- E. Aluminum Sheets: Comply with ASTM B 209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.

- F. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
  - 1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.
- G. Tie Rods: Galvanized steel, 1/4-inch 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. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
- B. Two-Part Tape Sealing System:
  - 1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
  - 2. Tape Width: 3 inches.
  - 3. Sealant: Modified styrene acrylic.
  - 4. Water resistant.
  - 5. Mold and mildew resistant.
  - 6. Maximum Static-Pressure Class: 10-inch wg, 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).
  - 11. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- C. Water-Based Joint and Seam Sealant:
  - 1. Application Method: Brush on.
  - 2. Solids Content: Minimum 65 percent.
  - 3. Shore A Hardness: Minimum 20.
  - 4. Water resistant.
  - 5. Mold and mildew resistant.
  - 6. VOC: Maximum 75 g/L (less water).
  - 7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
  - 8. Service: Indoor or outdoor.
  - 9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.
- D. Flanged Joint Sealant: Comply with ASTM C 920.
  - 1. General: Single-component, acid-curing, silicone, elastomeric.
  - 2. Type: S.
  - 3. Grade: NS.
  - 4. Class: 25.
  - 5. Use: O.
  - 6. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
  - 7. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.
- F. Round Duct Joint O-Ring Seals:
  - 1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for10-inch wg static-pressure class, positive or negative.
  - 2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
  - 3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

### 2.5 HANGERS AND SUPPORTS

- A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.
- B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
- C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."
- D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.
- E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.
- F. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.
- G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- H. Trapeze and Riser Supports:
  - 1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
  - 2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.

3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

## PART 3 - EXECUTION

## 3.1 DUCT INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.
- B. Install ducts according to SMACNA's "HVAC Duct Construction Standards Metal and Flexible" unless otherwise indicated.
- C. Install 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 233300 "Air Duct Accessories" for fire and smoke dampers.
- L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials.

### 3.2 INSTALLATION OF EXPOSED DUCTWORK

- A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.
- B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.
- C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.
- D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.
- E. Repair or replace damaged sections and finished work that does not comply with these requirements.

### 3.3 DUCT SEALING

- A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards Metal and Flexible."
- B. Seal ducts at a minimum to the following seal classes according to SMACNA's "HVAC Duct Construction Standards Metal and Flexible":
  - 1. Comply with SMACNA's "HVAC Duct Construction Standards Metal and Flexible."
  - 2. Outdoor, Supply-Air Ducts: Seal Class A.
  - 3. Outdoor, Exhaust Ducts: Seal Class C.
  - 4. Outdoor, Return-Air Ducts: Seal Class C.
  - 5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class B.
  - 6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.
  - 7. Unconditioned Space, Exhaust Ducts: Seal Class C.
  - 8. Unconditioned Space, Return-Air Ducts: Seal Class B.
  - 9. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class C.
  - 10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class B.
  - 11. Conditioned Space, Exhaust Ducts: Seal Class B.
  - 12. Conditioned Space, Return-Air Ducts: Seal Class C.

## 3.4 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

- B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
  - 1. Where practical, install concrete inserts before placing concrete.
  - 2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
  - 3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches 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.
- 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 intervals 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 CONNECTIONS

- A. Make connections to equipment with flexible connectors complying with Section 233300 "Air Duct Accessories."
- B. Comply with SMACNA's "HVAC Duct Construction Standards Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

### 3.6 DUCT CLEANING

- A. Clean new and existing duct system(s) before testing, adjusting, and balancing.
- B. Use service openings for entry and inspection.
  - 1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Section 233300 "Air Duct Accessories" for access panels and doors.
  - 2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
  - 3. Remove and reinstall ceiling to gain access during the cleaning process.

- C. Particulate Collection and Odor Control:
  - 1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
  - 2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.
- D. Clean the following components by removing surface contaminants and deposits:
  - 1. Air outlets and inlets (registers, grilles, and diffusers).
  - 2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
  - 3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
  - 4. Coils and related components.
  - 5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
  - 6. Supply-air ducts, dampers, actuators, and turning vanes.
  - 7. Dedicated exhaust and ventilation components and makeup air systems.
- E. Mechanical Cleaning Methodology:
  - 1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
  - 2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
  - 3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
  - 4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
  - 5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
  - 6. Provide drainage and cleanup for wash-down procedures.
  - 7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

## 3.7 START UP

A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

### 3.8 DUCT SCHEDULE

- A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:
  - 1. Underground Ducts: Concrete-encased, PVC-coated, galvanized sheet steel with thicker coating on duct exterior.
- B. Supply Ducts:
  - 1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units :
    - a. Pressure Class: Positive 2-inch wg.
    - b. Minimum SMACNA Seal Class: C.
  - 2. Ducts Connected to Equipment Not Listed Above:
    - a. Pressure Class: Positive 2-inch wg.
    - b. Minimum SMACNA Seal Class: A.
- C. Return Ducts:
  - 1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:
    - a. Pressure Class: Positive or negative 2-inch wg.
    - b. Minimum SMACNA Seal Class: C.
  - 2. Ducts Connected to Equipment Not Listed Above:
    - a. Pressure Class: Positive or negative 2-inch wg.
    - b. Minimum SMACNA Seal Class: A.
- D. Exhaust Ducts:
  - 1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:
    - a. Pressure Class: Negative 2-inch wg.
    - b. Minimum SMACNA Seal Class: B if negative pressure, and A if positive pressure.
  - 2. Ducts Connected to Equipment Not Listed Above:
    - a. Pressure Class: Positive or negative 2-inch wg.
    - b. Minimum SMACNA Seal Class: A if negative pressure, and A if positive pressure.
- E. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:
  - 1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:
    - a. Pressure Class: Positive or negative 1-inch wg.
    - b. Minimum SMACNA Seal Class: B.

- 2. Ducts Connected to Equipment Not Listed Above:
  - a. Pressure Class: Positive or negative 2-inch wg.
  - b. Minimum SMACNA Seal Class: A.
- F. Intermediate Reinforcement:
  - 1. Galvanized-Steel Ducts: Galvanized steel.
  - 2. PVC-Coated Ducts:
    - a. Exposed to Airstream: Match duct material.
    - b. Not Exposed to Airstream: Match duct material.
  - 3. Stainless-Steel Ducts:
    - a. Exposed to Airstream: Match duct material.
    - b. Not Exposed to Airstream: Galvanized.
  - 4. Aluminum Ducts: Aluminumor galvanized sheet steel coated with zinc chromate.
- G. Elbow Configuration:
  - 1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards Metal and Flexible," Figure 4-2, "Rectangular Elbows."
    - a. Velocity 1000 fpm or Lower:
      - 1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
      - 2) Mitered Type RE 4 without vanes.
    - b. Velocity 1000 to 1500 fpm:
      - 1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
      - 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."

- 2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards Metal and Flexible," Figure 4-2, "Rectangular Elbows."
  - a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
  - b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
  - c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
- 3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards Metal and Flexible," Figure 3-4, "Round Duct Elbows."
  - a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
    - 1) Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
    - 2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
    - 3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
    - 4) Radius-to Diameter Ratio: 1.5.
  - b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
  - c. Round Elbows, 14 Inches and Larger in Diameter: Standing seam or Welded.
- H. Branch Configuration:
  - 1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards Metal and Flexible," Figure 4-6, "Branch Connection."
    - a. Rectangular Main to Rectangular Branch: 45-degree entry.
    - b. Rectangular Main to Round Branch: Spin in.
  - 2. Round: Comply with SMACNA's "HVAC Duct Construction Standards Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.
    - a. Velocity 1000 fpm or Lower: 90-degree tap.
    - b. Velocity 1000 to 1500 fpm: Conical tap.
    - c. Velocity 1500 fpm or Higher: 45-degree lateral.

## END OF SECTION 233113

# SECTION 233300 - AIR DUCT ACCESSORIES

#### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section Includes:
  - 1. Backdraft and pressure relief dampers.
  - 2. Manual volume dampers.
  - 3. Control dampers.
  - 4. Fire dampers.
  - 5. Flange connectors.
  - 6. Turning vanes.
  - 7. Duct-mounted access doors.
  - 8. Flexible connectors.
  - 9. Duct accessory hardware.

#### 1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- 1.3 CLOSEOUT SUBMITTALS
  - A. Operation and maintenance data.

#### 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: G90.
- 2. Exposed-Surface Finish: Mill phosphatized.
- B. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304, and having a No. 2 finish for concealed ducts and finish for exposed ducts.
- C. Aluminum Sheets: Comply with ASTM B 209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.
- D. Extruded Aluminum: Comply with ASTM B 221, Alloy 6063, Temper T6.
- E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.
- F. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

## 2.3 BACKDRAFT AND PRESSURE RELIEF DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Air Balance Inc.; a division of Mestek, Inc.
  - 2. American Warming and Ventilating; a division of Mestek, Inc.
  - 3. Greenheck Fan Corporation.
  - 4. NCA Manufacturing, Inc.
  - 5. Ruskin Company.
  - 6. Vent Products Company, Inc.
- B. Description: Gravity balanced.
- C. Maximum Air Velocity: 2000 fpm.
- D. Maximum System Pressure: 1-inch wg.
- E. Frame: Hat-shaped, 0.05-inch- thick, galvanized sheet steel, with welded corners or mechanically attached and mounting flange.
- F. Blades: Multiple single-piece blades, end pivoted, maximum 6-inch width, 0.025-inch- thick, roll-formed aluminum with sealed edges.
- G. Blade Action: Parallel.
- H. Blade Seals: Extruded vinyl, mechanically locked.
- I. Blade Axles:
  - 1. Material: Galvanized steel.
  - 2. Diameter: 0.20 inch.

- J. Tie Bars and Brackets: Galvanized steel.
- K. Return Spring: Adjustable tension.
- L. Bearings: Steel ball or synthetic pivot bushings.
- M. Accessories:
  - 1. Adjustment device to permit setting for varying differential static pressure.
  - 2. Counterweights and spring-assist kits for vertical airflow installations.
  - 3. Electric actuators.
  - 4. Chain pulls.
  - 5. Screen Mounting: Front mounted in sleeve.
    - a. Sleeve Thickness: 20 gage minimum.
    - b. Sleeve Length: 6 inches minimum.
  - 6. Screen Mounting: Rear mounted.
  - 7. Screen Material: Galvanized steel.
  - 8. Screen Type: Bird.
  - 9. 90-degree stops.

### 2.4 MANUAL VOLUME DAMPERS

- A. Standard, Steel, Manual Volume Dampers:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Air Balance Inc.; a division of Mestek, Inc.
    - b. American Warming and Ventilating; a division of Mestek, Inc.
    - c. Flexmaster U.S.A., Inc.
    - d. McGill AirFlow LLC.
    - e. Nailor Industries Inc.
    - f. Pottorff.
    - g. Ruskin Company.
    - h. Trox USA Inc.
    - i. Vent Products Company, Inc.
  - 2. Standard leakage rating, with linkage outside airstream.
  - 3. Suitable for horizontal or vertical applications.
  - 4. Frames:
    - a. Frame: Hat-shaped, 0.094-inch- thick, galvanized sheet steel.
    - b. Mitered and welded corners.
    - c. Flanges for attaching to walls and flangeless frames for installing in ducts.
  - 5. Blades:

- a. Multiple or single blade.
- b. Parallel- or opposed-blade design.
- c. Stiffen damper blades for stability.
- d. Galvanized-steel, 0.064 inch thick.
- 6. Blade Axles: Galvanized steel.
- 7. Bearings:
  - a. Molded synthetic.
  - b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
- 8. Tie Bars and Brackets: Galvanized steel.
- B. Standard, Aluminum, Manual Volume Dampers:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Air Balance Inc.; a division of Mestek, Inc.
    - b. American Warming and Ventilating; a division of Mestek, Inc.
    - c. McGill AirFlow LLC.
    - d. Ruskin Company.
    - e. Vent Products Company, Inc.
  - 2. Standard leakage rating, with linkage outside airstream.
  - 3. Suitable for horizontal or vertical applications.
  - 4. Frames: Hat-shaped, 0.10-inch- thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
  - 5. Blades:
    - a. Multiple or single blade.
    - b. Parallel- or opposed-blade design.
    - c. Stiffen damper blades for stability.
    - d. Roll-Formed Aluminum Blades: 0.10-inch- thick aluminum sheet.
    - e. Extruded-Aluminum Blades: 0.050-inch- thick extruded aluminum.
  - 6. Blade Axles: Galvanized steel.
  - 7. Bearings:
    - a. Molded synthetic.
    - b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
  - 8. Tie Bars and Brackets: Aluminum.
- C. Jackshaft:
  - 1. Size: 1-inch diameter.

- 2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
- 3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.
- D. Damper Hardware:
  - 1. Zinc-plated, die-cast core with dial and handle made of 3/32-inch- thick zinc-plated steel, and a 3/4-inch hexagon locking nut.
  - 2. Include center hole to suit damper operating-rod size.
  - 3. Include elevated platform for insulated duct mounting.

## 2.5 CONTROL DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. American Warming and Ventilating; a division of Mestek, Inc.
  - 2. Arrow United Industries; a division of Mestek, Inc.
  - 3. Greenheck Fan Corporation.
  - 4. McGill AirFlow LLC.
  - 5. NCA Manufacturing, Inc.
  - 6. Ruskin Company.
  - 7. Vent Products Company, Inc.
  - 8. Young Regulator Company.

### B. Frames:

- 1. U shaped.
- 2. 0.094-inch- thick, galvanized sheet steel.
- 3. Mitered and welded corners.
- C. Blades:
  - 1. Multiple blade with maximum blade width of 8 inches.
  - 2. [Parallel-blade design.
  - 3. Galvanized-steel.
  - 4. 0.064 inch thick single skin.
  - 5. Blade Edging: PVC.
  - 6. Blade Edging: Inflatable seal blade edging, or replaceable rubber seals.
- D. Blade Axles: 1/2-inch- diameter; galvanized steel; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings.
  - 1. Operating Temperature Range: From minus 40 to plus 200 deg F.
- E. Bearings:

- 1. Molded synthetic.
- 2. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
- 3. Thrust bearings at each end of every blade.

# 2.6 FIRE DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Air Balance Inc.; a division of Mestek, Inc.
  - 2. Arrow United Industries; a division of Mestek, Inc.
  - 3. Greenheck Fan Corporation.
  - 4. NCA Manufacturing, Inc.
  - 5. Ruskin Company.
  - 6. Vent Products Company, Inc.
  - 7. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
- B. Type: Static and dynamic; rated and labeled according to UL 555 by an NRTL.
- C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000-fpm velocity.
- D. Fire Rating: 1-1/2 and 3 hours.
- E. Frame: Curtain type with blades outside airstream; fabricated with roll-formed, 0.034-inch-thick galvanized steel; with mitered and interlocking corners.
- F. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.
  - 1. Minimum Thickness: 0.05 thick, as indicated, and of length to suit application.
  - 2. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.
- G. Mounting Orientation: Vertical or horizontal as indicated.
- H. Blades: Roll-formed, interlocking, 0.034-inch- thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- thick, galvanized-steel blade connectors.
- I. Horizontal Dampers: Include blade lock and stainless-steel closure spring.
- J. Heat-Responsive Device: Replaceable, 165 deg F rated, fusible links.

# 2.7 FLANGE CONNECTORS

A. Manufacturers: Subject to compliance with requirementsprovide products by one of the following:

- 1. Ductmate Industries, Inc.
- 2. Nexus PDQ; Division of Shilco Holdings Inc.
- 3. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
- B. Description: Add-on or roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.
- C. Material: Galvanized steel.
- D. Gage and Shape: Match connecting ductwork.

## 2.8 TURNING VANES

- 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. METALAIRE, Inc.
  - 5. SEMCO Incorporated.
  - 6. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
- B. 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.
- C. 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.
- D. 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."
- E. Vane Construction: Double wall.

# 2.9 DUCT-MOUNTED ACCESS DOORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. American Warming and Ventilating; a division of Mestek, Inc.
  - 2. Ductmate Industries, Inc.
  - 3. Elgen Manufacturing.

- 4. Flexmaster U.S.A., Inc.
- 5. Greenheck Fan Corporation.
- 6. McGill AirFlow LLC.
- 7. Ventfabrics, Inc.
- 8. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
- B. Duct-Mounted 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.
    - d. Hinges and Latches: 1-by-1-inch butt 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. Number of Hinges and Locks:
    - a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
    - b. Access Doors up to 18 Inches Square: Two hinges and two sash locks.
    - c. Access Doors up to 24 by 48 Inches: Three hinges and two compression latches.
    - d. Access Doors Larger Than 24 by 48 Inches: Continuous and two compression latches with outside and inside handles.
- 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 10-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.

# 2.10 DUCT ACCESS PANEL ASSEMBLIES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Ductmate Industries, Inc.

- 2. Flame Gard, Inc.
- 3. 3M.
- B. Labeled according to UL 1978 by an NRTL.
- C. Panel and Frame: Minimum thickness 0.0528-inch carbon steel.
- D. Fasteners: Carbon steel. Panel fasteners shall not penetrate duct wall.
- E. Gasket: Comply with NFPA 96; grease-tight, high-temperature ceramic fiber, rated for minimum 2000 deg F.
- F. Minimum Pressure Rating: 10-inch wg, positive or negative.

### 2.11 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. Ventfabrics, Inc.
  - 5. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
- B. Materials: Flame-retardant or noncombustible fabrics.
- C. Coatings and Adhesives: Comply with UL 181, Class 1.
- D. Metal-Edged Connectors: Factory fabricated with a fabric strip 5-3/4 inches wide attached to two strips of 2-3/4-inch- wide, 0.028-inch- thick, galvanized sheet steel or 0.032-inch- thick aluminum sheets. Provide metal compatible with connected ducts.
- E. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
  - 1. Minimum Weight: 26 oz./sq. yd..
  - 2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
  - 3. Service Temperature: Minus 40 to plus 200 deg F.

### 2.12 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

## PART 3 - EXECUTION

## 3.1 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, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.
- B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.
- C. Install backdraft or control dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.
- D. 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.
  - 1. Install steel volume dampers in steel ducts.
  - 2. Install aluminum volume dampers in aluminum ducts.
- E. Set dampers to fully open position before testing, adjusting, and balancing.
- F. Install test holes at fan inlets and outlets and elsewhere as indicated.
- G. Install fire dampers according to UL listing.
- H. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
  - 1. On both sides of duct coils.
  - 2. Upstream from duct filters.
  - 3. At outdoor-air intakes and mixed-air plenums.
  - 4. At drain pans and seals.
  - 5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
  - 6. 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.
  - 7. At each change in direction and at maximum 50-foot spacing.

- 8. Upstream and downstream from turning vanes.
- 9. Upstream or downstream from duct silencers.
- 10. Control devices requiring inspection.
- 11. Elsewhere as indicated.
- I. Install access doors with swing against duct static pressure.
- J. Access Door Sizes:
  - 1. One-Hand or Inspection Access: 8 by 5 inches.
  - 2. Two-Hand Access: 12 by 6 inches.
  - 3. Head and Hand Access: 18 by 10 inches.
  - 4. Head and Shoulders Access: 21 by 14 inches.
  - 5. Body Access: 25 by 14 inches.
- K. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.
- L. Install flexible connectors to connect ducts to equipment.
- M. Connect terminal units to supply ducts directly or with maximum 12-inch lengths of flexible duct. Do not use flexible ducts to change directions.
- N. Connect diffusers or light troffer boots to ducts with maximum 60-inch lengths of flexible duct clamped or strapped in place.
- O. Connect flexible ducts to metal ducts with adhesive and draw bands.
- P. Install duct test holes where required for testing and balancing purposes.

## 3.2 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 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 233300

## SECTION 233423 - HVAC POWER VENTILATORS

### PART 1 - GENERAL

## 1.1 SUMMARY

- A. Section Includes:
  - 1. Centrifugal roof ventilators.

### 1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
  - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 2. Wiring Diagrams: For power, signal, and control wiring.
  - 3. 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.
  - 4. Design Calculations: Calculate requirements for selecting vibration isolators and for designing vibration isolation bases.

### 1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

### 1.4 QUALITY ASSURANCE

- 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. AMCA Compliance: Fans shall have AMCA-Certified performance ratings and shall bear the AMCA-Certified Ratings Seal.

## PART 2 - PRODUCTS

## 2.1 CENTRIFUGAL ROOF VENTILATORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Acme Engineering & Manufacturing Corporation.
  - 2. Carnes Company.
  - 3. Greenheck Fan Corporation.
  - 4. Loren Cook Company.
  - 5. PennBarry.
- B. Housing: Removable, spun-aluminum, dome top and outlet baffle; square, one-piece, aluminum base with venturi inlet cone.
  - 1. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains and grease collector.
  - 2. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.
- C. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.
- D. Belt Drives:
  - 1. Resiliently mounted to housing.
  - 2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
  - 3. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
  - 4. Pulleys: Cast-iron, adjustable-pitch motor pulley.
  - 5. Fan and motor isolated from exhaust airstream.
- E. Accessories:
  - 1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
  - 2. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted outside fan housing, factory wired through an internal aluminum conduit.
  - 3. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.
  - 4. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
  - 5. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.
- F. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch- thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.

- 1. Configuration: Self-flashing without a cant strip, with mounting flange.
- 2. Overall Height: 16 inches.
- 3. Sound Curb: Curb with sound-absorbing insulation.
- 4. Pitch Mounting: Manufacture curb for roof slope.
- 5. Metal Liner: Galvanized steel.
- 6. Burglar Bars: 5/8-inch- thick steel bars welded in place to form 6-inch squares.
- 7. Mounting Pedestal: Galvanized steel with removable access panel.
- 8. Vented Curb: Unlined with louvered vents in vertical sides.
- G. Capacities and Characteristics:
  - 1. As indicated on the drawings.

## 2.2 MOTORS

- A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
  - 1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
- B. Enclosure Type: Totally enclosed, fan cooled.

# 2.3 SOURCE QUALITY CONTROL

- A. Certify sound-power level ratings according to AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.
- B. Certify fan performance ratings, including flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating." Label fans with the AMCA-Certified Ratings Seal.

# PART 3 - EXECUTION

# 3.1 INSTALLATION

- A. Equipment Mounting:
  - 1. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- B. Secure roof-mounted fans to roof curbs with cadmium-plated hardware. See Section 077200 "Roof Accessories" for installation of roof curbs.

- C. Ceiling Units: Suspend units from structure; use steel wire or metal straps.
- D. Support suspended units from structure using threaded steel rods and elastomeric hangers or spring hangers with vertical-limit stops having a static deflection of 1 inch. Install units with clearances for service and maintenance.
- E. Label units according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

## 3.2 CONNECTIONS

- A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 233300 "Air Duct Accessories."
- B. Install ducts adjacent to power ventilators to allow service and maintenance.
- C. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- D. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

### 3.3 FIELD QUALITY CONTROL

- A. Tests and Inspections:
  - 1. Verify that shipping, blocking, and bracing are removed.
  - 2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
  - 3. Verify that cleaning and adjusting are complete.
  - 4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
  - 5. Adjust belt tension.
  - 6. Adjust damper linkages for proper damper operation.
  - 7. Verify lubrication for bearings and other moving parts.
  - 8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
  - 9. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
  - 10. Shut unit down and reconnect automatic temperature-control operators.
  - 11. Remove and replace malfunctioning units and retest as specified above.
- B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Prepare test and inspection reports.

# 3.4 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Adjust belt tension.
- C. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.
- D. Replace fan and motor pulleys as required to achieve design airflow.
- E. Lubricate bearings.

# END OF SECTION 233423

## SECTION 233713.13 - AIR DIFFUSERS

### PART 1 - GENERAL

### 1.1 SUMMARY

- A. Section Includes:
  - 1. Rectangular and square ceiling diffusers.
- B. Related Requirements:
  - 1. Section 233300 "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers.
  - 2. Section 233713.23 "Air Registers and Grilles" for adjustable-bar register and grilles, fixed-face registers and grilles, and linear bar grilles.

#### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

#### PART 2 - PRODUCTS

#### 2.1 RECTANGULAR AND SQUARE CEILING DIFFUSERS

- 1. Basis-of-Design Product: Subject to compliance with requirements, provide Price Industries SCDA or comparable product by one of the following:
  - a. Carnes.
  - b. Hart & Cooley Inc.
  - c. Krueger.
  - d. METALAIRE, Inc.
  - e. Price Industries.
  - f. Titus.
  - g. Tuttle & Bailey.
- B. Material: Steel.
- C. Finish: Baked enamel, white.
- D. Face Size: 24 by 24 inches.
- E. Face Style: Three cone.
- F. Mounting: Refer to drawings for mounting style.

- G. Pattern: Adjustable.
- H. Dampers: Radial opposed blade.
- I. Accessories:
  - 1. Equalizing grid.
  - 2. Plaster ring.
  - 3. Safety chain.
  - 4. Wire guard.
  - 5. Sectorizing baffles.
  - 6. Operating rod extension.

### PART 3 - EXECUTION

## 3.1 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.

## 3.2 ADJUSTING

A. After installation, adjust diffusers to air patterns indicated, or as directed, before starting air balancing.

## END OF SECTION 233713.13

## SECTION 233713.23 - REGISTERS AND GRILLES

### PART 1 - GENERAL

### 1.1 SUMMARY

- A. Section Includes:
  - 1. Adjustable blade face registers and grilles.
  - 2. Fixed face registers and grilles.
- B. Related Requirements:
  - 1. Section 233300 "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to registers and grilles.

## 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

### PART 2 - PRODUCTS

### 2.1 REGISTERS

- A. Fixed Face Register RR-1:
  - 1. Basis-of-Design Product: Subject to compliance with requirements, provide Price 80/81/82 or comparable product by one of the following:
    - a. Carnes.
    - b. Hart & Cooley Inc.
    - c. Krueger.
    - d. Price Industries.
    - e. Titus.
    - f. Tuttle & Bailey.
  - 2. Size: 24"x24"
  - 3. Material: Aluminum.
  - 4. Finish: Baked enamel, white.
  - 5. Face Blade Arrangement: 1/2-by-1/2-by-1/2-inch grid.
  - 6. Face Arrangement: Egg crate.
  - 7. Core Construction: Removable.
  - 8. Frame: None.
  - 9. Mounting: Lay in.
- B. Fixed Face Register RR-1:

- 1. Basis-of-Design Product: Subject to compliance with requirements, provide Price 80/81/82 or comparable product by one of the following:
  - a. Carnes.
  - b. Hart & Cooley Inc.
  - c. Krueger.
  - d. Price Industries.
  - e. Titus.
  - f. Tuttle & Bailey.
- 2. Size: 24"x48"
- 3. Material: Aluminum.
- 4. Finish: Baked enamel, white.
- 5. Face Blade Arrangement: 1/2-by-1/2-by-1/2-inch grid.
- 6. Face Arrangement: Egg crate.
- 7. Core Construction: Removable.
- 8. Frame: None.
- 9. Mounting: Lay in.

## 2.2 GRILLES

- A. Fixed Blade Face Grille TG-1:
  - 1. Basis-of-Design Product: Subject to compliance with requirements, provide Price 20 series or comparable product by one of the following:
    - a. Carnes.
    - b. Dayus Register & Grille Inc.
    - c. Hart & Cooley Inc.
    - d. Krueger.
    - e. METALAIRE, Inc.
    - f. Price Industries.
    - g. Titus.
    - h. Tuttle & Bailey.
  - 2. Size: 30"x16"
  - 3. Material: Aluminum.
  - 4. Finish: Baked enamel, white.
  - 5. Face Blade Arrangement: Horizontal spaced 3/4 inch apart.
  - 6. Core Construction: Integral.
  - 7. Frame: 1-1/4 inches wide.
  - 8. Mounting: Countersunk screw.
- B. Fixed Blade Face Grille TG-2:
  - 1. Basis-of-Design Product: Subject to compliance with requirements, provide Price 20 series or comparable product by one of the following:
    - a. Carnes.
    - b. Dayus Register & Grille Inc.
    - c. Hart & Cooley Inc.
    - d. Krueger.

- e. METALAIRE, Inc.
- f. Price Industries.
- g. Titus.
- h. Tuttle & Bailey.
- 2. Size: 16"x16"
- 3. Material: Aluminum.
- 4. Finish: Baked enamel, white.
- 5. Face Blade Arrangement: Horizontal spaced 3/4 inch apart.
- 6. Core Construction: Integral.
- 7. Frame: 1-1/4 inches wide.
- 8. Mounting: Countersunk screw.

## PART 3 - EXECUTION

## 3.1 INSTALLATION

- A. Install registers and grilles level and plumb.
- B. Outlets and Inlets Locations: 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 registers and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

# 3.2 ADJUSTING

A. After installation, adjust registers and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 233713.23

## SECTION 235216 - CONDENSING BOILERS

### PART 1 - GENERAL

### 1.1 SUMMARY

A. Section includes gas-fired, water-tube condensing boilers, trim, and accessories for generating hot water.

## 1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: For boilers, boiler trim, and accessories. Include plans, elevations, sections, and mounting details.
  - 1. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 2. Include diagrams for power, signal, and control wiring.

### 1.3 INFORMATIONAL SUBMITTALS

- A. Source quality-control reports.
- B. Field quality-control reports.
- C. Sample Warranty: For special warranty.

#### 1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

### 1.5 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of boilers that fail in materials or workmanship within specified warranty period.
  - 1. Warranty Period for Water-Tube Condensing Boilers: 10 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 application.
- B. ASME Compliance: Fabricate and label boilers to comply with 2010 ASME Boiler and Pressure Vessel Code.
- C. ASHRAE/IES 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers Minimum Efficiency Requirements."
- D. DOE Compliance: Minimum efficiency shall comply with 10 CFR 430, Subpart B, Appendix N.
- E. UL Compliance: Test boilers for compliance with UL 795. Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.
- F. CSA Compliance: Test boilers for compliance with CSA B51.
- G. Mounting Base: For securing boiler to concrete base.
  - 1. Seismic Fabrication Requirements: Fabricate mounting base and attachment to boiler pressure vessel, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC" when mounting base is anchored to building structure.

### 2.2 WATER-TUBE CONDENSING BOILERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Lochinvar.
  - 2. Thermal Solutions.
  - 3. Burnham.
  - 4. Weil-Mclain
- B. Description: Factory-fabricated, -assembled, and -tested, copper-finned, water-tube condensing boiler with heat exchanger sealed pressure tight, built on a steel base, including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls. Water-heating service only.
- C. Heat Exchanger: Finned-copper primary and stainless-steel secondary heat exchangers.
- D. Combustion Chamber: Stainless steel.
- E. Burner: Natural gas, forced draft drawing from gas premixing valve.

- F. Gas Train: Combination gas valve with manual shutoff and pressure regulator.
- G. Ignition: Silicone carbide hot-surface ignition that includes flame safety supervision and 100 percent main-valve shutoff.
- H. Integral Circulator: Cast-iron body and stainless-steel impeller sized for minimum flow required in heat exchanger.
- I. Casing:
  - 1. Jacket: Heavy duty 16 gauge steel jacket.
  - 2. Control Compartment Enclosures: NEMA 250, Type 1A.
  - 3. Finish: rust resistant powder coat finish.
  - 4. Insulation: Minimum 1-inch- thick, mineral-fiber insulation surrounding the heat exchanger.
  - 5. Combustion-Air Connections: Inlet and vent duct collars.
- J. Capacities and Characteristics:
  - 1. As indicated on drawings.

## 2.3 TRIM

- A. Include devices sized to comply with ASME B31.1.
- B. Safety Relief Valve: ASME rated.
- C. Pressure and Temperature Gage: Minimum 3-1/2-inch- diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges, so normal operating range is about 50 percent of full range.
- D. Boiler Air Vent: Automatic.
- E. Drain Valve: Minimum NPS 3/4 hose-end gate valve.
- F. Circulation Pump: Nonoverloading, in-line pump with split-capacitor motor having thermaloverload protection and lubricated bearings; designed to operate at specified boiler pressures and temperatures.

# 2.4 CONTROLS

- A. Refer to Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."
- B. Boiler operating controls shall include the following devices and features:
  - 1. Control transformer.
  - 2. Set-Point Adjust: Set points shall be adjustable.

- 3. Sequence of Operation: Electric, factory-fabricated and field-installed panel to control burner firing rate to maintain space temperature in response to thermostat with heat anticipator located in heated space.
  - a. Include automatic, alternating-firing sequence for multiple boilers to ensure maximum system efficiency throughout the load range and to provide equal runtime for boilers.
- 4. Sequence of Operation: Electric, factory-fabricated and field-installed panel to control burner firing rate to reset supply-water temperature inversely with outside-air temperature. At 0 deg F outside-air temperature, set supply-water temperature at 190 deg F; at 60 deg F outside-air temperature, set supply-water temperature at 140 deg F.
  - a. Include automatic, alternating-firing sequence for multiple boilers to ensure maximum system efficiency throughout the load range and to provide equal runtime for boilers.
- C. Burner Operating Controls: To maintain safe operating conditions, burner safety controls limit burner operation.
  - 1. High Cutoff: Manual reset stops burner if operating conditions rise above maximum boiler design temperature.
  - 2. Low-Water Cutoff Switch: Electronic probe shall prevent burner operation on low water. Cutoff switch shall be manual-reset type.
  - 3. Blocked Inlet Safety Switch: Manual-reset pressure switch field mounted on boiler combustion-air inlet.
  - 4. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.
- D. Building Automation System Interface: Factory install hardware and software to enable building automation system to monitor, control, and display boiler status and alarms.
  - 1. Hardwired Points:
    - a. Monitoring: On/off status, common trouble alarm and low-water-level alarm.
    - b. Control: On/off operation, hot-water-supply temperature set-point adjustment .
  - 2. A communication interface with building automation system shall enable building automation system operator to remotely control and monitor the boiler from an operator workstation. Control features available, and monitoring points displayed, locally at boiler control panel shall be available through building automation system.

# 2.5 ELECTRICAL POWER

A. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in electrical Sections.

- B. Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.
  - 1. House in NEMA 250, Type 1 enclosure.
  - 2. Wiring shall be numbered and color coded to match wiring diagram.
  - 3. Install factory wiring outside of an enclosure in a metal raceway.
  - 4. Field power interface shall be to nonfused disconnect switch.
  - 5. Provide branch power circuit to each motor and to controls with a disconnect switch or circuit breaker.
  - 6. Provide each motor with overcurrent protection.

## 2.6 VENTING KITS

- A. Kit: The exhaust vent must be UL 1738 listed for use with Category II and IV appliances and compatible with operating temperatures up to 210°F, positive pressure, condensing flue gas service. UL certified vent material shall be CPVC, Polypropylene or Stainless
- B. Combustion-Air Intake: Complete system, PVC, pipe, vent terminal with screen, inlet air coupling, and sealant.

## 2.7 SOURCE QUALITY CONTROL

- A. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.
- B. Test and inspect factory-assembled boilers, before shipping, according to 2010 ASME Boiler and Pressure Vessel Code.

# PART 3 - EXECUTION

### 3.1 BOILER INSTALLATION

- A. Equipment Mounting:
  - 1. Install boilers on cast-in-place concrete equipment base(s).
- B. Install gas-fired boilers according to NFPA 54.
- C. Assemble and install boiler trim.
- D. Install electrical devices furnished with boiler but not specified to be factory mounted.
- E. Install control wiring to field-mounted electrical devices.

## 3.2 CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to boiler to allow service and maintenance.
- C. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.
- D. Connect piping to boilers, except safety relief valve connections, with flexible connectors of materials suitable for service. Flexible connectors and their installation are specified in Section 232116 "Hydronic Piping Specialties."
- E. Connect gas piping to boiler gas-train inlet with union. Piping shall be at least full size of gastrain connection. Provide a reducer if required.
- F. Connect hot-water piping to supply- and return-boiler tappings with shutoff valve and union or flange at each connection.
- G. Install piping from safety relief valves to nearest floor drain.
- H. Boiler Venting:
  - 1. Install flue venting kit and combustion-air intake.
  - 2. Connect full size to boiler connections.
- I. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- J. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

## 3.3 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
  - 1. Perform installation and startup checks according to manufacturer's written instructions.
  - 2. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
  - 3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
  - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
    - a. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level, and water temperature.

- b. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- B. Boiler will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.
- D. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

## 3.4 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain boilers. Refer to Section 017900 "Demonstration and Training."

END OF SECTION 235216
## SECTION 236426.13 - AIR-COOLED, ROTARY-SCREW WATER CHILLERS

#### PART 1 - GENERAL

#### 1.1 SUMMARY

A. Section includes packaged, air-cooled chillers.

#### 1.2 DEFINITIONS

- A. COP: Coefficient of performance. The ratio of the rate of heat removal to the rate of energy input using consistent units for any given set of rating conditions.
- B. DDC: Direct digital control.
- C. EER: Energy-efficiency ratio. The ratio of the cooling capacity given in terms of Btu/h to the total power input given in terms of watts at any given set of rating conditions.
- D. IPLV: Integrated part-load value. A single-number part-load efficiency figure of merit calculated per the method defined by AHRI 550/590 and referenced to AHRI standard rating conditions.
- E. kW/Ton: The ratio of total power input of the chiller in kilowatts to the net refrigerating capacity in tons at any given set of rating conditions.
- F. NPLV: Nonstandard part-load value. A single-number part-load efficiency figure of merit calculated per the method defined by AHRI 550/590 and intended for operating conditions other than AHRI standard rating conditions.

## 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings:
  - 1. Include plans, elevations, sections, and attachment details.
  - 2. Include details of equipment 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.

#### 1.4 INFORMATIONAL SUBMITTALS

A. Source quality-control reports.

- B. Field Test Reports: Startup service reports.
- C. Sample warranty.
- 1.5 CLOSEOUT SUBMITTALS
  - A. Operation and maintenance data.

## 1.6 QUALITY ASSURANCE

- A. AHRI Certification: Certify chiller according to AHRI 590 certification program(s).
- B. AHRI Rating: Rate chiller performance according to requirements in AHRI 550/590.
- C. ASHRAE Compliance:
  - 1. ASHRAE 15 for safety code for mechanical refrigeration.
  - 2. ASHRAE 147 for refrigerant leaks, recovery, and handling and storage requirements.
- D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1.
- E. ASME Compliance: Fabricate and label chiller to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, and include an ASME U-stamp and nameplate certifying compliance.
- F. Comply with NFPA 70.
- G. Comply with requirements of UL and UL Canada and include label by a qualified testing agency showing compliance.

## 1.7 WARRANTY

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

## PART 2 - PRODUCTS

- 2.1 PERFORMANCE REQUIREMENTS
  - A. Performance Tolerance: Comply with the following in lieu of AHRI 550/590:
    - 1. Allowable Capacity Tolerance: **Zero** percent.

# 2.2 PACKAGED, AIR-COOLED CHILLERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Trane.
  - 2. Carrier.
- B. Description: Factory-assembled and run-tested chiller complete with base and frame, condenser casing, compressors, compressor motors and motor controllers, evaporator, condenser coils, condenser fans and motors, electrical power, controls, and accessories.
- C. Cabinet:
  - 1. Base: Galvanized-steel base extending the perimeter of chiller. Secure frame, compressors, and evaporator to base to provide a single-piece unit.
  - 2. Frame: Rigid galvanized-steel frame secured to base and designed to support cabinet, condenser, control panel, and other chiller components not directly supported by base.
  - 3. Casing: Galvanized steel.
- D. Compressors:
  - 1. Description: Positive displacement, hermetically sealed.
  - 2. Casing: Cast iron, precision machined for minimum clearance about periphery of rotors.
  - 3. Rotors: Manufacturer's standard one- or two-rotor design.
  - 4. Each compressor provided with suction and discharge shutoff valves, crankcase oil heater, and suction strainer.
- E. Service: Easily accessible for inspection and service.
- F. Capacity Control: On-off compressor cycling and modulating slide-valve assembly or port unloaders combined with hot-gas bypass, if necessary, to achieve performance indicated.
  - 1. Maintain stable operation throughout range of operation. Configure to achieve most energy-efficient operation possible.
  - 2. Operating Range: From 100 to 20 percent of design capacity.
  - 3. Condenser-Air Unloading Requirements over Operating Range: Constant-design, entering condenser-air temperature.
- G. Oil Lubrication System: Consisting of pump if required, filtration, heater, cooler, factory-wired power connection, and controls.
  - 1. Provide lubrication to bearings, gears, and other rotating surfaces at all operating, startup, shutdown, and standby conditions including power failure.
  - 2. Thermostatically controlled oil heater properly sized to remove refrigerant from oil.
  - 3. Factory-installed and pressure-tested piping with isolation valves and accessories.
  - 4. Oil compatible with refrigerant and chiller components.
  - 5. Positive visual indication of oil level.

- H. Vibration Control:
  - 1. Vibration Balance: Balance chiller compressors and drive assemblies to provide a precision balance that is free of noticeable vibration over the entire operating range.
    - a. Overspeed Test: 25 percent above design operating speed.
  - 2. Isolation: Mount individual compressors on vibration isolators.
- I. Compressor Motors:
  - 1. Hermetically sealed and cooled by refrigerant suction gas.
  - 2. High-torque, induction type with inherent thermal-overload protection on each phase.
- J. Compressor Motor Controllers:
  - 1. Across the Line: NEMA ICS 2, Class A, full voltage, nonreversing.
  - 2. Star-Delta, Reduced-Voltage Controller: NEMA ICS 2, closed transition.
  - 3. Solid-state controller.
- K. Refrigerant Circuits:
  - 1. Refrigerant Type: R-134a. Classified as Safety Group A1 according to ASHRAE 34.
  - 2. Refrigerant Compatibility: Chiller parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
  - 3. Refrigerant Circuit: Each shall include a thermal- or electronic-expansion valve, refrigerant charging connections, a hot-gas muffler, compressor suction and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core filter-dryer, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.
  - 4. Pressure Relief Device:
    - a. Comply with requirements in ASHRAE 15 and in applicable portions of ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
    - b. ASME-rated, spring-loaded pressure relief valve; single- or multiple-reseating type.
- L. Evaporator:
  - 1. Description: Shell-and-tube design.
    - a. Direct-expansion type with fluid flowing through the shell, and refrigerant flowing through the tubes within the shell.
    - b. Flooded type with fluid flowing through tubes and refrigerant flowing around tubes within the shell.
  - 2. Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
  - 3. Shell Material: Carbon steel.
  - 4. Shell Heads: Removable carbon-steel heads located at each end of the tube bundle.

- 5. Fluid Nozzles: Terminated with mechanical-coupling or flanged end connections for connection to field piping.
- 6. Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.
- M. Air-Cooled Condenser:
  - 1. Plate-fin coil with integral subcooling on each circuit, rated at 450 psig (3103 kPa).
    - a. Construct coil casing of galvanized or stainless steel.
    - b. Construct coils of copper tubes mechanically bonded to aluminum with precoated epoxy-phenolic fins.
    - c. Hail Protection: Provide condenser coils with louvers, baffles, or hoods to protect against hail damage.
  - 2. Fans: Direct-drive propeller type with statically and dynamically balanced fan blades, arranged for vertical air discharge.
  - 3. Fan Motors: Totally enclosed nonventilating or totally enclosed air over enclosure, with permanently lubricated bearings. Equip each motor with overload protection integral to either the motor or chiller controls.
  - 4. Fan Guards: Steel safety guards with PVC or corrosion-resistant coating.
- N. Electrical Power:
  - 1. Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point, field-power connection to chiller.
  - 2. House in a unit-mounted, NEMA 250, Type 3R enclosure with hinged access door.
  - 3. Wiring shall be numbered and color-coded to match wiring diagram.
  - 4. Install factory wiring outside of an enclosure in a raceway.
  - 5. Field-power interface shall be to NEMA KS 1, heavy-duty, nonfused disconnect switch.
    - a. Disconnect means shall be interlocked with door operation.
    - b. Minimum withstand rating shall be as required by electrical power distribution system, but not less than 42,000 A.
  - 6. Provide branch power circuit to each motor and to controls with one of the following disconnecting means:
    - NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.
    - b. UL 489, motor-circuit protector (circuit breaker) with field-adjustable, shortcircuit-trip set point.
  - 7. Provide each motor with overcurrent protection.
  - 8. Overload relay sized according to UL 1995 or an integral component of chiller control microprocessor.
  - 9. Phase-Failure and Undervoltage Relays: Solid-state sensing with adjustable settings.

- 10. Control Transformer: Unit-mounted transformer with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.
  - a. Power unit-mounted controls where indicated.
  - b. Power unit-mounted, ground fault interrupt duplex receptacle.
- 11. Control Relays: Auxiliary and adjustable time-delay relays.
- 12. For chiller electrical power supply, indicate the following:
  - a. Current and phase to phase for all three phases.
  - b. Voltage, phase to phase, and phase to neutral for all three phases.
  - c. Three-phase real power (kilowatts).
  - d. Three-phase reactive power (kilovolt amperes reactive).
  - e. Power factor.
  - f. Running log of total power versus time (kilowatt-hours).
  - g. Fault log, with time and date of each.
- O. Controls:
  - 1. Standalone and microprocessor based.
  - 2. Enclosure: Share enclosure with electrical power devices or provide a separate enclosure for remote mounting in the field.
  - 3. Operator Interface: Multiple-character digital or graphic display with dynamic update of information and with keypad or touch-sensitive display located on front of control enclosure. In either imperial or metric units, display the following information:
    - a. Date and time.
    - b. Operating or alarm status.
    - c. Operating hours.
    - d. Outdoor-air temperature if required for chilled-water reset.
    - e. Temperature and pressure of operating set points.
    - f. Entering and leaving temperatures of chilled water.
    - g. Refrigerant pressures in evaporator and condenser.
    - h. Saturation temperature in evaporator and condenser.
    - i. No cooling load condition.
    - j. Elapsed time meter (compressor run status).
    - k. Pump status.
    - I. Antirecycling timer status.
    - m. Percent of maximum motor amperage.
    - n. Current-limit set point.
    - o. Number of compressor starts.
  - 4. Control Functions:
    - a. Manual or automatic startup and shutdown time schedule.
    - b. Entering and leaving chilled-water temperatures, control set points, and motor load limits. Chilled-water leaving temperature shall be reset based on outdoor-air temperature.

- c. Current limit and demand limit.
- d. External chiller emergency stop.
- e. Antirecycling timer.
- f. Automatic lead-lag switching.
- g. Variable evaporator flow.
- h. Thermal storage.
- 5. Manually Reset Safety Controls: The following conditions shall shut down chiller and require manual reset:
  - a. Low evaporator pressure or high condenser pressure.
  - b. Low chilled-water temperature.
  - c. Refrigerant high pressure.
  - d. High or low oil pressure.
  - e. High oil temperature.
  - f. Loss of chilled-water flow.
  - g. Control device failure.
- 6. Trending: Capability to trend analog data of up to five parameters simultaneously over an adjustable period and frequency of polling.
- 7. 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.
- 8. Control Authority: At least four conditions: Off, local manual control at chiller, local automatic control at chiller, and automatic control through a remote source.
- 9. Interface with DDC System for HVAC: Factory-installed hardware and software to enable the DDC system for HVAC to monitor, control, and display chiller status and alarms.
  - a. Industry-accepted, open-protocol communication interface with the DDC system for HVAC shall enable the DDC system for HVAC operator to remotely control and monitor the chiller from an operator workstation. Control features and monitoring points displayed locally at chiller control panel shall be available through the DDC system for HVAC.
- P. Insulation: Closed-cell, flexible elastomeric, thermal insulation complying with ASTM C534, Type I for tubular materials and Type II for sheet materials.
- Q. Accessories:
  - 1. Factory-furnished, chilled-water flow switches for field installation.
  - 2. Individual compressor suction and discharge pressure gages with shutoff valves for each refrigerant circuit.
- R. Capacities and Characteristics:
  - 1. As indicated on the drawings.

# 2.3 SOURCE QUALITY CONTROL

- A. Perform functional tests of chillers before shipping.
- B. Factory run test each air-cooled chiller with water flowing through evaporator.
- C. Factory performance test air-cooled chillers, before shipping, according to AHRI 550/590.
  - 1. Test the following conditions:
    - a. Design conditions indicated.
    - b. Reduction in capacity from design to minimum load in steps of **10** with condenser air at design conditions.
  - 2. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.
  - 3. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.
- D. Factory test and inspect evaporator and condenser according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
- E. For chillers located outdoors, rate sound power level according to AHRI 370.

## PART 3 - EXECUTION

# 3.1 CHILLER INSTALLATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchorbolt inserts into bases.
- B. Maintain manufacturer's recommended clearances for service and maintenance.
- C. Charge chiller with refrigerant and fill with oil if not factory installed.
- D. Install separate devices furnished by manufacturer and not factory installed.

## 3.2 CONNECTIONS

- Comply with requirements for piping specified in Section 232113 "Hydronic Piping," Section 232116 Hydronic Piping Specialties," and Section 232300 "Refrigerant Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to chiller to allow service and maintenance.

- C. Evaporator Fluid Connections: Connect to evaporator inlet with shutoff valve, strainer, flexible connector, thermometer, and plugged tee with pressure gage. Connect to evaporator outlet with shutoff valve, balancing valve, flexible connector, flow switch, thermometer, plugged tee with shutoff valve and pressure gage, flow meter, and drain connection with valve. Make connections to chiller with a flange or mechanical coupling.
- D. Condenser Fluid Connections: Connect to condenser inlet with shutoff valve, strainer, flexible connector, thermometer, and plugged tee with pressure gage. Connect to condenser outlet with shutoff valve, balancing valve, flexible connector, flow switch, thermometer, plugged tee with shutoff valve and pressure gage, flow meter, and drain connection with valve. Make connections to chiller with a flange or mechanical coupling.

# 3.3 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
  - 1. Complete installation and startup checks according to manufacturer's written instructions.
  - 2. Verify that refrigerant charge is sufficient and chiller has been leak tested.
  - 3. Verify that pumps are installed and functional.
  - 4. Verify that thermometers and gages are installed.
  - 5. Operate chiller for run-in period.
  - 6. Check bearing lubrication and oil levels.
  - 7. For chillers installed indoors, verify that refrigerant pressure relief device is vented outdoors.
  - 8. Verify proper motor rotation.
  - 9. Verify static deflection of vibration isolators, including deflection during chiller startup and shutdown.
  - 10. Verify and record performance of fluid flow and low-temperature interlocks for evaporator and condenser.
  - 11. Verify and record performance of chiller protection devices.
  - 12. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.
- B. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assembly, installation, and connection.
- C. Prepare test and inspection startup reports.

# 3.4 DEMONSTRATION

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

END OF SECTION 236426.13

# SECTION 236426.16 - WATER-COOLED, ROTARY-SCREW WATER CHILLERS

#### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section includes packaged, water-cooled, multiple-compressor chillers.
- B. Related Requirements:
  - 1. Section 284400 "Refrigerant Detection and Alarm" for refrigerant monitors, alarms, supplemental breathing apparatus, and ventilation equipment interlocks.

#### 1.2 DEFINITIONS

- A. COP: Coefficient of performance. The ratio of the rate of heat removal to the rate of energy input using consistent units for any given set of rating conditions.
- B. DDC: Direct digital control.
- C. EER: Energy-efficiency ratio. The ratio of the cooling capacity given in terms of Btu/h to the total power input given in terms of watts at any given set of rating conditions.
- D. IPLV: Integrated part-load value. A single-number part-load efficiency figure of merit calculated per the method defined by AHRI 550/590 and referenced to AHRI standard rating conditions.
- E. kVAr: Kilovolt amperes reactive.
- F. kW/Ton: The ratio of total power input of the chiller in kilowatts to the net refrigerating capacity in tons at any given set of rating conditions.
- G. NPLV: Nonstandard part-load value. A single-number part-load efficiency figure of merit calculated per the method defined by AHRI 550/590 and intended for operating conditions other than AHRI standard rating conditions.
- H. RTD: Resistance temperature detector.

# 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings:
  - 1. Include plans, elevations, sections, and attachment details.

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- 2. Include details of equipment 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.

# 1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans, drawn to scale, and coordinated with each other, using input from installers of the items involved.
- B. Source quality-control reports.
- C. Field Quality-Control: Startup service reports.
- D. Sample warranty.

# 1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

# 1.6 QUALITY ASSURANCE

- A. AHRI Certification: Certify chiller according to AHRI 550 certification program.
- B. AHRI Rating: Rate chiller performance according to requirements in AHRI 550/590.
- C. ASHRAE Compliance:
  - 1. ASHRAE 15 for safety code for mechanical refrigeration.
  - 2. ASHRAE 147 for refrigerant leaks, recovery, and handling and storage requirements.
- D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1.
- E. ASME Compliance: Fabricate and label chiller to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, and include an ASME U-stamp and nameplate certifying compliance.
- F. Comply with NFPA 70.
- G. Comply with requirements of UL and UL Canada and include label by a qualified testing agency showing compliance.

## 1.7 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of chillers that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

# PART 2 - PRODUCTS

# 2.1 PERFORMANCE REQUIREMENTS

- A. Condenser-Fluid Temperature Performance:
  - 1. Startup Condenser-Fluid Temperature: Chiller shall be capable of starting with an entering condenser-fluid temperature of 55 deg F and providing stable operation until the system temperature is elevated to the minimum operating entering condenser-fluid temperature.
  - 2. Minimum Operating Condenser-Fluid Temperature: Chiller shall be capable of continuous operation over the entire capacity range indicated with an entering condenser-fluid temperature of 65 deg F.
  - 3. Make factory modifications to standard chiller design if necessary to comply with performance indicated.
- B. Site Altitude: Chiller shall be suitable for altitude in which installed without affecting performance indicated. Make adjustments to affected chiller components to account for site altitude.

# 2.2 PACKAGED, WATER-COOLED, MULTIPLE-COMPRESSOR CHILLERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Trane.
  - 2. Carrier.
- B. Description: Factory-assembled and run-tested chiller with compressor(s), compressor motors and motor controllers, evaporator, condenser where indicated, electrical power, controls, and indicated accessories.
- C. Compressors:
  - 1. Description: Positive displacement, hermetically sealed.
  - 2. Casing: Cast iron, precision machined for minimum clearance about periphery of rotors.
  - 3. Rotors: Manufacturer's standard one- or two-rotor design.
- D. Service: Easily accessible for inspection and service.
- E. Capacity Control: On-off compressor cycling and modulating slide-valve assembly or port unloaders combined with hot-gas bypass, if necessary, to achieve performance indicated.
  - 1. Maintain stable operation throughout range of operation. Configure to achieve most energy-efficient operation possible.

- 2. Operating Range: From 100 to 20 percent of design capacity.
- 3. Condenser-Fluid Unloading Requirements over Operating Range: Constant-design, entering condenser-fluid temperature.
- F. Oil Lubrication System: Consisting of pump if required, filtration, heater, cooler, factory-wired power connection, and controls.
  - 1. Provide lubrication to bearings, gears, and other rotating surfaces at all operating, startup, shutdown, and standby conditions including power failure.
  - 2. Thermostatically controlled oil heater properly sized to remove refrigerant from oil.
  - 3. Factory-installed and pressure-tested piping with isolation valves and accessories.
  - 4. Oil compatible with refrigerant and chiller components.
  - 5. Positive visual indication of oil level.
- G. Vibration Control:
  - 1. Vibration Balance: Balance chiller compressor and drive assembly to provide a precision balance that is free of noticeable vibration over the entire operating range.
    - a. Overspeed Test: 25 percent above design operating speed.
  - 2. Isolation: Mount individual compressors on vibration isolators.
- H. Compressor Motors:
  - 1. Hermetically sealed and cooled by refrigerant suction gas.
  - 2. High-torque, induction type with inherent thermal-overload protection on each phase.
- I. Refrigerant Circuits:
  - 1. Refrigerant Type: R-134a or R513A. Classified as Safety Group A1 according to ASHRAE 34.
  - 2. Refrigerant Compatibility: Chiller parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
  - 3. Refrigerant Circuit: Each shall include a thermal- or electronic-expansion valve, refrigerant charging connections, a hot-gas muffler, compressor suction and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core filter-dryer, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.
  - 4. Pressure Relief Device:
    - a. Comply with requirements in ASHRAE 15 and in applicable portions of ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
    - b. ASME-rated, spring-loaded pressure relief valve; single- or multiple-reseating type.
- J. Evaporator:
  - 1. Description: Shell-and-tube design.

- a. Direct-expansion type with fluid flowing through the shell, and refrigerant flowing through the tubes within the shell.
- b. Flooded type with fluid flowing through tubes and refrigerant flowing around tubes within the shell.
- 2. Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
- 3. Shell Material: Carbon steel.
- 4. Shell Heads: Removable carbon-steel heads with multipass baffles, and located at each end of the tube bundle.
- 5. Fluid Nozzles: Terminated with mechanical-coupling or flanged end connections for connection to field piping.
- 6. Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.
- K. Condenser:
  - 1. Shell and tube, or without integral condenser; as indicated.
  - 2. Provide chiller without an integral condenser and design chiller for field connection to remote condenser. Coordinate requirements with Section 236313 "Air-Cooled Refrigerant Condensers."
- L. Electrical Power:
  - 1. Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point, field-power connection to chiller.
  - 2. House in a unit-mounted, NEMA 250, Type 1 enclosure with hinged access door.
  - 3. Wiring shall be numbered and color-coded to match wiring diagram.
  - 4. Install factory wiring outside of an enclosure in a raceway.
  - 5. Field-power interface shall be to NEMA KS 1, heavy-duty, nonfused disconnect switch.
    - a. Disconnect means shall be interlocked with door operation.
    - b. Minimum withstand rating shall be as required by electrical power distribution system, but not less than 42,000 A.
  - 6. Provide branch power circuit to each motor and to controls with one of the following disconnecting means:
    - NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.
    - b. UL 489, motor-circuit protector (circuit breaker) with field-adjustable, shortcircuit-trip set point.
  - 7. Provide each motor with overcurrent protection.
  - 8. Overload relay sized according to UL 1995 or an integral component of chiller control microprocessor.

- 9. Phase-Failure and Undervoltage Relays: Solid-state sensing with adjustable settings.
- 10. Control Transformer: Unit-mounted transformer with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.
- 11. Control Relays: Auxiliary and adjustable time-delay relays.
- 12. For chiller electrical power supply, indicate the following:
  - a. Current and phase to phase for all three phases.
  - b. Voltage, phase to phase, and phase to neutral for all three phases.
  - c. Three-phase real power (kilowatts).
  - d. Three-phase reactive power (kVAr).
  - e. Power factor.
  - f. Running log of total power versus time (kilowatt-hours).
  - g. Fault log, with time and date of each.
- M. Compressor Motor Controllers:
  - 1. Across the Line: NEMA ICS 2, Class A, full voltage, nonreversing, or solid state.
- N. Controls:
  - 1. Standalone and microprocessor based.
  - 2. Enclosure: Share enclosure with electrical-power devices or provide a separate enclosure of matching construction.
  - 3. Operator Interface: Multiple-character digital or graphic display with dynamic update of information and with keypad or touch-sensitive display located on front of control enclosure. In either imperial or metric units, display the following information:
    - a. Date and time.
    - b. Operating or alarm status.
    - c. Fault history with not less than last 10 faults displayed.
    - d. Set points of controllable parameters.
    - e. Trend data.
    - f. Operating hours.
    - g. Number of chiller starts.
    - h. Outdoor-air temperature or space temperature if required for chilled-water reset.
    - i. Temperature and pressure of operating set points.
    - j. Entering- and leaving-fluid temperatures of evaporator and condenser.
    - k. Difference in fluid temperatures of evaporator and condenser.
    - I. Refrigerant pressures in evaporator and condenser.
    - m. Refrigerant saturation temperature in evaporator and condenser.
    - n. No cooling load condition.
    - o. Elapsed time meter (compressor run status).
    - p. Pump status.
    - q. Antirecycling timer status.
    - r. Percent of maximum motor amperage.
    - s. Current-limit set point.
    - t. Number of compressor starts.
    - u. Compressor refrigerant suction and discharge temperature.

- v. Oil temperature.
- w. Oil discharge pressure.
- x. Phase current.
- y. Percent of motor rated load amperes.
- z. Phase voltage.
- 4. Control Functions:
  - a. Manual or automatic startup and shutdown time schedule.
  - b. Entering and leaving chilled-water temperatures, control set points, and motor load limits. Chilled-water leaving temperature shall be reset based on outdoor-air temperature.
  - c. Current limit and demand limit.
  - d. Condenser-fluid temperature.
  - e. External chiller emergency stop.
  - f. Antirecycling timer.
  - g. Automatic lead-lag switching.
  - h. Variable evaporator flow.
  - i. Thermal storage.
- 5. Manually Reset Safety Controls: The following conditions shall shut down chiller and require manual reset:
  - a. Low evaporator pressure or high condenser pressure.
  - b. Low chilled-water temperature.
  - c. Refrigerant high pressure.
  - d. High or low oil pressure.
  - e. High oil temperature.
  - f. Loss of chilled-water flow.
  - g. Loss of condenser-fluid flow.
  - h. Control device failure.
- 6. Trending: Capability to trend analog data of up to five parameters simultaneously over an adjustable period and frequency of polling.
- 7. 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.
- 8. Control Authority: At least four conditions: Off, local manual control at chiller, local automatic control at chiller, and automatic control through a remote source.
- 9. Interface with DDC System for HVAC: Factory-installed hardware and software to enable the DDC system for HVAC to monitor, control, and display chiller status and alarms.
  - a. Industry-accepted, open-protocol communication interface with the DDC system for HVAC shall enable the DDC system for HVAC operator to remotely control and monitor the chiller from an operator workstation. Control features and monitoring points displayed locally at chiller control panel shall be available through the DDC system for HVAC.

- O. Insulation: Closed-cell, flexible elastomeric, thermal insulation complying with ASTM C534, Type I for tubular materials and Type II for sheet materials.
- P. Finish: Paint chiller, using manufacturer's standard procedures.
- Q. Accessories:
  - 1. Factory-furnished, chilled- and condenser-water flow switches for field installation.
  - 2. Individual compressor suction and discharge pressure gages with shutoff valves for each refrigerant circuit.
- R. Capacities and Characteristics:
  - 1. As indicated on the drawings.
- 2.3 SOURCE QUALITY CONTROL
  - A. Perform functional tests of chillers before shipping.
  - B. Factory performance test water-cooled chillers, before shipping, according to AHRI 550/590.
    - 1. Test the following conditions:
      - a. Design conditions indicated.
      - b. Reduction in capacity from design to minimum load in steps of 10 with condenser fluid at design conditions.
    - 2. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.
  - C. Factory test and inspect evaporator according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
  - D. For chillers located indoors, rate sound power level according to AHRI 575.
  - E. For chillers located outdoors, rate sound power level according to AHRI 370.
- PART 3 EXECUTION
- 3.1 CHILLER INSTALLATION
  - A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchorbolt inserts into bases.
  - B. Equipment Mounting:

- 1. Install chillers on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
- C. Maintain manufacturer's recommended clearances for service and maintenance.
- D. Charge chiller with refrigerant and fill with oil if not factory installed.
- E. Install separate devices furnished by manufacturer and not factory installed.

# 3.2 CONNECTIONS

- A. Comply with requirements for piping specified in Section 232113 "Hydronic Piping," Section 232116 "Hydronic Piping Specialties," Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to chiller to allow service and maintenance.
- C. Evaporator Fluid Connections: Connect to evaporator inlet with shutoff valve, strainer, flexible connector, thermometer, and plugged tee with pressure gage. Connect to evaporator outlet with shutoff valve, balancing valve, flexible connector, flow switch, thermometer, plugged tee with shutoff valve and pressure gage, flow meter, and drain connection with valve. Make connections to chiller with a flange or mechanical coupling.
- D. Condenser Fluid Connections: Connect to condenser inlet with shutoff valve, strainer, flexible connector, thermometer, and plugged tee with pressure gage. Connect to condenser outlet with shutoff valve, balancing valve, flexible connector, flow switch, thermometer, plugged tee with shutoff valve and pressure gage, flow meter, and drain connection with valve. Make connections to chiller with a flange or mechanical coupling.
- E. Refrigerant Pressure Relief Device Connections: For chillers installed indoors, extend vent piping to the outdoors without valves or restrictions. Comply with ASHRAE 15. Connect vent to chiller pressure relief device with flexible connector and dirt leg with drain valve.
- F. Connect each chiller drain connection with a union and drain pipe, and extend pipe, full size of connection, to floor drain. Provide a shutoff valve at each connection.

## 3.3 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
  - 1. Complete installation and startup checks according to manufacturer's written instructions.
  - 2. Verify that refrigerant charge is sufficient and chiller has been leak tested.
  - 3. Verify that pumps are installed and functional.
  - 4. Verify that thermometers and gages are installed.
  - 5. Operate chiller for run-in period.
  - 6. Check bearing lubrication and oil levels.

- 7. For chillers installed indoors, verify that refrigerant pressure relief device is vented outdoors.
- 8. Verify proper motor rotation.
- 9. Verify static deflection of vibration isolators, including deflection during chiller startup and shutdown.
- 10. Verify and record performance of fluid flow and low-temperature interlocks for evaporator.
- 11. Verify and record performance of chiller protection devices.
- 12. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.
- B. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assembly, installation, and connection.
- C. Prepare test and inspection startup reports.

# 3.4 DEMONSTRATION

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

END OF SECTION 236426.16

# SECTION 236514.14-OPEN-CIRCUIT, INDUCED-DRAFT, CROSSFLOW COOLING TOWERS

# PART 1 - GENERAL

#### 1.1 SUMMARY

A. Section includes factory-assembled, open-circuit, induced-draft, crossflow cooling towers.

#### 1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings:
  - 1. Manufacturer's drawings of assembled cooling towers, control panels, sections, and elevations.
  - 2. Diagram showing each separate piece requiring field assembly.
  - 3. Shipped sub-assembly dimensions and weights for field assembly.
  - 4. Operating weight and load distribution.
  - 5. Unit vibration isolation.
  - 6. Required clearances for maintenance and operation.
  - 7. Sizes and dimensioned locations of piping and wiring connections.
  - 8. Diagrams for power, signal, and control wiring.

## 1.3 INFORMATIONAL SUBMITTALS

- A. Product Certificates: For certification required in "Quality Assurance" Article.
- B. Field test reports.
- C. Source quality-control reports.
- D. Field quality-control reports.
- E. Sample warranty.

# 1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

# 1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Certified by CTI.

# 1.6 WARRANTY

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

# PART 2 - PRODUCTS

## 2.1 MANUFACTURERS

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

# 2.2 PERFORMANCE REQUIREMENTS

- A. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1.
- B. 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.
- C. Operation Following Loss of Normal Power:
  - 1. Equipment, associated factory- and field-installed controls, and associated electrical equipment and power supply connected to backup power system shall automatically return equipment and associated controls to the operating state occurring immediately before loss of normal power without need for manual intervention by an operator when power is restored either through a backup power source, or through normal power if restored before backup power is brought on-line.
  - 2. Include means and methods required to satisfy requirement even if not explicitly indicated.
- D. Vibration:
  - 1. Rotating assemblies shall be dynamically balanced to achieve a balance level of "good" while complying with industry-standard requirements for cooling towers.
  - 2. Critical speed shall be at least 115 percent of design speed.

# 2.3 DESIGN ARRANGEMENT

A. Crossflow design with airflow from two sides and induced-draft, top-mounted axial fan and gravity distribution basin.

# 2.4 CASING AND FRAME

- A. Casing Material: Galvanized steel, ASTM A653/A653M, G235 coating.
- B. Frame Material: galvanized steel, ASTM A653/A653M, G235 coating.
- C. Hardware: Galvanized or stainless steel.
- D. Joints and Seams: Sealed watertight.
- E. Welded Connections: Sealed watertight.

# 2.5 COLLECTION BASIN

- A. Factory-Assembled Collection Basin:
  - 1. Material: Galvanized steel, ASTM A653/A653M, G235 coating.
  - 2. Hardware: Galvanized or stainless steel.
  - 3. Joints and Seams: Sealed watertight.
  - 4. Welded Connections: Sealed watertight.
  - 5. Removable stainless-steel strainer with openings smaller than nozzle orifices.
  - 6. Overflow and drain connections.
  - 7. Makeup-water connection.
  - 8. Outlet Connection: Configured to mate to ASME B16.5, Class 150 flange.

# 2.6 COLLECTION BASIN MAKEUP-WATER ASSEMBLY

- A. Electric/Electronic, Collection Basin Water-Level Controller with Makeup-Water Valve:
  - 1. Enclosures: NEMA 250, Type 4.
  - 2. Sensor: Solid-state controls with multiple electrode probes and relays factory wired to a terminal strip to control makeup-water valve, low- and high-level alarms, and output for shutoff of pump on low level.
  - 3. Electrode Probes: Stainless steel.
  - 4. Water Stilling Chamber: Corrosion-resistant material or PVC pipe.
  - 5. Makeup-Water Valve:
    - a. Slow closing.
    - b. Actuator controlled and powered through level controller in response to waterlevel set point.
  - 6. Electrical Connection Requirements: 120-V ac, single phase, 60 Hz.

# 2.7 COLLECTION BASIN HEATER

A. Electric Heater:

- 1. Stainless-Steel Electric Immersion Heaters: Installed in a threaded coupling on the side of the collection basin.
- 2. Heater Control Panel: Mounted on the side of each cooling tower cell.
- 3. Enclosure: NEMA 250, Type 3R.
- 4. Magnetic contactors controlled by a temperature sensor/controller to maintain collection basin water-temperature set point. Water-level probe shall monitor cooling tower water level and de-energize the heater when the water reaches low-level set point.
- 5. Control-circuit transformer with primary and secondary side fuses.
- 6. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
- 7. Single-point, field-power connection to a nonfused disconnect switch and heater branch circuiting complying with NFPA 70.
- 8. Factory Wiring Method: Metal raceway for factory-installed wiring outside of enclosures, except connections to each electric basin heater shall be liquidtight conduit.
  - a. Raceway shall be corrosion-resistant stainless steel or PVC coated steel.

## 2.8 GRAVITY WATER DISTRIBUTION BASIN

- A. Design: Non-pressurized design with head of water level in basin adequate to overcome spray nozzle losses and designed to evenly distribute water over fill throughout the flow range indicated.
  - 1. Material: galvanized steel, ASTM A653/A653M, G235 coating.
  - 2. Location: Over each bank of fill with easily replaceable plastic spray nozzles mounted in bottom of basin.
  - 3. Inlet Connection: Configured to mate to ASME B16.5, Class 150 flange.
  - 4. Fasteners: Galvanized or stainless steel.
  - 5. Joints and Seams: Sealed watertight.
  - 6. Welded Connections: Sealed watertight.
  - 7. Partitioning Dams: Same material as basin to distribute water over the fill to minimize icing and achieve proper operation while operating throughout the flow range indicated.
    - a. Manufacturer has option to use individual nozzle cups in lieu of partitioning dams to achieve operation within flow range (design to minimum) indicated.
  - 8. Removable Panels: Same material as basin to completely cover top of basin. Secure panels to basin with removable corrosion-resistant hardware. Panels reinforced to accommodate service personnel walking on the panels without resulting in permanent deflection and damage.
  - 9. Valves: Manufacturer's standard valve installed at each inlet connection and arranged to balance or shut off flow to each gravity distribution basin.

# 2.9 FILL

A. Materials: PVC, with maximum flame-spread index of 25 according to ASTM E84.

- B. Fabrication: Fill-type sheets, fabricated, formed, and bonded together after forming into removable assemblies that are factory installed by manufacturer.
- C. Fill Material Operating Temperature: Suitable for entering-water temperatures up through 120 deg F.
- D. Hardware: Galvanized or stainless steel.
- 2.10 DRIFT ELIMINATORS
  - A. Material: FRP or PVC; with maximum flame-spread index of 25 according to ASTM E84.
  - B. UV Treatment: Inhibitors to protect against damage caused by UV radiation.

## 2.11 AIR INLET

- A. Air-Intake Louvers:
  - 1. Material: PVC.
  - 2. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
  - 3. Louver Blades: Arranged to uniformly direct air into cooling tower, to minimize air resistance, and to prevent water from splashing out of tower during all modes of operation including operation with fans off.
- B. Hardware: Galvanized or stainless steel.

## 2.12 FAN AND DRIVE ASSEMBLY

- A. Axial Fan: Balanced at the factory.
  - 1. Blade Material: Aluminum.
  - 2. Hub Material: Aluminum.
  - 3. Fan Shaft: Corrosion resistant.
  - 4. Fan Shaft Bearings: Self-aligning ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F. Bearings designed for an L-10 life of 40,000 hours.
  - 5. Bearings Grease Fittings: Extended lubrication lines to an easily accessible location.
- B. Belt Drive:
  - 1. Service Factor: 1.5 based on motor nameplate horsepower.
  - 2. Sheaves: Fan and motor shafts shall have taper-lock sheaves fabricated from corrosion-resistant materials.
  - 3. Belt: Multiple V-belt design with a matched set of belts.
  - 4. Belt: One-piece, multi-grooved, solid-back belt.
  - 5. Belt Material: Oil resistant, non-static conducting, and constructed of neoprene polyester cord.

- 6. Belt-Drive Guard: Comply with OSHA regulations.
- C. Fan Motor:
  - 1. Comply with NEMA MG 1 unless otherwise indicated.
  - 2. Description: NEMA MG 1, Design B, as required to comply with capacity and torque characteristics; medium induction motor.
  - 3. 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.
  - 4. Motor Enclosure: Totally enclosed.
  - 5. Rotor: Random-wound, squirrel cage.
  - 6. Energy Efficiency: Comply with ASHRAE/IES 90.1.
  - 7. Service Factor: 1.15.
  - 8. Temperature Rise: Match insulation rating.
  - 9. Variable-Speed Motors: Inverter-duty rated per NEMA MG 1, Section IV, "Performance Standard Applying to All Machines," Part 31, "Definite-Purpose, Inverter-Fed, Polyphase Motors."
  - 10. Motor Location: Mounted outside of cooling tower casing and cooling tower discharge airstream.
- D. "Hardware: Galvanized or stainless steel.

# 2.13 AIR DISCHARGE

- A. Low-Profile Fan Discharge Stack:
  - 1. Manufacturer's standard low-profile design.
  - 2. Stack Termination: Wire-mesh, polymer-coated, galvanized-steel or stainless-steel screens; segmented into multiple removable pie sections and complying with OSHA regulations.
- B. Hardware: Galvanized or stainless steel.

## 2.14 ELECTRICAL POWER

- A. Factory Install: A variable-frequency controller for each fan motor.
  - 1. Locate in a convenient and field-accessible location within sight of motor.
  - 2. Installation shall comply with NFPA 70.
  - 3. Wire, Conduit, and Enclosures:
    - a. Minimum Conduit Size: 0.75 inch.
    - b. Materials: Corrosion resistant and constructed of stainless steel or PVC coated steel.
    - c. Motor Termination: Liquidtight conduit, not to exceed 36 inches long.

- d. Supports: Support conduits, boxes, and enclosures using corrosion-resistant fastening hardware constructed of stainless steel.
- e. Boxes, Condulets, and Enclosures: NEMA 250, Type 3R.
- B. Disconnect Switches:
  - 1. Specification Grade; "Heavy Duty Type"; "quick-make," "quick-break" construction.
  - 2. Three pole, nonfused.
  - 3. 600 V rated.
  - 4. Minimum SCCR: As required by electrical power distribution system, but not less than 42,000 A.
  - 5. Enclosure: NEMA 250, Type 3R.
  - 6. Operating handle shall be of box-mounted type that directly drives switch mechanism.
  - 7. Disconnect switch shall use a flange-operated visible blade that is close coupled to a vertical-lift-type handle that achieves a positive visible indication of disconnect with cover open or closed.
  - 8. Disconnect switch shall have a defeatable, front-accessible, mechanical interlock to prevent opening of cover when switch is in "ON" position, and to prevent turning switch "ON" when the door is open.
  - 9. Include a solid neutral as required by authorities having jurisdiction.
  - 10. Disconnect switch shall have a ground lug for ground wire termination.
  - 11. Operating handle shall be lockable in open position.
  - 12. Horsepower rated.
  - 13. Feed through or double lugged.
  - 14. Elapsed-Time Meters: Numerical readout in hours on face of enclosure.
  - 15. Number-of-Starts Counter: Numerical readout on face of enclosure.
- C. Variable-Frequency Controllers:
  - 1. Description: NEMA ICS 2; arranged to achieve motor variable speed by adjusting output voltage and frequency.
  - 2. Enclosure: Unit mounted, NEMA 250, Type 3R, with hinged full-front access door with lock and key.
  - 3. Externally Operated, Door-Interlocked Disconnect: Nonfused disconnect switch with lockable handle.
  - 4. Minimum SCCR: As required by electrical power distribution system, but not less than 42,000 A.
  - 5. Technology: Pulse-width-modulated (PWM) output with insulated gate bipolar transistors (IGBT); suitable for variable torque loads.
  - 6. Controller shall consist of a rectifier converter section, a digital/analog driver regulator section, and an inverter output section.
  - 7. Output Rating: Three phase; with voltage proportional to frequency throughout voltage range.
  - 8. Output signal shall be programmed to not cause mechanical vibration issues with fan drive assembly.
  - 9. Operating Requirements:

- a. Input AC Voltage Tolerance: 10 percent.
- b. Input frequency tolerance of 60 Hz, plus or minus 2 Hz.
- c. Capable of driving full motor load, without derating.
- d. Minimum Efficiency: 96 percent at 60 Hz, full load.
- e. Minimum Displacement Primary-Side Power Factor: 95 percent.
- f. Overload Capability: 1.05 times the full-load current for 7 seconds.
- g. Starting Torque: As required by fan and motor drive assembly.
- h. Speed Regulation: 1 percent.
- i. Speed Range: 10:1 speed range.
- j. To avoid equipment resonant vibrations, include critical speed lockout circuitry to allow bands of operating frequency at which controller shall not operate continuously.
- k. Capable of being restarted into a motor coasting in either the forward or reverse direction without tripping.
- 10. Controller Adjustability Capabilities: Minimum and maximum output frequency, acceleration and deceleration, and current limit.
- 11. Self-Protection and Reliability Features: Subjecting the controller to any of the following conditions shall not result in component failure or the need for replacement:
  - a. Overtemperature.
  - b. Short circuit at controller output.
  - c. Ground fault at controller output. Variable-frequency controller shall be able to start a grounded motor.
  - d. Open circuit at controller output.
  - e. Input undervoltage.
  - f. Input overvoltage.
  - g. Loss of input phase.
  - h. Reverse phase.
  - i. AC line switching transients.
  - j. Instantaneous overload, line to line or line to ground.
  - k. Sustained overload exceeding 100 percent of controller rated current.
  - I. Starting a rotating motor.
- 12. Motor Protection: Controller shall protect motor against overvoltage and undervoltage, phase loss, reverse phase, overcurrent, overtemperature, and ground fault.
- 13. Automatic Reset and Restart:
  - a. Capable of multiple restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction.
  - b. Capable of automatic restart on phase-loss and overvoltage and undervoltage trips.
- 14. Visual Indication: On face of controller; indicating the following conditions:
  - a. Power on.
  - b. Run.
  - c. Overcurrent and overvoltage.

- d. Motor speed (percent).
- e. Various faults with alarm status.
- f. Input kilovolt amperes.
- g. Power factor.
- h. Input kilowatts and kilowatt-hours.
- i. Three-phase input and output voltage.
- j. Three-phase input and output current.
- k. Output frequency.
- I. Elapsed operating time (hours).
- m. Diagnostic and service parameters.
- 15. Operator Interface: Start-stop and auto-manual selector with manual-speed-control potentiometer.
- 16. Control Signal Interface: A minimum of two analog inputs (0 to 10 V or 0/4 to 20 mA) and four programmable digital inputs.

# 2.15 CONTROLS

- A. Vibration Switch: For each fan drive.
  - 1. Enclosure: NEMA 250, Type 4.
  - 2. Vibration Detection: Sensor with a field-adjustable, acceleration-sensitivity set point in a range of 0 to 1 g and frequency range of 0 to 3000 cycles per minute. Cooling tower manufacturer shall recommend switch set point for proper operation and protection.
  - 3. Switch shall have manual-reset button hardwired connection to fan motor electrical circuit.
  - 4. Switch shall have field connection to a control system hardwired connection to fan motor electrical circuit.
  - 5. Switch shall, on sensing excessive vibration, signal an alarm for connection to control system and shut down the fan.
- B. Vibration Transmitter with Switch: For each fan drive.
  - 1. Enclosure: NEMA 250, Type 4X.
  - 2. Display: Local display of measured value, power, and alarm.
  - 3. Vibration Detection: Sensor with a field-adjustable, acceleration-sensitivity set point.
    - a. Cooling tower manufacturer shall select range that is suitable for cooling tower and recommend switch set point for proper operation and protection.
  - 4. Transmitter: Continuous vibration level indication through a 4- to 20-mA signal for connection to control system.
  - 5. Switch:
    - a. Relay and switch with manual-reset button for field connection to control system and hardwired connection to fan motor electrical circuit.
    - b. Switch shall, on sensing excessive vibration, signal an alarm to control system and shut down the fan.

- 6. Mounting: Locate out of cooling tower discharge airstream and mount in a location that is accessible and where display is easily viewable.
- 7. Field Electrical Connection Requirements: 120 V, single phase, 60 Hz.

# 2.16 HOISTING ASSEMBLY

- A. Hoisting assembly consisting of pedestal base, davit arm, and winch to accommodate lowering and raising cooling tower components from their installed location to the base of cooling tower supports.
  - 1. Cooling tower components serviceable by hoisting assembly shall include, but not be limited to, fan stack, fan, fan drive, and fan motor.
  - 2. Hoisting assembly shall be designed to accommodate heaviest single component plus a safety factor of 1.5.
  - 3. Construct cooling tower structural supports and reinforcing to accommodate lifting heaviest load with safety factor.
- B. Pedestal Base:
  - 1. Equip each cooling tower cell with a pedestal base to accommodate an easily removable davit arm and winch assembly.
  - 2. Position pedestal base at a location on cooling tower fan (top) deck for hoisting assembly coverage to fan, fan motor, and fan drive assembly.
  - 3. Pedestal base design shall be open-socket, or comparable, design that is configured to accept and secure an inserted portable davit arm.
  - 4. Fit each pedestal base with an easily removable cap or plug designed to seal the open top of the base when the davit arm is not installed.
  - 5. Fasten pedestal base to cooling tower using threaded hardware.
  - 6. Construct pedestal base of hot-dip galvanized steel.
- C. Davit Arm:
  - 1. Each cooling tower shall have a davit arm.
  - 2. Davit arm shall be an adjustable telescoping design with angular adjustment to accommodate varying lifting conditions required by the application.
  - 3. Davit arm assembly shall be portable and capable of being relocated to any cooling tower cell pedestal base.
  - 4. Construct davit arm of hot-dip galvanized steel or 300L series stainless steel.
- D. Hardware: 304 or 316 series stainless steel.
- E. Nameplate:
  - 1. Stamped or engraved aluminum or stainless-steel nameplate with rated load capacity on each davit arm and pedestal.
  - 2. Letter size legible from a distance of 60 inches and not less than 1/2 inch.
  - 3. Fasten nameplate at multiple points with stainless-steel rivets or screws.

#### 2.17 CAPACITIES AND CHARACTERISTICS 1. As indicated on the

## 2.18 SOURCE QUALITY CONTROL

- A. Performance Test: Factory test and certify cooling tower performance according to CTI STD 201RS, "Standard for the Certification of Water-Cooling Tower Thermal Performance."
- B. Factory Functional Tests:
  - 1. Test collection and distribution basins after assembly, and prove free of leaks.
  - 2. Test factory-installed electric/electronic water-level controls for proper operation.
  - 3. Test factory-installed electric basin heaters for proper operation.
  - 4. Test factory-installed fan and drive assemblies for proper operation.
  - 5. Test factory-installed control package for proper operation.
  - 6. Test access doors to ensure smooth operation and proper fit.

# PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Examine cooling towers before installation. Reject cooling towers that are damaged.
- B. Install cooling towers on support structure.
- C. Equipment Mounting:
  - 1. Install cooling towers on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
- D. Install anchor bolts to elevations required for proper attachment to supported equipment.
- E. Maintain manufacturer's recommended clearances for service and maintenance.
- F. Maintain clearances required by governing code.

## 3.2 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to cooling towers, allow space for service and maintenance.
- C. Install flexible pipe connectors at pipe connections of cooling towers mounted on vibration isolators.

- D. Install drain piping with valve at cooling tower drain connections and at low points in piping.
- E. Connect cooling tower overflows and drains, and piping drains, to sanitary sewage system.
- F. Makeup-Water Piping:
  - 1. Comply with applicable requirements in Section 221116 "Domestic Water Piping."
  - 2. Connect to makeup-water connections with shutoff valve, plugged tee with pressure gage, flow meter, and drain connection with valve and union.
- G. Supply and Return Piping:
  - 1. Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."
  - 2. Connect to entering cooling tower connections with shutoff valve, strainer, balancing valve, thermometer, plugged tee with pressure gage, flow meter, and drain connection with valve.
  - 3. Connect to leaving cooling tower connection with shutoff valve thermometer, plugged tee with full port ball valve for portable field instruments, and drain connection with valve.
  - 4. Make connections to cooling tower with a flange.
- H. Equalizer Piping:
  - 1. Piping requirements to match supply and return piping.
  - 2. Connect an equalizer pipe, full size of cooling tower connection, between tower cells.
  - 3. Connect to cooling tower with shutoff valve and drain connection with valve.
  - 4. Make connections to cooling tower with a flange.

# 3.3 ELECTRICAL POWER CONNECTIONS

- A. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.
- B. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems" for grounding connections.
- C. Install nameplate for each electrical connection indicating electrical equipment designation and circuit number feeding connection. Nameplate shall be laminated phenolic layers of black with engraved white letters at least 1/2 inch high. Locate nameplate where easily visible.

## 3.4 CONTROLS CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring between cooling towers and other equipment to interlock operation as required to achieve a complete and functioning system.

#### 3.5 FIELD QUALITY CONTROL

- A. Perform tests and inspections with the assistance of a factory-authorized service representative.
- B. Cooling towers will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

## 3.6 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
- B. Inspect field-assembled components, equipment installation, and piping; controls; and electrical connections for proper assemblies, installations, and connections.
- C. Obtain performance data from manufacturer.
  - 1. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
    - a. Clean entire unit including basins.
    - b. Verify that accessories are properly installed.
    - c. Verify clearances for airflow and for cooling tower servicing.
    - d. Check for vibration isolation and structural support.
    - e. Lubricate bearings.
    - f. Verify fan rotation for correct direction and for vibration or binding and correct problems.
    - g. Adjust belts to proper alignment and tension.
    - h. Operate variable-speed fans through entire operating range and check for harmonic vibration imbalance. Set motor controller to skip speeds resulting in abnormal vibration.
    - i. Check vibration switch setting. Verify operation.
    - j. Verify water level in tower basin. Fill to proper startup level. Check makeupwater-level control and valve.
    - k. Verify operation of basin heater and control.
    - I. Verify that cooling tower air discharge is not recirculating air into tower or HVAC air intakes. Recommend corrective action.
    - m. Replace defective and malfunctioning units.
- D. Start cooling tower and associated water pumps. Follow manufacturer's written starting procedures.
- E. Prepare a written startup report that records the results of tests and inspections.

# 3.7 ADJUSTING

- A. Set and balance water flow to each tower inlet.
- B. Adjust water-level control for proper operating level.
- C. Adjust basin heater control for proper operating set point.

# 3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain cooling towers.

END OF SECTION 236514.14

# SECTION 237313.13 - INDOOR, BASIC AIR-HANDLING UNITS

#### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section includes factory-assembled, indoor air-handling units with limited features, including the following components and accessories:
  - 1. Casings.
  - 2. Fans, drives, and motors.
  - 3. Coils.
  - 4. Air filtration.
  - 5. Dampers.

## 1.2 ACTION SUBMITTALS

- A. Product Data: For each air-handling unit.
- B. Shop Drawings: For each type and configuration of indoor, basic, air-handling unit.
  - 1. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 2. Include diagrams for power, signal, and control wiring.

## 1.3 INFORMATIONAL SUBMITTALS

- A. Source quality-control reports.
- B. Startup service reports.
- C. Field quality-control reports.
- D. Sample Warranty: For manufacturer's warranty.

#### 1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air-handling units to include in emergency, operation, and maintenance manuals.

## 1.5 WARRANTY

- A. Warranty: Manufacturer agrees to repair or replace components of indoor, basic, air-handling units that fail in materials or workmanship within specified warranty period.
  - 1. Warranty Period: Manufacturer's standard, but not less than one year(s) 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 application.
- B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of airhandling units and components.
- C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 "Systems and Equipment" and Section 7 "Construction and Startup."
- D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 "Heating, Ventilating, and Air-Conditioning."

# 2.2 CAPACITIES AND CHARACTERISTICS

A. As indicated on the drawings.

## 2.3 MANUFACTURERS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
  - 1. Carrier Corporation.
  - 2. McQuay International.
  - 3. Trane; American Standard Companies, Inc.

## 2.4 UNIT CASINGS

- A. General Fabrication Requirements for Casings;
  - 1. Forming: Form walls, roofs, and floors with at least two breaks at each joint.
  - 2. Joints: Sheet metal screws or pop rivets.
  - 3. Sealing: Seal all joints with water-resistant sealant. Hermetically seal at each corner and around entire perimeter.

- B. Double-Wall Construction:
  - 1. Outside Casing Wall: Galvanized steel, minimum 18 gauge thick, with manufacturer's standard finish.
  - 2. Inside Casing Wall: galvanized steel, solid, minimum 18 gauge thick.
  - 3. Casing Insulation:
    - a. Insulation Thickness: 1 inch.
    - b. Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roofs of air-handling unit.
- C. Panels and Doors:
  - 1. Panels:
    - a. Fabrication: Formed and reinforced with same materials and insulation thickness as casing.
    - b. Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against airflow.
    - c. Gasket: Neoprene, applied around entire perimeters of panel frames.
    - d. Size: Large enough to allow unobstructed access for inspection and maintenance of air-handling unit's internal components.
  - 2. Doors:
    - a. Fabrication: Formed and reinforced with same materials and insulation thickness as casing.
    - b. 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 airflow. Provide safety latch retainers on doors so that doors do not open uncontrollably.
    - c. Gasket: Neoprene, applied around entire perimeters of frame.
    - d. Size: Large enough to allow for unobstructed access for inspection and maintenance of air-handling unit's internal components.
  - 3. Locations and Applications:
    - a. Fan Section: Panels.
    - b. Coil Section: Panels.
    - c. Access Section: Panels.
    - d. Damper Section: Panels.
    - e. Filter Section: Panels large enough to allow periodic removal and installation of filters.
    - f. Mixing Section: Panels.
- D. Condensate Drain Pans:
  - 1. Location: Each type of cooling coil.
  - 2. Construction:
- a. Single-wall, galvanized-steel or noncorrosive polymer sheet.
- 3. Drain Connection:
  - a. Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.
  - b. Minimum Connection Size: NPS 3/4.

### 2.5 FAN, DRIVE, AND MOTOR SECTION

- A. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.
- B. Fans: Centrifugal, galvanized steel; mounted on solid-steel shaft.
  - 1. Shafts: With field-adjustable alignment.
    - a. Turned, ground, and polished hot-rolled steel with keyway.
  - 2. Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.
    - a. Bracing: Steel angle or channel supports for mounting and supporting fan scroll, wheel, motor, and accessories.
  - 3. Housings, Plenum Fans: Steel frame and panel; fabricated without fan scroll and volute housing. Provide inlet screens for Type SWSI fans.
  - 4. Forward-Curved, Centrifugal Fan Wheels: Inlet flange, backplate, and shallow blades with inlet and tip curved forward in direction of airflow and mechanically fastened to flange and backplate; steel or aluminum hub swaged to backplate and fastened to shaft with setscrews.
- C. Drive, Direct: Factory-mounted, direct drive.
- D. Motors:
  - 1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
  - 2. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
  - 3. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.

### 2.6 COIL SECTION

A. General Requirements for Coil Section:

- 1. Comply with AHRI 410.
- 2. Fabricate coil section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
- 3. Coils shall not act as structural component of unit.
- B. Heating Coils:
  - 1. Hot-Water Coils: Continuous circuit.
    - a. Piping Connections: Sweat, same end of coil.
    - b. Tube Material: Copper.
    - c. Fin Type: Plate.
    - d. Fin Material: Aluminum.
- C. Cooling Coils:
  - 1. Chilled-Water Coil: Continuous circuit.
    - a. Piping Connections: Sweat, same end of coil.
    - b. Tube Material: Copper.
    - c. Fin Type: Plate.
    - d. Fin Material: Aluminum.

### 2.7 AIR FILTRATION SECTION

- A. Particulate air filtration is specified in Section 234100 "Particulate Air Filtration."
- B. Panel Filters:
  - 1. Description: Pleated factory-fabricated, self-supported disposable air filters with holding frames.
- C. Side-Access Filter Mounting Frames:
  - 1. Particulate Air Filter Frames: Match inner casing and outer casing material, and insulation thickness. Galvanized steel track.
    - a. Sealing: Incorporate positive-sealing device to ensure seal between gasketed material on channels to seal top and bottom of filter cartridge frames to prevent bypass of unfiltered air.
- 2.8 DAMPERS
  - A. Outdoor- and Return-Air Dampers: Low-leakage, double-skin, airfoil-blade, galvanized-steel dampers with compressible jamb seals and extruded-vinyl blade edge seals in parallel-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. Combination Filter and Mixing Section:

- 1. Cabinet support members shall hold 2-inch- thick, pleated, flat, permanent or throwaway filters.
- 2.9 MATERIALS
  - A. Steel:
    - 1. ASTM A36/A36M for carbon structural steel.
    - 2. ASTM A568/A568M for steel sheet.
  - B. Stainless Steel:
    - 1. Manufacturer's standard grade for casing.
    - 2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.
  - C. Galvanized Steel: ASTM A653/A653M.
  - D. Aluminum: ASTM B209.
- 2.10 SOURCE QUALITY CONTROL
  - A. AHRI 430 Certification: Test, rate, and label air-handling units and their components in accordance with AHRI 430.
  - B. Fan Operating Limits: Classify fans in accordance with AMCA 99, Section 14.
  - C. Water Coils: Factory tested to 300 psig according to AHRI 410 and ASHRAE 33.

PART 3 - EXECUTION

- 3.1 INSTALLATION, GENERAL
  - A. Examine roughing-in for steam, hydronic, and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.
  - B. Equipment Mounting:
  - C. Suspended Units: Suspend units from structural-steel support frame using threaded steel rods and spring hangers. Coordinate sizes and locations of structural-steel support members with actual equipment provided.
  - D. Arrange installation of units to provide access space around air-handling units for service and maintenance.

- E. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing with new, clean filters.
- F. Connect duct to air-handling units with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."

### 3.2 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to air-handling unit, allow for service and maintenance.
- C. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.
- D. Connect condensate drain pans using NPS 3/4, ASTM B88, Type M copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.
- E. Hot- and Chilled-Water Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.
- F. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Install shutoff valve and union or flange at each supply and return connection.

### 3.3 ELECTRICAL CONNECTIONS

- A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
  - 1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."

### 3.4 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

### 3.5 STARTUP SERVICE

- A. Perform startup service.
  - 1. Complete installation and startup checks according to manufacturer's written instructions.
  - 2. Verify that shipping, blocking, and bracing are removed.
  - 3. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.
  - 4. Verify proper motor rotation direction, free fan wheel rotation, and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
  - 5. Verify that bearings, pulleys, belts, and other moving parts are lubricated with factory-recommended lubricants.
  - 6. Verify that outdoor- and return-air mixing dampers open and close, and maintain minimum outdoor-air setting.
  - 7. Comb coil fins for parallel orientation.
  - 8. Verify that proper thermal-overload protection is installed for electric coils.
  - 9. Install new, clean filters.
  - 10. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.
- B. Starting procedures for air-handling units include the following:
  - 1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm.
  - 2. Measure and record motor electrical values for voltage and amperage.
  - 3. Manually operate dampers from fully closed to fully open position and record fan performance.

### 3.6 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.

## 3.7 CLEANING

A. After completing system installation and testing, adjusting, and balancing of air-handling unit and air-distribution systems, and after completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

### 3.8 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
  - 1. Leak Test: After installation, fill water and steam 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 motor rotation and unit operation.
  - 4. Air-handling unit and components will be considered defective if unit or components do not pass tests and inspections.
  - 5. Prepare test and inspection reports.

END OF SECTION 237313.13

### SECTION 237416.11 – PACKAGED, SMALL-CAPACITY, ROOFTOP AIR-CONDITIONING UNITS

#### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section includes packaged, small-capacity, rooftop air-conditioning units (RTUs) with the following components and accessories:
  - 1. Casings.
  - 2. Fans.
  - 3. Motors.
  - 4. Rotary heat exchangers.
  - 5. Coils.
  - 6. Refrigerant circuit components.
  - 7. Air filtration.
  - 8. Gas furnaces.
  - 9. Dampers.
  - 10. Electrical power connections.
  - 11. Controls.
  - 12. Accessories.
  - 13. Roof curbs.

### 1.2 ACTION SUBMITTALS

- A. Product Data: For each RTU.
- B. Shop Drawings:
  - 1. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 2. Include diagrams for power, signal, and control wiring.
- C. Delegated-Design Submittal: For RTU supports indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

### 1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

### 1.4 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of RTUs that fail in materials or workmanship within specified warranty period.

### PART 2 - PRODUCTS

### 2.1 DESCRIPTION

- A. AHRI Compliance:
  - 1. Comply with AHRI 210/240 for testing and rating energy efficiencies for RTUs.
  - 2. Comply with AHRI 340/360 for testing and rating energy efficiencies for RTUs.
  - 3. Comply with AHRI 270 for testing and rating sound performance for RTUs.
  - 4. Comply with AHRI 1060 for testing and rating performance for air-to-air exchanger.
- B. AMCA Compliance:
  - 1. Comply with AMCA 11 and bear the AMCA-Certified Ratings Seal for air and sound performance according to AMCA 211 and AMCA 311.
  - 2. Damper leakage tested according to AMCA 500-D.
  - 3. Operating Limits: Classify according to AMCA 99.
- C. ASHRAE Compliance:
  - 1. Comply with ASHRAE 15 for refrigeration system safety.
  - 2. Comply with ASHRAE 33 for methods of testing cooling and heating coils.
  - 3. Comply with applicable requirements in ASHRAE 62.1, Section 5 "Systems and Equipment" and Section 7 "Construction and Startup."
- D. ASHRAE/IES Compliance: Comply with applicable requirements in ASHRAE/IES 90.1, Section 6 "Heating, Ventilating, and Air-Conditioning."
- E. NFPA Compliance: Comply with NFPA 90A or NFPA 90B.
- F. UL Compliance: Comply with UL 1995.
- G. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

### 2.2 MANUFACTURERS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
  - 1. AAON, Inc.
  - 2. Carrier Corporation.

- 3. Lennox Industries Inc.
- 4. McQuay International.
- 5. Trane; American Standard Companies, Inc.
- 6. YORK International Corporation.

## 2.3 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design mounting and restraints for RTUs, including comprehensive engineering analysis.
  - 1. Design RTU supports to comply with wind and seismic performance requirements.
- B. Wind-Restraint Performance:
  - 1. Minimum 10 lb/sq. ft. multiplied by the maximum area of the mechanical component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.

### 2.4 CAPACITIES AND CHARACTERISTICS

- A. Supply-Air Fan:
  - 1. Fan Type: Belt driven, double width, forward curved, centrifugal.
  - 2. Fan Type: Double width, forward curved, centrifugal.
  - 3. Airflow: As indicated on drawings.
  - 4. External Static Pressure: As indicated on drawings.
  - 5. Fan Speed: As indicated on drawings.
  - 6. Motor Characteristics:
    - a. As indicated on drawings
- B. Rotary Heat Exchanger:
  - 1. As indicated on drawings.
- C. Supply-Air Refrigerant Coil:
  - 1. As indicated on drawings
- D. Outdoor-Air Refrigerant Coil:
  - 1. As indicated on drawings.
- E. Compressors:
  - 1. Number of Refrigerant Circuits: Two.

- F. Gas Furnace:
  - 1. Gas Control Valve: Two stage.
  - 2. Input: As indicated on drawings.
  - 3. Output: As indicated on drawings.
- G. Dampers:
  - 1. Outdoor- and Return-Air Mixing Dampers: Opposed-blade galvanized-steel dampers mechanically fastened to cadmium plated for galvanized-steel operating rod in reinforced cabinet. Connect operating rods with common linkage or gears and interconnect so dampers operate simultaneously.
  - 2. Relief-Air Damper: Gravity actuated or motorized, as required by ASHRAE/IES 90.1.
  - 3. Barometric relief dampers.
- H. Recirculating-Air Filters:
  - 1. Thickness: 2 inches.
  - 2. Filter Type: Glass fiber with minimum 80 percent arrestance, and MERV 8.
  - 3. Pleated with minimum 90 percent arrestance, and MERV 13.
- I. RTU Electrical Characteristics for Single-Point Connection:
  - 1. As indicated on drawings.
- 2.5 CASINGS
  - A. General Fabrication Requirements for Casings: Formed and reinforced double-wall insulated panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed.
  - B. Double-Wall Construction: Fill space between walls with 1-inch (25-mm) foam insulation and seal moisture tight for R-7 performance.
  - C. Exterior Casing Material: Galvanized steel with factory-painted finish, with pitched roof panels and knockouts with grommet seals for electrical and piping connections and lifting lugs.
  - D. Casing Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.
    - 1. Materials: ASTM C 1071, Type I.
    - 2. Thickness: 1 inch.
    - 3. Liner materials shall have airstream surface coated with erosion- and temperatureresistant coating or faced with a plain or coated fibrous mat or fabric.
    - 4. Liner Adhesive: Comply with ASTM C 916, Type I.
  - E. Plastic Condensate Drain Pans: Fabricated using rigid heavy plastic polymer, a minimum of 2 inches deep, and complying with ASHRAE 62.1 for design and construction of drain pans.
  - F. Condensate Drain Pans: Fabricated using G-90-coated galvanized-steel sheet 0.028 inch thick or stainless-steel sheet 0.025 inch thick, a minimum of 2 inches deep, and complying with ASHRAE 62.1 for design and construction of drain pans.

- 1. Double-Wall Construction: Fill space between walls with foam insulation and seal moisture tight.
- 2. Drain Connections: Threaded nipple.
- G. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

## 2.6 FANS

- A. Supply-Air Fans: Aluminum or painted-steel wheels, and galvanized- or painted-steel fan scrolls.
  - 1. Direct-Driven Supply-Air Fans: Motor shall be resiliently mounted in the fan inlet.
  - 2. Belt-Driven Supply-Air Fans: Motors shall be installed on an adjustable fan base resiliently mounted in the casing.
- B. Condenser-Coil Fan: Propeller, mounted on shaft of permanently lubricated motors.

### 2.7 MOTORS

- A. Comply with Section 230513 "Common Motor Requirements for HVAC Equipment" and the requirements of this Article.
- B. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
- C. Service Factor: 1.15.
- D. Efficiency: Premium efficient.

## 2.8 COILS

- A. Supply-Air Refrigerant Coil:
  - 1. Aluminum-plate fin and seamless copper tube in steel casing with equalizing-type vertical distributor.
  - 2. Polymer strip shall prevent all copper coils from contacting steel coil frame or condensate pan.
  - 3. Coil Split: Interlaced.
  - 4. Coated.
- B. Outdoor-Air Refrigerant Coil:
  - 1. Aluminum-plate fin and seamless copper tube in steel casing with equalizing-type vertical distributor.
  - 2. Polymer strip shall prevent all copper coils from contacting steel coil frame or condensate pan.

### 2.9 REFRIGERANT CIRCUIT COMPONENTS

- A. Compressor: Hermetic, scroll, mounted on vibration isolators; with internal overcurrent and high-temperature protection, internal pressure relief, and crankcase heater.
- B. Refrigeration Specialties:
  - 1. Refrigerant: R-410A.
  - 2. Expansion valve with replaceable thermostatic element.
  - 3. Refrigerant filter/dryer.
  - 4. Manual-reset high-pressure safety switch.
  - 5. Automatic-reset low-pressure safety switch.
  - 6. Minimum off-time relay.
  - 7. Automatic-reset compressor motor thermal overload.
  - 8. Brass service valves installed in compressor suction and liquid lines.

### 2.10 AIR FILTRATION

A. Minimum arrestance and MERV according to ASHRAE 52.2.

### 2.11 GAS FURNACE

- A. Description: Factory assembled, piped, and wired; complying with ANSI Z21.47/CSA 2.3 and NFPA 54.
  - 1. CSA Approval: Designed and certified by and bearing label of CSA.
- B. Burners: Stainless steel.
  - 1. Fuel: Natural gas.
  - 2. Ignition: Electronically controlled electric spark or hot-surface igniter with flame sensor.
- C. Heat-Exchanger and Drain Pan: Stainless steel.
- D. Power Vent: Integral, motorized centrifugal fan interlocked with gas valve.
- E. Gas Valve Train: Single-body, regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff.

### 2.12 DAMPERS

- A. Leakage Rate: Comply with ASHRAE/IES 90.1.
- B. Damper Motor: Modulating with adjustable minimum position.

#### 2.13 ELECTRICAL POWER CONNECTIONS

A. RTU shall have a single connection of power to unit with unit-mounted disconnect switch accessible from outside unit and control-circuit transformer with built-in overcurrent protection.

### 2.14 CONTROLS

- A. Control equipment and sequence of operation are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
- B. Interface Requirements for HVAC Instrumentation and Control System:
  - 1. Interface relay for scheduled operation.
  - 2. Interface relay to provide indication of fault at the central workstation and diagnostic code storage.
  - 3. Provide BACnet or LonWorks compatible interface for central HVAC control workstation for the following:
    - a. Adjusting set points.
    - b. Monitoring supply fan start, stop, and operation.
    - c. Inquiring data to include outdoor-air damper position, supply- and room-air temperature and humidity.
    - d. Monitoring occupied and unoccupied operations.
    - e. Monitoring constant and variable motor loads.
    - f. Monitoring variable-frequency drive operation.
    - g. Monitoring cooling load.
    - h. Monitoring economizer cycles.
    - i. Monitoring air-distribution static pressure and ventilation air volume.

#### 2.15 ACCESSORIES

- A. Duplex, 115-V, ground-fault-interrupter outlet with 15-A overcurrent protection. Include transformer if required. Outlet shall be energized even if the unit main disconnect is open.
- B. Filter differential pressure switch with sensor tubing on either side of filter. Set for final filter pressure loss.
- C. Remote potentiometer to adjust minimum economizer damper position.
- D. Safeties:
  - 1. Smoke detector.
  - 2. Condensate overflow switch.
  - 3. High and low pressure control.
  - 4. Gas furnace airflow-proving switch.

- E. Coil guards of painted, galvanized-steel wire.
- F. Door switches to disable heating or reset set point when open.
- G. Outdoor-air intake weather hood with moisture eliminator.
- H. Hinged access panels: Panels shall provide easy access through integrated quarter turn latches. Shall be on major panels of filter, control box, fan motor, and compressor.

## 2.16 ROOF CURBS

- A. Roof curbs with vibration isolators and wind or seismic restraints are specified in Section 230548 "Vibration and Seismic Controls for HVAC."
- B. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factoryinstalled wood nailer; complying with NRCA standards.
  - 1. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.
    - a. Materials: ASTM C 1071, Type I or II.
    - b. Thickness: 1-1/2 inches.
  - 2. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.
    - a. Liner Adhesive: Comply with ASTM C 916, Type I.
    - b. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
    - c. Liner materials applied in this location shall have airstream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity.
    - d. Liner Adhesive: Comply with ASTM C 916, Type I.
- C. Curb Dimensions: Height of 14 inches.

## PART 3 - EXECUTION

## 3.1 INSTALLATION

A. Roof Curb: Install on roof structure or concrete base, level and secure, according to NRCA's "NRCA Roofing Manual: Membrane Roof Systems." Install RTUs on curbs and coordinate roof penetrations and flashing with roof construction specified in Section 077200 "Roof Accessories." Secure RTUs to upper curb rail, and secure curb base to roof framing with anchor bolts.

### 3.2 CONNECTIONS

- A. Comply with duct installation requirements specified in other HVAC Sections. Drawings indicate general arrangement of ducts. The following are specific connection requirements:
  - 1. Install ducts to termination at top of roof curb.
  - 2. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
  - 3. Connect supply ducts to RTUs with flexible duct connectors specified in Section 233300 "Air Duct Accessories."
  - 4. Install return-air duct continuously through roof structure.
- B. Install condensate drain, minimum connection size, with trap and indirect connection to nearest roof drain or area drain.
- C. Where installing piping adjacent to RTUs, allow space for service and maintenance.
  - 1. Gas Piping: Comply with applicable requirements in Section 231123 "Facility Natural-Gas Piping." Connect gas piping to burner, full size of gas train inlet, and connect with union and shutoff valve with sufficient clearance for burner removal and service.
- D. Connect electrical wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- E. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- F. Install nameplate for each electrical connection indicating electrical equipment designation and circuit number feeding connection.

### 3.3 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
  - 1. After installing RTUs and after electrical circuitry has been energized, test units for compliance with requirements.
  - 2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
  - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
  - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. RTU will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

### 3.4 CLEANING AND ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.
- B. After completing system installation and testing, adjusting, and balancing RTU and airdistribution systems, clean filter housings and install new filters.

### 3.5 DEMONSTRATION

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

END OF SECTION 237416.11

## SECTION 237416.13 - PACKAGED, LARGE-CAPACITY, ROOFTOP AIR-CONDITIONING UNITS

### PART 1 - GENERAL

### 1.1 SUMMARY

- A. Section includes packaged, large-capacity, rooftop air conditioning units (RTUs) with the following components and accessories:
  - 1. Casings.
  - 2. Fans.
  - 3. Motors.
  - 4. Coils.
  - 5. Refrigerant circuit components.
  - 6. Air filtration.
  - 7. Supported bag filters.
  - 8. Gas furnaces.
  - 9. Dampers.
  - 10. Electrical power connections.
  - 11. Controls.
  - 12. Accessories
  - 13. Roof curbs.

#### 1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings:
  - 1. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 2. Include diagrams for power, signal, and control wiring.

#### 1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

#### 1.4 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of RTUs 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 Gas Furnace Heat Exchangers: Manufacturer's standard, but not less than five years from date of Substantial Completion.
- 3. Warranty Period for Solid-State Ignition Modules: Manufacturer's standard, but not less than [hree years from date of Substantial Completion.
- 4. Warranty Period for Control Boards: Manufacturer's standard, but not less than three years from date of Substantial Completion.

### PART 2 - PRODUCTS

### 2.1 SYSTEM DESCRIPTION

- A. AHRI Compliance:
  - 1. Comply with AHRI 340/360 for testing and rating energy efficiencies for RTUs.
  - 2. Comply with AHRI 270 for testing and rating sound performance for RTUs.
  - 3. Comply with AHRI 1060 for testing and rating performance for air-to-air exchanger.
  - 4. Comply with AHRI 210/240 for testing and rating energy efficiencies for RTUs.
- B. AMCA Compliance:
  - 1. Comply with AMCA 11 and bear the AMCA-Certified Ratings Seal for air and sound performance according to AMCA 211 and AMCA 311.
  - 2. Damper leakage tested in accordance with AMCA 500-D.
  - 3. Operating Limits: Classify according to AMCA 99.
- C. ASHRAE Compliance:
  - 1. Comply with ASHRAE 15 for refrigeration system safety.
  - 2. Comply with ASHRAE 33 for methods of testing cooling and heating coils.
  - 3. Comply with applicable requirements in ASHRAE 62.1, Section 5 "Systems and Equipment" and Section 7 "Construction and Startup."
- D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 "Heating, Ventilating, and Air-Conditioning."
- E. NFPA Compliance: Comply with NFPA 90A or NFPA 90B.
- F. UL Compliance: Comply with UL 1995.
- G. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

### 2.2 MANUFACTURERS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
  - 1. AAON, Inc.
  - 2. Carrier Corporation.
  - 3. Lennox Industries Inc.
  - 4. McQuay International.
  - 5. Trane; American Standard Companies, Inc.
  - 6. YORK International Corporation.

## 2.3 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design mounting and restraints for RTUs, including comprehensive engineering analysis.
  - 1. Design RTU supports to comply with wind and seismic performance requirements.
- B. Wind-Restraint Performance:
  - 1. Minimum 10 lb/sq. ft. multiplied by the maximum area of the mechanical component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.

## 2.4 CAPACITIES AND CHARACTERISTICS

- A. Supply-Air Fan:
  - 1. Fan Type: Belt-driven, double width, forward curved, centrifugal.
  - 2. Fan Type: Double width, forward curved, centrifugal.
  - 3. Airflow: As indicated on drawings.
  - 4. External Static Pressure: As indicated on drawings.
  - 5. Fan Speed: As indicated on drawings.
  - 6. Motor Horsepower: As indicated on drawings.
- B. Relief (Exhaust)-Air Fan:
  - 1. Airflow: As indicated on drawings.
  - 2. External Static Pressure: As indicated on drawings.
  - 3. Fan Speed: As indicated on drawings.
  - 4. Motor Horsepower: As indicated on drawings.
  - 5. Motor Speed: As indicated on drawings.
- C. Outdoor-Air-Intake Relief-Air Fan:
  - 1. Airflow: As indicated on drawings.

- 2. Static Pressure: As indicated on drawings.
- 3. Fan Speed: As indicated on drawings.
- 4. Motor Horsepower: As indicated on drawings.
- 5. Motor Speed: As indicated on drawings.
- D. Motors:
  - 1. Service Factor: 1.15.
  - 2. Efficiency: Premium efficient.
- E. Supply-Air Refrigerant Coil:
  - 1. As indicated on drawings.
- F. Outdoor-Air Refrigerant Coil:
  - 1. As indicated on drawings.
- G. Gas Furnace:
  - 1. Input: As indicated on drawings.
  - 2. Output: As indicated on drawings.
- H. Recirculating-Air Filters:
  - 1. Thickness: 2 inches.
  - 2. Filter Type: Glass fiber with minimum 80 percent arrestance, and MERV 8.
  - 3. Pleated with minimum 90 percent arrestance, and MERV 13.
- I. Electrical Characteristics for Single-Point Connection:
  - 1. As indicated on drawings

## 2.5 CASINGS

- A. General Fabrication Requirements for Casings: Formed and reinforced double-wall insulated panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed.
- B. Double-Wall Construction: Fill space between walls with 1 inch (25 mm) foam insulation and seal moisture tight for R-7 performance.
- C. Exterior Casing Material: Galvanized steel with factory-painted finish, with pitched roof panels and knockouts with grommet seals for electrical and piping connections and lifting lugs.
- D. Casing Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.
  - 1. Materials: ASTM C 1071, Type I.
  - 2. Thickness: 1 inch.

- 3. Liner materials shall have air-stream surface coated with an erosion- and temperatureresistant coating or faced with a plain or coated fibrous mat or fabric.
- 4. Liner Adhesive: Comply with ASTM C 916, Type I.
- E. Plastic Condensate Drain Pans: Fabricated using rigid heavy plastic polymer complying with ASTM G21, a minimum of 2 inches deep, and complying with ASHRAE 62.1 for design and construction of drain pans.
- F. Condensate Drain Pans: Fabricated using G-90-coated galvanized 0.028 inch thick or stainless 0.025 inch thick steel sheet, a minimum of 2 inches deep, and complying with ASHRAE 62.1 for design and construction of drain pans.
  - 1. Double-Wall Construction: Fill space between walls with foam insulation and seal moisture tight.
  - 2. Drain Connections: Threaded nipple.
- G. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

### 2.6 FANS

- A. Supply-Air Fans: Aluminum or painted-steel wheels, and galvanized- or painted-steel fan scrolls.
  - 1. Direct-Driven Supply-Air Fans: Motor shall be resiliently mounted in the fan inlet.
  - 2. Belt-Driven Supply-Air Fans: Motors shall be installed on an adjustable fan base resiliently mounted in the casing.
- B. Condenser-Coil Fan: Propeller, mounted on shaft of permanently lubricated motors.
- C. Seismic Fabrication Requirements: Fabricate fan section, internal mounting frame and attachment to fans, fan housings, motors, casings, accessories, and other fan section components with reinforcement strong enough to withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC" when fan-mounted frame and RTU-mounted frame are anchored to building structure.

### 2.7 MOTORS

- A. Comply with Section 230513 "Common Motor Requirements for HVAC Equipment" and the requirements of this Article.
- B. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
- C. Service Factor: 1.15.
- D. Efficiency: Premium efficient.

### 2.8 COILS

- A. Supply-Air Refrigerant Coil:
  - 1. Aluminum-plate fin and seamless copper tube in steel casing with equalizing-type vertical distributor.
  - 2. Polymer strip shall prevent all copper coil from contacting steel coil frame or condensate pan.
  - 3. Coil Split: Interlaced.
  - 4. Condensate Drain Pan: Galvanized steel with corrosion-resistant coating or Stainless steel formed with pitch and drain connections complying with ASHRAE 62.1.
- B. Outdoor-Air Refrigerant Coil:
  - 1. Aluminum-plate fin and seamless copper tube in steel casing with equalizing-type vertical distributor.
  - 2. Polymer strip shall prevent all copper coil from contacting steel coil frame or condensate pan.

### 2.9 REFRIGERANT CIRCUIT COMPONENTS

- A. Number of Refrigerant Circuits: Two.
- B. Compressor: Hermetic, scroll, mounted on vibration isolators; with internal overcurrent and high-temperature protection, internal pressure relief, and crankcase heater.
- C. Refrigeration Specialties:
  - 1. Refrigerant: R-410A.
  - 2. Expansion valve with replaceable thermostatic element.
  - 3. Refrigerant filter/dryer.
  - 4. Manual-reset high-pressure safety switch.
  - 5. Automatic-reset low-pressure safety switch.
  - 6. Minimum off-time relay.
  - 7. Automatic-reset compressor motor thermal overload.
  - 8. Brass service valves installed in compressor suction and liquid lines.

### 2.10 AIR FILTRATION

- A. Minimum arrestance and a minimum efficiency reporting value according to ASHRAE 52.2.
- B. Flat Panel Filters:
  - 1. Description: Factory-fabricated, self-supported, flat, nonpleated, panel-type, disposable air filters with holding frames.
- C. Pleated Panel Filters:

1. Description: Factory-fabricated, self-supported, extended-surface, pleated, panel-type, disposable air filters with holding frames.

#### 2.11 GAS FURNACES

- A. Description: Factory assembled, piped, and wired; complying with ANSI Z21.47/CSA 2.3 and NFPA 54.
  - 1. CSA Approval: Designed and certified by and bearing label of CSA.
- B. Burners: Stainless steel.
  - 1. Fuel: Natural gas.
  - 2. Ignition: Electronically controlled electric spark or hot-surface igniter with flame sensor.
  - 3. High-Altitude Kit: For Project elevations more than 2000 feet (610 m) above sea level.
- C. Heat-Exchanger and Drain Pan: Stainless steel.
- D. Power Vent: Integral, motorized centrifugal fan interlocked with gas valve.
- E. Safety Controls:
  - 1. Gas Control Valve: Two stage.
  - 2. Gas Train: Single-body, regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff.

### 2.12 DAMPERS

- A. Outdoor- and Return-Air Mixing Dampers: [Opposed-blade galvanized-steel dampers mechanically fastened to cadmium plated for galvanized-steel operating rod in reinforced cabinet. Connect operating rods with common linkage or gears and interconnect so dampers operate simultaneously.
  - 1. Leakage Rate: As required by ASHRAE/IES 90.1.
  - 2. Damper Motor: Modulating with adjustable minimum position.
  - 3. Relief-Air Damper: Gravity actuated or motorized, as required by ASHRAE/IES 90.1, with bird screen and hood.
- B. Barometric relief dampers.

## 2.13 ELECTRICAL POWER CONNECTIONS

A. RTU shall have a single connection of power to unit with unit-mounted disconnect switch accessible from outside unit and control-circuit transformer with built-in overcurrent protection.

### 2.14 CONTROLS

- A. Interface Requirements for HVAC Instrumentation and Control System:
  - 1. Interface relay for scheduled operation.
  - 2. Interface relay to provide indication of fault at the central workstation and diagnostic code storage.
  - 3. Provide BACnet or LonWorks compatible interface for central HVAC control workstation for the following:
    - a. Adjusting set points.
    - b. Monitoring supply fan start, stop, and operation.
    - c. Inquiring data to include outdoor-air damper position, supply- and room-air temperature and humidity.
    - d. Monitoring occupied and unoccupied operations.
    - e. Monitoring constant and variable motor loads.
    - f. Monitoring variable-frequency drive operation.
    - g. Monitoring cooling load.
    - h. Monitoring economizer cycles.
    - i. Monitoring air-distribution static pressure and ventilation air volume.

### 2.15 ACCESSORIES

- A. Duplex, 115-V, ground-fault-interrupter outlet with 15-A overcurrent protection. Include transformer if required. Outlet shall be energized even if the unit main disconnect is open.
- B. Filter differential pressure switch with sensor tubing on either side of filter. Set for final filter pressure loss.
- C. Remote potentiometer to adjust minimum economizer damper position.
- D. Return-air bypass damper.
- E. Factory- or field-installed demand-controlled ventilation.
- F. Safeties:
  - 1. Smoke detector.
  - 2. Condensate overflow switch.
  - 3. High and low pressure control.
  - 4. Gas furnace airflow-proving switch.
- G. Coil guards of painted, galvanized-steel wire.
- H. Hail guards of galvanized steel, painted to match casing.
- I. Concentric diffuser with white louvers and polished aluminum return grilles, insulated diffuser box with mounting flanges, and interior transition.

- J. Vertical vent extensions to increase the separation between the outdoor-air intake and the flue-gas outlet.
- K. Door switches to disable heating or reset set point when open.
- L. Outdoor air intake weather hood with moisture eliminator.
- M. Hinged access panels: Panels shall provide easy access through integrated quarter turn latches. Shall be on major panels of filter, control box, fan motor, and compressor.

### 2.16 ROOF CURBS

- A. Roof curbs with vibration isolators and wind or seismic restraints are specified in Section 230548 "Vibration and Seismic Controls for HVAC."
- B. Wind and Seismic Restraints: Metal brackets compatible with the curb and casing, painted to match RTU, used to anchor unit to the curb, and designed for loads at Project site. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for wind-load requirements.
- C. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factoryinstalled wood nailer; complying with NRCA standards.
  - 1. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.
    - a. Materials: ASTM C 1071, Type I or II.
    - b. Thickness: 1-1/2 inches.
  - 2. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.
    - a. Liner Adhesive: Comply with ASTM C 916, Type I.
    - b. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
    - c. Liner materials applied in this location shall have air-stream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity.
    - d. Liner Adhesive: Comply with ASTM C 916, Type I.
- D. Curb Dimensions: Height of 14 inches.

### PART 3 - EXECUTION

## 3.1 INSTALLATION

- A. Roof Curb: Install on roof structure, level and secure, according to NRCA's "NRCA Roofing Manual: Membrane Roof Systems." Install RTUs on curbs and coordinate roof penetrations and flashing with roof construction specified in Section 077200 "Roof Accessories." Secure RTUs to upper curb rail, and secure curb base to roof framing.
- B. Equipment Mounting:
  - 1. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
  - 2. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

### 3.2 CONNECTIONS

- A. Install condensate drain, minimum connection size, with trap and indirect connection to nearest roof drain or area drain.
- B. Install piping adjacent to RTUs to allow service and maintenance.
  - 1. Gas Piping: Comply with applicable requirements in Section 231123 "Facility Natural-Gas Piping." Connect gas piping to burner, full size of gas train inlet, and connect with union and shutoff valve with sufficient clearance for burner removal and service.
- C. Duct installation requirements are specified in other HVAC Sections. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:
  - 1. Install ducts to termination at top of roof curb.
  - 2. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
  - 3. Connect supply ducts to RTUs with flexible duct connectors specified in Section 233300 "Air Duct Accessories."
  - 4. Install return-air duct continuously through roof structure.
- D. Connect electrical wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- E. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- F. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

### 3.3 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Perform the following tests and inspections:
  - 1. After installing RTUs and after electrical circuitry has been energized, test units for compliance with requirements.
  - 2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
  - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
  - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. RTU will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

### 3.4 DEMONSTRATION

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

## END OF SECTION 237416.13

### SECTION 237423.13 - PACKAGED, DIRECT-FIRED, OUTDOOR, HEATING-ONLY MAKEUP-AIR UNITS

#### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section includes outdoor, direct, gas-fired heating-only, makeup air units, including the following components:
  - 1. Casings.
  - 2. Outdoor-air intake hood.
  - 3. Roof curbs.
  - 4. Fans, drives, and motors.
  - 5. Air filtration.
  - 6. Dampers.
  - 7. Direct, gas-fired burners.
  - 8. Unit control panel.
  - 9. Controls.
  - 10. Accessories.

#### 1.2 ACTION SUBMITTALS

- A. Product Data: For each outdoor, direct, gas-fired heating-only, makeup air unit.
- B. Shop Drawings: For each outdoor, direct, gas-fired, heating-only, makeup air unit.
  - 1. Include plans, elevations, sections, and mounting details.
  - 2. Include details of equipment 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.

## 1.3 INFORMATIONAL SUBMITTALS

- A. Sample Warranty: For manufacturer's warranty.
- B. Startup service reports.
- C. Field quality-control reports.

### 1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For direct, gas-fired, heating-only, makeup air units to include in emergency, operation, and maintenance manuals.

### 1.5 WARRANTY

- A. Warranty: Manufacturer agrees to repair or replace components of direct-fired heating and ventilating units that fail in materials or workmanship within specified warranty period.
  - 1. Warranty Period for Entire Unit: Manufacturer's standard, but not less than one year(s) from date of Substantial Completion.
  - 2. Warranty Period for Burners: Manufacturer's standard, but not less than five 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 an NRTL, and marked for intended location and application.
- B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of units and components.

### 2.2 CAPACITIES AND CHARACTERISTICS

A. As indicated on the drawings:

### 2.3 MANUFACTURERS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
  - 1. AbsolutAire, Inc.
  - 2. CaptiveAire Systems.
  - 3. Greenheck Fan Corporation.
  - 4. Modine Manufacturing Company.
  - 5. Rapid Engineering, Inc.
  - 6. Reznor/Thomas & Betts Corporation.

### 2.4 UNIT CASINGS

- A. General Fabrication Requirements for Casings:
  - 1. Forming: Form walls, roofs, and floors with at least two breaks at each joint.
  - 2. Casing Joints: Sheet metal screws or pop rivets, factory sealed with water-resistant sealant.
  - 3. Makeup Air Unit Mounting Frame: Formed galvanized-steel channel or structural channel supports, designed for low deflection, welded with integral lifting lugs.

- B. Configuration: Horizontal unit with bottom discharge for roof-mounting installation.
- C. Double-Wall Construction:
  - 1. Outside Casing Wall: Galvanized steel, minimum 18 gauge thick, with manufacturer's standard finish.
  - 2. Inside Casing Wall:
    - a. Inside Casing, Burner Section: Galvanized steel, solid, minimum 14-gauge- thick steel.
  - 3. Casing Insulation:
    - a. Materials: Glass-fiber blanket or board insulation, Type I or Type II ASTM C1071.
    - b. Insulation Thickness: 1 inch.
    - c. Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roof of unit.
  - 4. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.
- D. Panels and Doors:
  - 1. Panels:
    - a. Fabrication: Formed and reinforced, with same materials and insulation thickness as casing.
    - b. Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against airflow.
    - c. Gasket: Neoprene, applied around entire perimeters of panel frames.
    - d. Size: Large enough to allow unobstructed access for inspection and maintenance of unit's internal components.
  - 2. Doors:
    - a. Fabrication: Formed and reinforced with same materials and insulation thickness as casing.
    - b. 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 airflow. Provide safety latch retainers on doors so that doors do not open uncontrollably.
    - c. Gasket: Neoprene, applied around entire perimeters of panel frames.
    - d. Size: Large enough to allow unobstructed access for inspection and maintenance of unit's internal components.
  - 3. Locations and Applications:
    - a. Fan Section: Inspection and access panels.
    - b. Access Section: Doors.
    - c. Gas-Fired Burner Section: Inspection and access panels.

- d. Damper Section: Inspection and access panels.
- e. Filter Section: Inspection and access panels large enough to allow periodic removal and installation of filters.
- f. Mixing Section: Doors.

### 2.5 OUTDOOR-AIR INTAKE HOOD

- A. Type: Manufacturer's standard hood or louver.
- B. Materials: Match cabinet.
- C. Bird Screen: Comply with requirements in ASHRAE 62.1.
- D. Filter: Aluminum, 1 inch cleanable.
- E. Configuration: Designed to inhibit wind-driven rain and snow from entering unit.

### 2.6 ROOF CURBS

- A. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factoryinstalled wood nailer; complying with NRCA standards.
  - 1. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.
    - a. Materials: ASTM C1071, Type I or Type II.
    - b. Thickness: 1-1/2 inches.
  - 2. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.
    - a. Liner Adhesive: Comply with ASTM C916, Type I.
    - b. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
    - c. Liner materials applied in this location shall have air-stream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity.
    - d. Liner Adhesive: Comply with ASTM C916, Type I.
- B. Curb Height: 14 inches.
- C. Wind and Seismic Restraints: Metal brackets compatible with the curb and casing, painted to match unit, used to anchor unit to the curb, and designed for loads at Project site. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for wind-load requirements.

### 2.7 FANS, DRIVES, AND MOTORS

- A. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.
- B. Fans: Centrifugal, rated according to AMCA 210; galvanized steel; mounted on solid-steel shaft.
  - 1. Shafts: With field-adjustable alignment.
  - 2. Shaft Bearings: Heavy-duty, self-aligning, permanently lubricated ball bearings, or pillow-block bearings with an L50 rated life of 100,000> hours according to ABMA 9.
  - 3. Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.
  - 4. Shaft Lubrication Lines: Extended to a location outside the casing.
  - 5. Flexible Connector: Factory fabricated with a fabric strip minimum 3-1/2 inches wide, attached to two strips of minimum 2-3/4-inch- wide by 0.028-inch- thick, galvanized-steel sheet.
    - a. Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives shall comply with UL 181, Class 1.
- C. Drives: Factory-mounted V-belt drive, with adjustable alignment and belt tensioning, and with 1.5 service factor based on fan motor.
  - 1. Pulleys: Cast iron or cast steel with split, tapered bushing, dynamically balanced at the factory.
  - 2. Belts: Oil resistant, non-sparking and nonstatic; in matched sets for multiple-belt drives.
- D. Motors:
  - 1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
  - 2. Enclosure: Open, dripproof.

### 2.8 AIR FILTRATION

- A. Particulate air filtration is specified in Section 234100 "Particulate Air Filtration."
- B. Panel Filters:
  - 1. Description: Pleated factory-fabricated, self-supported, disposable air filters with holding frames.
- C. Cleanable Filters:
  - 1. Cleanable metal mesh.

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## 2.9 DAMPERS

- A. Outdoor- and Return-Air Dampers: Low-leakage, double-skin, airfoil-blade, galvanized-steel dampers with compressible jamb seals and extruded-vinyl blade edge seals in opposed or parallel-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. (20 L/s per sq. m) at 1-inch wg (250 Pa) and 8 cfm/sq. ft. (40 L/s per sq. m) at 4-inch wg (1.0 MPa) rated in accordance with AMCA 500D.
- B. Electronic Damper Operators:
  - 1. Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
  - 2. Electronic damper position indicator shall have visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.
  - 3. Operator Motors:
    - a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
    - b. Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
    - c. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
  - 4. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running torque of 150 in. x lbf (16.9 N x m) and breakaway torque of 300 in. x lbf (33.9 N x m).
  - 5. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running and breakaway torque of 150 in. x lbf (16.9 N x m).
  - 6. Size dampers for running torque calculated as follows:
    - a. Parallel-Blade Damper with Edge Seals: 7 inch-lb/sq. ft. (86.8 kg-cm/sq. m) of damper.
    - b. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. (62 kg-cm/sq. m) of damper.
    - c. Parallel-Blade Damper without Edge Seals: 4 inch-lb/sq. ft (49.6 kg-cm/sq. m) of damper.
    - d. Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. (37.2 kg-cm/sq. m) of damper.
    - e. Dampers with 2- to 3-Inch wg (500 to 750 Pa) of Pressure Drop or Face Velocities of 1000 to 2500 fpm (5 to 13 m/s): Increase running torque by 1.5.
    - f. Dampers with 3- to 4-Inch wg (750 to 1000 Pa) of Pressure Drop or Face Velocities of 2500 to 3000 fpm (13 to 15 m/s): Increase running torque by 2.0.
  - 7. Coupling: V-bolt and V-shaped, toothed cradle.
  - 8. Overload Protection: Electronic overload or digital rotation-sensing circuitry.

- 9. Fail-Safe Operation: Mechanical, spring-return mechanism with external, manual gear release on nonspring-return actuators.
- 2.10 DIRECT-FIRED GAS BURNER
  - A. Description: Factory assembled, piped, and wired; and complying with ANSI Z21.47 and with NFPA 54.
  - B. CSA Approval: Designed and certified by and bearing label of CSA.
  - C. Burners: Aluminized steel with stainless-steel inserts or Stainless steel.
    - 1. Rated Minimum Turndown Ratio: 30 to 1.
    - 2. Fuel: Natural gas.
    - 3. Ignition: Electronically controlled electric spark with flame sensor.
    - 4. Gas Control Valve: Modulating.
    - 5. Gas Train: Regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, electronic-modulating temperature control valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.
  - D. Safety Controls:
    - 1. Vent Flow Verification: Differential pressure switch to verify open vent and Flame rollout switch.
    - 2. High Limit: Thermal switch or fuse to stop burner.
    - 3. Purge-period timer shall automatically delay burner ignition and bypass low-limit control.
    - 4. Airflow Proving Switch: Differential pressure switch senses correct airflow before energizing pilot.
    - 5. Automatic-Reset, High-Limit Control Device: Stops burner and closes main gas valve if high-limit temperature is exceeded.
    - 6. Safety Lockout Switch: Locks out ignition sequence if burner fails to light after three tries. Controls are reset manually by turning the unit off and on.
    - 7. Control Transformer: 24 V ac.

### 2.11 UNIT CONTROL PANEL

A. Factory-wired, fuse-protected control transformer, connection for power supply and fieldwired unit to remote control panel.

### 2.12 CONTROLS

A. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC" for control equipment and sequence of operation.

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- B. Fan Control, Interlocked: Fan to start with exhaust fan(s) to which this heating and ventilating unit is associated for makeup air.
- C. Outdoor-Air Damper Control, 100 Percent Outdoor-Air Units: Outdoor-air damper shall open when supply fan starts, and close when fan stops.
- D. Temperature Control:
  - 1. Operates gas valve to maintain discharge-air temperature with factory-mounted sensor in blower outlet.
  - 2. Burner Control, Stepped: Two or four steps of control using one or two burner sections in series.
  - 3. Burner Control, Modulating: 20 to 100 percent modulation of the firing rate. 10 to 100 percent with dual burner units.
  - 4. Hardwired Points:
    - a. Room temperature.
    - b. Discharge-air temperature.
    - c. Burner operating.

## 2.13 ACCESSORIES

- A. Duplex, 115-V, ground-fault-interrupter outlet with 15-A overcurrent protection. Include transformer if required. Outlet shall be energized even if the unit main disconnect is open.
- B. Filter differential pressure switch with sensor tubing on either side of filter. Set for final filter pressure loss.

## 2.14 MATERIALS

- A. Steel:
  - 1. ASTM A36/A36M for carbon structural steel.
  - 2. ASTM A568/A568M for steel sheet.
- B. Stainless Steel:
  - 1. Manufacturer's standard grade for casing.
  - 2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.
- C. Galvanized Steel: ASTM A653/A653M.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Examine roughing-in for piping, ducts, and electrical systems to verify actual locations of piping and electrical connections before equipment installation.
- B. Unit Support: Install unit level on structural curbs. Coordinate roof penetrations and flashing with roof construction. Secure units to structural support with anchor bolts. Coordinate sizes and locations of curbs with actual equipment provided.
- C. Install gas-fired units according to NFPA 54, "National Fuel Gas Code."
- D. Install controls and equipment shipped by manufacturer for field installation with direct-fired heating and ventilating units.

#### 3.2 PIPING CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
  - 1. Gas Piping: Comply with requirements in Section 231123 "Facility Natural-Gas Piping." Connect gas piping with shutoff valve and union, and with sufficient clearance for burner removal and service. Make final connections of gas piping to unit with corrugated, stainless-steel tubing flexible connectors complying with ANSI LC 1/CSA 6.26 equipment connections.
- B. Drain: Comply with requirements in Section 221316 "Sanitary Waste and Vent Piping" for traps and accessories on piping connections to condensate drain pans under condensing heat exchangers.
- C. Where installing piping adjacent to heating and ventilating units, allow space for service and maintenance.

### 3.3 DUCT CONNECTIONS

A. Duct Connections: Connect supply ducts to direct-fired heating and ventilating units with flexible duct connectors. Comply with requirements in Section 233300 "Air Duct Accessories" for flexible duct connectors.

### 3.4 ELECTRICAL CONNECTIONS

- A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
  - 1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
- 3.5 CONTROL CONNECTIONS
  - A. Install control and electrical power wiring to field-mounted control devices.
  - B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- 3.6 FIELD QUALITY CONTROL
  - A. Perform tests and inspections.
  - B. Units will be considered defective if they do not pass tests and inspections.
  - C. Prepare test and inspection reports.

#### END OF SECTION 237423.13

### SECTION 238126 - SPLIT-SYSTEM AIR-CONDITIONERS

#### PART 1 - GENERAL

#### 1.1 SUMMARY

A. Section includes split-system air-conditioning and heat-pump units consisting of separate evaporator-fan and compressor-condenser components.

## 1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
  - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

#### 1.3 INFORMATIONAL SUBMITTALS

- A. Warranty: Sample of special warranty.
- 1.4 CLOSEOUT SUBMITTALS
  - A. Operation and maintenance data.

#### 1.5 QUALITY ASSURANCE

- 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. ASHRAE Compliance:
  - 1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
  - ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - " Procedures," and Section 7 -"Construction and System Start-up."
- C. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.

#### 1.6 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.
  - 1. Warranty Period:
    - a. For Compressor: Five year(s) from date of Substantial Completion.
    - b. For Parts: One year(s) from date of Substantial Completion.
    - c. For Labor: One year(s) from date of Substantial Completion.

## PART 2 - PRODUCTS

## 2.1 MANUFACTURERS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
  - 1. Carrier Corporation; Home Comfort and HVAC Building & Industrial Systems.
  - 2. Mitsubishi Electric & Electronics USA, Inc.; HVAC Advanced Products Division.
  - 3. Mitsubishi Electric Sales Canada Inc.
  - 4. Mitsubishi Heavy Industries America, Inc.
  - 5. SANYO North America Corporation; SANYO Fisher Company.

## 2.2 INDOOR UNITS (5 TONS OR LESS)

- A. Wall-Mounted, Evaporator-Fan Components:
  - 1. Cabinet: Enameled steel with removable panels on front and ends in color selected by Architect, and discharge drain pans with drain connection.
  - 2. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermalexpansion valve. Comply with ARI 206/110.
  - 3. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements; with refractory ceramic support bushings, automatic-reset thermal cutout, built-in magnetic contactors, manual-reset thermal cutout, airflow proving device, and one-time fuses in terminal box for overcurrent protection.
  - 4. Fan: Direct drive, centrifugal.
  - 5. Fan Motors:
    - a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
    - b. Multitapped, multispeed with internal thermal protection and permanent lubrication.
    - c. Enclosure Type: Totally enclosed, fan cooled.

- d. NEMA Premium (TM) efficient motors as defined in NEMA MG 1.
- e. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
- f. Mount unit-mounted disconnect switches on interior of unit.
- 6. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- 7. Condensate Drain Pans:
  - a. Fabricated with one percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and humidifiers, and to direct water toward drain connection.
    - 1) Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1.
    - 2) Depth: A minimum of 1 inch deep.
  - b. Single-wall, galvanized-steel sheet.
  - c. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.
    - 1) Minimum Connection Size: NPS 1.
  - d. Pan-Top Surface Coating: Asphaltic waterproofing compound.
- 8. Air Filtration Section:
  - a. General Requirements for Air Filtration Section:
    - 1) Comply with NFPA 90A.
    - 2) Minimum MERV according to ASHRAE 52.2.
    - Filter-Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lifted out from access plenum.
  - b. Disposable Panel Filters:
    - 1) Factory-fabricated, viscous-coated, flat-panel type.
    - 2) Thickness: 1 inch.
    - 3) MERV according to ASHRAE 52.2: 5.
    - 4) Media: Interlaced glass fibers sprayed with nonflammable adhesive and antimicrobial agent.
    - 5) Frame: Galvanized steel, with metal grid on outlet side, steel rod grid on inlet side, and hinged; with pull and retaining handles.

#### 2.3 OUTDOOR UNITS (5 TONS OR LESS)

A. Air-Cooled, Compressor-Condenser Components:

- 1. Casing: Steel, finished with baked enamel in color selected by Architect, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
- 2. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation device. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
  - a. Compressor Type: Scroll.
  - b. Two-speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.
  - c. Refrigerant: R-410A.
  - d. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and liquid subcooler. Comply with ARI 206/110.
- 3. Heat-Pump Components: Reversing valve and low-temperature-air cutoff thermostat.
- 4. Fan: Aluminum-propeller type, directly connected to motor.
- 5. Motor: Permanently lubricated, with integral thermal-overload protection.
- 6. Low Ambient Kit: Permits operation down to 45 deg F.
- 7. Mounting Base: Polyethylene.

## 2.4 ACCESSORIES

- A. Thermostat: Wireless infrared functioning to remotely control compressor and evaporator fan, with the following features:
  - 1. Compressor time delay.
  - 2. 24-hour time control of system stop and start.
  - 3. Liquid-crystal display indicating temperature, set-point temperature, time setting, operating mode, and fan speed.
  - 4. Fan-speed selection including auto setting.
- B. Automatic-reset timer to prevent rapid cycling of compressor.
- C. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.
- D. Drain Hose: For condensate.
- E. Monitoring:
  - 1. Monitor constant and variable motor loads.
  - 2. Monitor variable-frequency-drive operation.
  - 3. Monitor economizer cycle.
  - 4. Monitor cooling load.
  - 5. Monitor air distribution static pressure and ventilation air volumes.

## 2.5 CAPACITIES AND CHARACTERISTICS

- A. Cooling Capacity:
  - 1. As indicated on drawings.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Install units level and plumb.
- B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.
- C. Install roof-mounted, compressor-condenser components on equipment supports specified in Section 077200 "Roof Accessories." Anchor units to supports with removable, cadmium-plated fasteners.
- D. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

#### 3.2 CONNECTIONS

A. Where piping is installed adjacent to unit, allow space for service and maintenance of unit.

#### 3.3 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
  - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- B. Tests and Inspections:
  - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
  - 2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
  - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Remove and replace malfunctioning units and retest as specified above.
- D. Prepare test and inspection reports.

## 3.4 DEMONSTRATION

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

END OF SECTION 238126

## SECTION 238223 - UNIT VENTILATORS

#### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section includes unit ventilators and accessories with the following heating and cooling features:
  - 1. Hydronic heating coil.
  - 2. Hydronic cooling coil.
- B. Related Requirements:

## 1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product
- B. Shop Drawings:
  - 1. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 2. Include diagrams for power, signal, and control wiring.
- C. Samples for Initial Selection: For units with factory-applied color finishes.

## 1.3 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.
- B. Sample warranty.

#### 1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.
- 1.5 QUALITY ASSURANCE
  - A. Comply with NFPA 70.

#### 1.6 COORDINATION

- A. Coordinate layout and installation of unit ventilators and suspension system components with other construction that penetrates or is supported by ceilings, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.
- B. Coordinate size and location of wall sleeves for outdoor-air intake.

#### 1.7 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of condensing units that fail in materials or workmanship within specified warranty period.
  - 1. Failures include, but are not limited to, the following:
    - a. Compressor failure.
    - b. Condenser coil leak.
  - 2. Warranty Period: Five years from date of Substantial Completion.

#### PART 2 - PRODUCTS

#### 2.1 SYSTEM DESCRIPTION

- 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. Factory-packaged and -tested units rated according to AHRI 840, ASHRAE 33, and UL 1995.

#### 2.2 MANUFACTURERS

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

## 2.3 MANUFACTURED UNITS

- A. Description: Unit ventilators consisting of finished cabinet, filter, cooling coil, drain pan, supply-air fan and motor in blow- or [draw-through configuration, and hydronic cooling coil.
  - 1. Unit Ventilator Coil Configurations: Row split.
    - a. Number of Heating Coils: One with two-pipe system.
    - b. Number of Cooling Coils: One with two-pipe system.

#### 2.4 CABINETS

- A. Insulation: Minimum 1/2-inch- thick, bonded glass fiber complying with ASTM C1071 and attached with adhesive complying with ASTM C916.
  - 1. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E84 by a qualified testing agency.
- B. Coil Section Insulation: Insulate coil section according to Section 230616 "HVAC Equipment Insulation."
  - 1. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E84 by a qualified testing agency.
- C. Main and Auxiliary Drain Pans: non-corrosive, formed as required by ASHRAE 62.1.
- D. Cabinet Frame and Access Panels: Welded-steel frame with removable panels fastened with hex-head tamperproof fasteners and key-operated control and valve access doors.
  - 1. Steel components exposed to moisture shall be powder-coat finished.
- E. Cabinet Finish: Powder coat, in manufacturer's standard color as selected by Architect.
- F. Indoor-Supply-Air Grille: Aluminum, double deflection, adjustable.
- G. Return-Air Inlet: As indicated on the drawings.
- H. End Panels: Matching material and finish of unit ventilator.
- I. Outdoor-Air Wall Box: Minimum 0.1265-inch- thick, aluminum, rain-resistant louver and box with integral eliminators and bird screen.
  - 1. Louver Configuration: Horizontal, rain-resistant louver.
  - 2. Louver Material: Aluminum.
  - 3. Bird Screen: 1/2-inch mesh screen on interior side of louver.
  - 4. Decorative Grille: On outside of intake.
  - 5. Finish: Anodized aluminum, color as selected by Architect from manufacturer's standard colors.

## 2.5 COILS

- A. Test and rate unit ventilator coils according to ASHRAE 33.
- B. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain valve.

#### 2.6 INDOOR FAN

- A. Fan and Motor Board: Removable.
  - 1. Fan: Forward curved, double width, centrifugal; directly connected to motor. Thermoplastic or painted-steel wheels, and aluminum, painted-steel, or galvanized-steel fan scrolls.
  - 2. Fan Shaft and Bearings: Hollow-steel shaft with permanently lubricated, resiliently mounted bearings.
  - Motor: Permanently lubricated, multispeed, resiliently mounted on motor board. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."
  - 4. Wiring Termination: Connect motor to chassis wiring with plug connection.

### 2.7 DAMPERS

- A. Mixing Dampers: Galvanized-steel blades with edge and end seals and nylon bearings; with electric actuator.
- B. Outdoor-Air Dampers: Galvanized-steel blades with edge and end seals and nylon bearings; with electric actuator.

#### 2.8 ACCESSORIES

- A. Subbase: Sheet metal floor-mounting base with leveling screws and black enamel finish.
- B. Insulated false back with gasket seals on wall and outdoor-air plenum.
  - 1. Insulation: Minimum 1-inch- thick, coated glass fiber complying with ASTM C1071 and attached with adhesive complying with ASTM C916.
    - a. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E84 by a qualified testing agency.
- C. Return-air plenum, 6 inches thick, designed to take return air from top inlet grilles in cabinets on both sides of unit ventilator with gasket seals on wall and outdoor-air plenum extension.
- D. Duct flanges for supply-, return-, and outdoor-air connections.
- E. Filters:
  - 1. Material: Glass fiber, treated with adhesive, MERV 8.

- 2.9 FACTORY HYDRONIC PIPING PACKAGE
  - A. Piping: ASTM B88, Type L or ASTM B88, Type M copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet, and outlet. Crossover piping, NPS 1-1/2 with shutoff valves.
  - B. Control Valves: Electric actuators compatible with terminal controller and building controls.
    - 1. Two-way, modulating control valve for chilled-water coil.
    - 2. Two-way, modulating control valve for hot-water heating coil.
  - C. Hose Kits: Minimum 400-psig working pressure and operating temperatures from 33 to 211 deg F. Tag hose kits to equipment designations.
    - 1. Length: 24 inches.
    - 2. Minimum Diameter: Equal to unit ventilator connection size.
  - D. Isolation Valves, Strainers, Unions, and Balance Valves:
    - 1. Two-Piece Ball Valves: Bronze body with stainless-steel ball and stem and galvanizedsteel lever handle for each supply and return connection. If balancing device is combination shutoff type with memory stop, isolation valve may be omitted on the return.
    - 2. Calibrated-Orifice Balancing Valves: Bronze body, ball type; 125-psig working pressure, 250 deg F maximum operating temperature; with calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, threaded ends, and a memory stop to retain set position.
    - 3. Automatic Flow-Control Valve: Brass or ferrous-metal body; 300-psig working pressure at 250 deg F; with removable, corrosion-resistant, tamperproof, self-cleaning piston spring; factory set to maintain constant indicated flow with plus or minus 10 percent over differential pressure range of 2 to 80 psig.
    - 4. Y-Pattern Hydronic Strainers: Cast-iron body (ASTM A126, Class B); 125-psig working pressure; with threaded connections, bolted cover, perforated stainless-steel basket, and bottom drain connection. Include minimum NPS 1/2 hose-end, full-port, ball-type blowdown valve in drain connection.
    - 5. Wrought-Copper Unions: ASME B16.22.

#### 2.10 BASIC UNIT CONTROLS

- A. Control devices and operational sequences are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."
- B. DDC Terminal Controller:
  - 1. Safety Controls Operation: Freezestat shall stop fan and close outdoor-air damper if air less than 38 deg F enters coils.
  - 2. Scheduled Operation: Occupied and unoccupied periods on seven-day clock with a minimum of four programmable periods per day.

- 3. Unoccupied-Period-Override Operation: Two hours.
- 4. Dual-Temperature Coil Operation:
  - a. Occupied Periods: When chilled water is available, modulate control valve if room temperature exceeds thermostat set point. When hot water is available, modulate control valve if room temperature falls below thermostat set point.
  - b. Unoccupied Periods: When chilled water is available, close control valve. When hot water is available, modulate control valve if room temperature falls below thermostat setback temperature.
- 5. Hydronic Cooling-Coil Operation:
  - a. Occupied Periods: Modulate control valve to provide cooling if room temperature exceeds thermostat set point.
  - b. Unoccupied Periods: Close control valve.
- 6. Outdoor-Air Damper Operation: Open to 25> percent fixed minimum intake, and maximum 100 percent of the fan capacity to comply with ASHRAE Cycle II during occupied periods, and close during unoccupied periods. Microprocessor controller shall permit air-side economizer operation when outdoor air is less than 60 deg F.
- 7. Cooling Lockout: During economizer cycle operation, block out cooling.
- 8. Controller shall have volatile-memory backup.
- C. Electrical Connection: Factory wire motors and controls for a single electrical connection.

## 2.11 CAPACITIES AND CHARACTERISTICS

A. As indicated on the drawings

## PART 3 - EXECUTION

## 3.1 INSTALLATION

- A. Install unit ventilators to comply with NFPA 90A.
- B. Suspend horizontal unit ventilators from structure with threaded steel rods and minimum 0.25-inch (6.35-mm) static-deflection, elastomeric vibration isolation hanger or .0-inch staticdeflection spring hangers. Vibration isolators are specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

## 3.2 CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:
  - 1. Install piping adjacent to machine to allow service and maintenance.

- 2. Connect piping to unit ventilator factory hydronic piping package. Install piping package if shipped loose.
- 3. Connect condensate drain to indirect waste.
- B. Connect supply-air and return-air ducts to unit ventilators with flexible duct connectors specified in Section 233300 "Air Duct Accessories." Comply with safety requirements in UL 1995 for duct connections.
- C. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- D. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

#### 3.3 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
  - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
  - 2. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
- B. Remove and replace malfunctioning units and retest as specified above.
- C. Prepare test and inspection reports.

#### 3.4 ADJUSTING

A. Adjust initial temperature and humidity set points.

### END OF SECTION 238223

## SECTION 238239.13 - CABINET UNIT HEATERS

#### PART 1 - GENERAL

#### 1.1 SUMMARY

A. Section includes cabinet unit heaters with centrifugal fans and hot-water coils.

#### 1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
  - 1. Include rated capacities, operating characteristics, furnished specialties, and accessories.

#### 1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

#### PART 2 - PRODUCTS

#### 2.1 MANUFACTURERS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
  - 1. Carrier Corporation; a UTC company.
  - 2. McQuay International.
  - 3. Trane Inc.

#### 2.2 DESCRIPTION

- A. Factory-assembled and -tested unit complying with AHRI 440.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

## 2.3 PERFORMANCE REQUIREMENTS

A. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

- B. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 "Heating, Ventilating, and Air-Conditioning."
- 2.4 COIL SECTION INSULATION
  - A. Insulation Materials: ASTM C 1071; surfaces exposed to airstream shall have aluminum-foil facing to prevent erosion of glass fibers.
    - 1. Thickness: 1/2 inch.
    - 2. Thermal Conductivity (k-Value): 0.26 Btu x in./h x sq. ft. at 75 deg F mean temperature.
    - 3. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
    - 4. Adhesive: Comply with ASTM C 916 and with NFPA 90A or NFPA 90B.
    - 5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

#### 2.5 CABINETS

- A. Material: Steel with baked-enamel finish with manufacturer's standard paint, in color selected by Architect.
  - 1. Vertical Unit, Exposed Front Panels: Minimum 0.0528-inch- thick galvanized sheet steel, removable panels with channel-formed edges secured with tamperproof cam fasteners.
  - 2. Horizontal Unit, Exposed Bottom Panels: Minimum 0.0528-inch- thick galvanized sheet steel, removable panels secured with tamperproof cam fasteners and safety chain.
  - 3. Recessed Flanges: Steel, finished to match cabinet.
  - 4. Control Access Door: Key operated.
  - 5. Base: Minimum 0.0528-inch- thick steel, finished to match cabinet, 4 inches high with leveling bolts.
  - 6. Extended Piping Compartment: 8-inch- wide piping end pocket.
  - 7. False Back: Minimum 0.0428-inch- thick steel, finished to match cabinet.

#### 2.6 FILTERS

- A. Minimum Arrestance: According to ASHRAE 52.1 and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
  - 1. Washable Foam: 70 percent arrestance and MERV 3.
  - 2. Glass Fiber Treated with Adhesive: 80 percent arrestance and MERV 5.
  - 3. Pleated: 90 percent arrestance and MERV 7.

## 2.7 COILS

 Hot-Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain.

## 2.8 CONTROLS

- A. Fan and Motor Board: Removable.
  - 1. Fan: Forward curved, double width, centrifugal, directly connected to motor; thermoplastic or painted-steel wheels and aluminum, painted-steel, or galvanized-steel fan scrolls.
  - Motor: Permanently lubricated, multispeed; resiliently mounted on motor board. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."
  - 3. Wiring Terminations: Connect motor to chassis wiring with plug connection.
- B. Factory, Hot-Water Piping Package: ASTM B 88, Type L copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet, and outlet.
  - 1. Three-way, two-position control valve. Three-way valve packages shall include bypass line with manually adjustable balance device.
  - 2. Hose Kits: Minimum 400-psig working pressure, and operating temperatures from 33 to 211 deg F. Tag hose kits to equipment designations.
    - a. Length: 24 inches.
    - b. Minimum Diameter: Equal to cabinet unit-heater connection size.
  - 3. Two-Piece, Ball Valves: Bronze body with full-port, chrome-plated bronze ball; PTFE or TFE seats; and 600-psig minimum CWP rating and blowout-proof stem.
  - 4. Calibrated-Orifice Balancing Valves: Bronze body, ball type, 125-psig working pressure, 250 deg F maximum operating temperature; with calibrated orifice or venture, connection for portable differential pressure meter with integral seals, threaded ends, and equipped with a memory stop to retain set position.
  - 5. Automatic Flow-Control Valve: Brass or ferrous-metal body, 300-psig working pressure at 250 deg F, with removable, corrosion-resistant, tamperproof, self-cleaning piston spring; factory set to maintain constant indicated flow within plus or minus 10 percent of differential pressure range of 2 to 80 psig.
  - 6. Y-Pattern, Hot-Water Strainers: Cast-iron body (ASTM A 126, Class B); 125-psig minimum working pressure; with threaded connections, bolted cover, perforated stainless-steel basket, and bottom drain connection. Include minimum NPS 1/2 threaded pipe and full-port ball valve in strainer drain connection.
  - 7. Wrought-Copper Unions: ASME B16.22.
- C. Control devices and operational sequences are specified in Section 230900 "Instrumentation and Control for HVAC" and Section 230993 "Sequence of Operations for HVAC Controls."

- D. DDC Terminal Controller:
  - 1. Scheduled Operation: Occupied and unoccupied periods on seven-day clock with a minimum of four programmable periods per day.
  - 2. Unoccupied Period Override: Two hours.
  - 3. Unit Supply-Air Fan Operations:
    - a. Occupied Periods: Fan runs continuously.
    - b. Unoccupied Periods: Fan cycles to maintain setback room temperature.
  - 4. Heating-Coil Operations:
    - a. Occupied Periods: Open control valve to provide heating if room temperature falls below thermostat set point.
    - b. Unoccupied Periods: Start fan and open control valve if room temperature falls below setback temperature.
  - 5. Controller shall have volatile-memory backup.
- E. BAS Interface Requirements:
  - 1. Interface relay for scheduled operation.
  - 2. Interface relay to provide indication of fault at central workstation.
  - 3. Interface shall be BAC-net or LonWorks compatible for central BAS workstation and include the following functions:
    - a. Adjust set points.
    - b. Cabinet unit-heater start, stop, and operating status.
    - c. Data inquiry, including supply-air and room-air temperature.
    - d. Occupied and unoccupied schedules.
- F. Electrical Connection: Factory-wired motors and controls for a single field connection.

### 2.9 CAPACITIES AND CHARACTERISTICS

- A. Cabinet:
  - 1. Vertical, Fully Recessed: Upflow.
    - a. Air Inlet: Front, punched louver.
    - b. Air Outlet: Front, punched louver.
- B. Fan:
  - 1. As indicated on drawings.
- C. Heating Capacity:1. As indicated on drawings.
- D. Electrical Characteristics for Single-Point Connection:

1. As indicated on drawings.

#### PART 3 - EXECUTION

#### 3.1 EXAMINATION

- A. Examine areas to receive cabinet unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for piping and electrical connections to verify actual locations before unitheater installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

#### 3.2 INSTALLATION

- A. Install wall boxes in finished wall assembly; seal and weatherproof. Joint-sealant materials and applications are specified in Section 079200 "Joint Sealants."
- B. Install cabinet unit heaters to comply with NFPA 90A.
- C. Install new filters in each fan-coil unit within two weeks of Substantial Completion.

#### 3.3 CONNECTIONS

- A. Piping installation requirements are specified in Section 232113 "Hydronic Piping," Section 232116 Hydronic Piping Specialties," Section 232213 "Steam and Condensate Heating Piping," and Section 232216 Steam and Condensate Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to machine to allow service and maintenance.
- C. Connect piping to cabinet unit heater's factory, hot-water piping package. Install the piping package if shipped loose.
- D. Comply with safety requirements in UL 1995.
- E. Unless otherwise indicated, install union and gate or ball valve on supply-water connection and union and calibrated balancing valve on return-water connection of cabinet unit heater. Hydronic specialties are specified in Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties."
- F. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

- G. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- 3.4 FIELD QUALITY CONTROL
  - A. Perform the following tests and inspections:
    - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
    - 2. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
  - B. Units will be considered defective if they do not pass tests and inspections.
  - C. Prepare test and inspection reports.

END OF SECTION 238239.13

## SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section Includes:
  - 1. Copper building wire.
  - 2. Metal-clad cable, Type MC.
  - 3. Fire-alarm wire and cable.
  - 4. Connectors and splices.

#### 1.2 ACTION SUBMITTALS

- A. Product Data:
  - 1. Copper building wire.
  - 2. Metal-clad cable, Type MC.
  - 3. Fire-alarm wire and cable.
  - 4. Connectors and splices.

#### 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. Standards:
  - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
  - 2. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."
- C. Conductors: Copper, complying with ASTM B3 for bare annealed copper and with for stranded conductors.
- D. Conductor Insulation:
  - 1. Type THHN Type THWN-2. Comply with UL 83.

## 2.2 METAL-CLAD CABLE, TYPE MC

- A. Description: A factory assembly of one or more current-carrying insulated conductors in an overall metallic sheath.
- 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. Belden Inc.
  - 2. Okonite Company (The).
  - 3. Southwire Company, LLC.
- C. Standards:
  - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
  - 2. Comply with UL 1569.
  - 3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."
- D. Circuits:
  - 1. Single circuit.
- E. Conductors: Copper, complying with ASTM B3 for bare annealed copper and with ASTM B8 for stranded conductors.
- F. Ground Conductor: Insulated.
- G. Conductor Insulation:
  - 1. Type TFN/THHN/THWN-2. Comply with UL 83.
- H. Armor: Steel, interlocked.
- I. Jacket: PVC applied over armor.

# 2.3 FIRE-ALARM WIRE AND CABLE

- 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. Allied Wire & Cable Inc.

B. General Wire and Cable Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760.

## 2.4 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. Gardner Bender.
  - 3. Hubbell Utility Solutions; Hubbell Incorporated.
- 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: One Two hole with standard long barrels.
  - 3. Termination: Compression.
- PART 3 EXECUTION

## 3.1 CONDUCTOR MATERIAL APPLICATIONS

- A. Feeders:
  - 1. Copper; solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
  - Copper for feeders smaller than No. 4 AWG; copper or aluminum for feeders No. 4 AWG and larger. Conductors must be solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
- B. Branch Circuits:
  - 1. Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
  - 2. Copper. Solid for No. 12 AWG and smaller; stranded for No. 10 AWG and larger.
- C. ASD Output Circuits Cable: Extra-flexible stranded for all sizes.
- D. Power-Limited Fire Alarm and Control: Solid for No. 12 AWG and smaller.

- E. PV Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
- 3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS
  - A. Service Entrance: Type THHN/THWN-2, single conductors in raceway.
  - B. Exposed Feeders: Type THHN/THWN-2, single conductors in raceway.
  - C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN/THWN-2, single conductors in raceway Metal-clad cable, Type MC.
  - D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway.
  - E. Feeders Installed below Raised Flooring: Type THHN/THWN-2, single conductors in raceway.
  - F. Feeders in Cable Tray: Type THHN/THWN-2, single conductors in raceway.
  - G. Exposed Branch Circuits, Including in Crawlspaces: Type THHN/THWN-2, single conductors in raceway .
  - H. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway Metal-clad cable, Type MC.
  - I. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway.
  - J. Branch Circuits Installed below Raised Flooring: Type THHN/THWN-2, single conductors in raceway .
  - K. Branch Circuits in Cable Tray: Type THHN/THWN-2, single conductors in raceway Metal-clad cable, Type MC .
  - L. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless steel, wire-mesh, strain relief device at terminations to suit application.
  - M. ASD Output Circuits: Type XHHW-2 in metal conduit.
- 3.3 INSTALLATION, GENERAL
  - A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.
  - B. Complete raceway installation between conductor and cable termination points in accordance with Section 260533.13 "Conduits for Electrical Systems" prior to pulling conductors and cables.

- C. 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.
- D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
- E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
- F. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."
- G. Complete cable tray systems installation according to Section 260536 "Cable Trays for Electrical Systems" prior to installing conductors and cables.
- 3.4 INSTALLATION OF FIRE-ALARM WIRE AND CABLE
  - A. Comply with NFPA 72.
  - B. Wiring Method: Install wiring in metal pathway according to Section 270528.29 "Hangers and Supports for Communications Systems."
    - 1. Install plenum cable in environmental airspaces, including plenum ceilings.
    - 2. Fire-alarm circuits and equipment control wiring associated with fire-alarm system must be installed in a dedicated pathway system.
      - a. Cables and pathways used for fire-alarm circuits, and equipment control wiring associated with fire-alarm system, may not contain any other wire or cable.
    - 3. Fire-Rated Cables: Use of two-hour, fire-rated fire-alarm cables, NFPA 70, Types MI and CI, is not permitted.
  - C. Wiring within Enclosures: Separate power-limited and non-power-limited conductors as recommended by manufacturer. Install conductors parallel with or at right angles to sides and back of the enclosure. Bundle, lace, and train conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with fire-alarm system to terminal blocks. Mark each terminal according to system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.
  - D. Cable Taps: Use numbered terminal strips in junction, pull, and outlet boxes; cabinets; or equipment enclosures where circuit connections are made.

- E. Color-Coding: Color-code fire-alarm conductors differently from the normal building power wiring. Use one color-code for alarm circuit wiring and another for supervisory circuits. Color-code audible alarm-indicating circuits differently from alarm-initiating circuits. Use different colors for visible alarm-indicating devices. Paint fire-alarm system junction boxes and covers red.
- F. Risers: Install at least two vertical cable risers to serve the fire-alarm system. Separate risers in close proximity to each other with a minimum one-hour-rated wall, so the loss of one riser does not prevent receipt or transmission of signals from other floors or zones.
- G. Wiring to Remote Alarm Transmitting Device: 1 inch conduit between the fire-alarm control panel and the transmitter. Install number of conductors and electrical supervision for connecting wiring as needed to suit monitoring function.

## 3.5 CONNECTIONS

- A. Tighten electrical connectors and terminals according to manufacturer's published torquetightening 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.
  - 1. Use oxide inhibitor in each splice, termination, and tap for aluminum conductors.
- C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inch of slack.
- D. Comply with requirements in Section 284621.13 "Conventional Fire-Alarm Systems" for connecting, terminating, and identifying wires and cables.

#### 3.6 IDENTIFICATION

- A. Identify and color-code conductors and cables according to Section 260553 "Identification for Electrical Systems."
- B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

### 3.7 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

## 3.8 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."

### 3.9 FIELD QUALITY CONTROL

- A. Tests and Inspections:
  - 1. After installing conductors and cables and before electrical circuitry has been energized, test conductors feeding the following critical equipment and services for compliance with requirements:

a. .

- 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. Insulation-resistance test on each conductor for ground and adjacent conductors. Apply a potential of 500 V(dc) for 300 V rated cable and 1000 V(dc) for 600 V rated cable for a one-minute duration.
  - g. Continuity test on each conductor and cable.
  - h. Uniform resistance of parallel conductors.
- 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 260519

## SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

#### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section Includes:
  - 1. Grounding and bonding conductors.
  - 2. Grounding and bonding bushings.
  - 3. Grounding and bonding hubs.
  - 4. Grounding and bonding connectors.

#### 1.2 ACTION SUBMITTALS

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

### PART 2 - PRODUCTS

- 2.1 GROUNDING AND BONDING CONDUCTORS
  - A. Equipment Grounding Conductor:
    - 1. General Characteristics: 600 V, THHN/THWN-2, copper wire or cable, green color, in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

#### 2.2 GROUNDING AND BONDING BUSHINGS

- A. Description: Bonding bushings connect conduit fittings, tubing fittings, threaded metal conduit, and unthreaded metal conduit to metal boxes and equipment enclosures, and have one or more bonding screws intended to provide electrical continuity between bushing and enclosure. Grounding bushings have provision for connection of bonding or grounding conductor and may or may not also have bonding screws.
- B. Source Limitations: Obtain products from single manufacturer.
- C. Performance Criteria:
  - 1. Regulatory Requirements:

#### GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

- a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
- 2. Listing Criteria:
  - a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
- D. UL KDER Bonding Bushing :
  - 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. ABB, Electrification Business.
    - b. Crouse-Hinds; brand of Eaton, Electrical Sector.
    - c. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
  - 2. General Characteristics: Threaded bushing with insulated throat.
- E. UL KDER Grounding Bushing :
  - 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. ABB, Electrification Business.
    - b. Crouse-Hinds; brand of Eaton, Electrical Sector.
    - c. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
  - 2. General Characteristics: Threaded bushing with insulated throat and mechanical-type wire terminal.
- 2.3 GROUNDING AND BONDING HUBS
  - A. Description: Hubs with certified grounding or bonding locknut.
  - B. Source Limitations: Obtain products from single manufacturer.
  - C. Performance Criteria:
    - 1. Regulatory Requirements:
      - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

- 2. Listing Criteria:
  - a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
- D. UL KDER Grounding and Bonding Hub :
  - 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. ABB, Electrification Business.
    - b. Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
    - c. Crouse-Hinds; brand of Eaton, Electrical Sector.
  - 2. General Characteristics: Insulated, gasketed, watertight hub with mechanical-type wire terminal.
- 2.4 GROUNDING AND BONDING CONNECTORS
  - A. Source Limitations: Obtain products from single manufacturer.
  - B. Performance Criteria:
    - 1. Regulatory Requirements:
      - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
    - 2. Listing Criteria:
      - a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
      - b. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.
  - C. UL KDER Crimped Pressure-Type Grounding and Bonding Cable Connector :
    - 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. ABB, Electrification Business.
      - b. Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
      - c. ILSCO.
    - 2. General Characteristics: Crimp-and-compress connectors that bond to conductor when connector is compressed around conductor.

a. Copper, C and H shaped.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine facility's grounding electrode system and equipment grounding for compliance with requirements for maximum ground-resistance level and other conditions affecting performance of grounding and bonding of electrical system.
- B. Inspect test results of grounding system measured at point of electrical service equipment connection.
- C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
- D. Proceed with connection of electrical service equipment only after unsatisfactory conditions have been corrected.

#### 3.2 SELECTION OF GROUNDING AND BONDING CONDUCTORS

- A. Conductors: Install solid conductor for 8 AWG and smaller, and stranded conductors for 6 AWG and larger unless otherwise indicated.
- B. Custom-Length Insulated Equipment Bonding Jumpers: 6 AWG, 19-strand, Type THHN.
- C. Bonding Cable: 28 kcmil, 14 strands of 17 AWG conductor, 1/4 inch in diameter.
- D. Bonding Conductor: 4 AWG or 6 AWG, stranded conductor.
- E. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inch wide and 1/16 inch thick.
- F. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inch wide and 1/16 inch thick.
- G. Underground Grounding Conductors: Install bare copper conductor, 2/0 AWG minimum.
  - 1. Bury at least 30 inch below grade.
  - 2. Duct-Bank Grounding Conductor: Bury 12 inch above duct bank when indicated as part of duct-bank installation.

#### 3.3 SELECTION OF CONNECTORS

A. Conductor Terminations and Connections: GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

- 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
- 2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
- 3. Connections to Ground Rods at Test Wells: Bolted connectors.
- 4. Connections to Structural Steel: Welded connectors.

## 3.4 INSTALLATION

- A. Comply with manufacturer's published instructions.
- B. Reference Standards:
  - 1. Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.
  - 2. Consult Architect for resolution of conflicting requirements.
- C. Special Techniques:
  - 1. Conductors:
    - a. Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
  - 2. Connections: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact are galvanically compatible.
    - a. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
    - b. Make connections with clean, bare metal at points of contact.
    - c. Make aluminum-to-steel connections with stainless steel separators and mechanical clamps.
    - d. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
    - e. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.
    - f. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.
      - 1) Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate adjacent parts.

- 2) Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
- 3) Use exothermic-welded connectors for outdoor locations; if disconnect-type connection is required, use bolted clamp.
- g. Grounding and Bonding for Piping:
  - 1) Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use bolted clamp connector or bolt lug-type connector to pipe flange by using one of lug bolts of flange. Where dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
  - 2) Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with bolted connector.
  - 3) Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.
- h. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned bonding jumper to bond across flexible duct connections to achieve continuity.
- i. Grounding for Steel Building Structure: Install driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 ft apart.
- 3. Equipment Grounding:
  - a. Install insulated equipment grounding conductors with feeders and branch circuits.
  - b. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
    - 1) Feeders and branch circuits.
    - 2) Lighting circuits.
    - 3) Receptacle circuits.
    - 4) Single-phase motor and appliance branch circuits.
    - 5) Three-phase motor and appliance branch circuits.
    - 6) Flexible raceway runs.
    - 7) Armored and metal-clad cable runs.
    - 8) Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.

- 9) X-Ray Equipment Circuits: Install insulated equipment grounding conductor in circuits supplying x-ray equipment.
- c. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.
- d. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.
- e. Isolated Grounding Receptacle Circuits: Install insulated equipment grounding conductor connected to receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of applicable derived system or service unless otherwise indicated.
- f. Isolated Equipment Enclosure Circuits: For designated equipment supplied by branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of applicable derived system or service unless otherwise indicated.
- g. Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.
- h. Metallic Fences: Comply with requirements of IEEE C2.
  - 1) Grounding Conductor: Bare copper, not less than 8 AWG.
  - 2) Gates: Must be bonded to grounding conductor with flexible bonding jumper.
  - 3) Barbed Wire: Strands must be bonded to grounding conductor.

## 3.5 FIELD QUALITY CONTROL

- A. Tests and Inspections:
  - 1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
  - 2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with calibrated torque wrench in accordance with manufacturer's published instructions.
- B. Nonconforming Work:
  - 1. Grounding system will be considered defective if it does not pass tests and inspections.

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2. Remove and replace defective components and retest.

# 3.6 PROTECTION

A. After installation, protect grounding and bonding cables and equipment from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

## END OF SECTION 260526

## SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

## PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section Includes:
  - 1. Support, anchorage, and attachment components.

## 1.2 ACTION SUBMITTALS

- A. Product Data:
  - 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.

## PART 2 - PRODUCTS

## 2.1 PERFORMANCE REQUIREMENTS

- A. Surface-Burning Characteristics: Comply with ASTM E84; 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 D635.

## 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 inch on center in at least one surface.
- 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; Atkore International.
  - b. G-Strut.
  - c. Unistrut; Atkore International.
- 2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
- 3. Material for Channel, Fittings, and Accessories: Galvanized steel.
- 4. Channel Width: 1-5/8 inch.
- 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 must have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body must be made of malleable iron.
- D. 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.
    - 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) Hilti, Inc.
      - 2) ITW Ramset/Red Head; Illinois Tool Works, Inc.
      - 3) Simpson Strong-Tie Co., Inc.
  - 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.
    - 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) Hilti, Inc.
      - 2) ITW Ramset/Red Head; Illinois Tool Works, Inc.
      - 3) MKT Fastening, LLC.

- 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 F3125/F3125M, Grade A325.
- 6. Toggle Bolts: All steel springhead type.
- 7. Hanger Rods: Threaded steel.

## PART 3 - EXECUTION

## 3.1 SELECTION

- A. Comply with the following standards for selection and installation of hangers and supports, except where requirements on Drawings or in this Section are stricter:
  - 1. NECA NEIS 101
  - 2. NECA NEIS 102.
  - 3. NECA NEIS 105.
  - 4. NECA NEIS 111.
- 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 specified in Section 260533.13 "Conduits for Electrical Systems."
- D. Comply with requirements for boxes specified in Section 260533.16 "Boxes and Covers for Electrical Systems."
- E. Maximum Support Spacing and Minimum Hanger Rod Size for Raceways: Space supports for EMT, IMC, and ERMC as required by NFPA 70. Minimum rod size must be 1/4 inch in diameter.
- F. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
  - 1. Secure raceways and cables to these supports with two-bolt conduit clamps.
- G. 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 INSTALLATION OF SUPPORTS

A. Comply with NECA NEIS 101 for installation requirements except as specified in this article.

- B. Raceway Support Methods: In addition to methods described in NECA NEIS 1, EMT may be supported by openings through structure members, in accordance with NFPA 70.
- 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 must 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 inch thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inch thick.
  - 6. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts.
  - 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 CONCRETE BASES

- A. Construct concrete bases of dimensions indicated, but not less than 4 inch larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.
- B. Use 3000 psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Section 033000 "Cast-in-Place Concrete."
- C. Anchor equipment to concrete base as follows:
  - 1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

- 2. Install anchor bolts to elevations required for proper attachment to supported equipment.
- 3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

# 3.4 PAINTING

- A. Touchup:
  - 1. 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.
    - a. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780.

END OF SECTION 260529

## SECTION 260533.13 - CONDUITS FOR ELECTRICAL SYSTEMS

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section Includes:
  - 1. Type EMT-S duct raceways and elbows.
  - 2. Type IMC duct raceways.
  - 3. Type LFMC duct raceways.
  - 4. Fittings for conduit, tubing, and cable.
  - 5. Electrically conductive corrosion-resistant compounds for threaded conduit.
- B. Products Installed, but Not Furnished, under This Section:
  - 1. See Section 260553 "Identification for Electrical Systems" for electrical equipment labels.
- C. Related Requirements:
  - 1. Section 260519 "Low-Voltage for Electrical Power Conductors and Cables" for nonmetallic underground conduit with conductors (Type NUCC).

#### 1.2 DEFINITIONS

- A. Conduit: A structure containing one or more duct raceways.
- B. Duct Raceway: A single enclosed raceway for conductors or cable.

#### 1.3 ACTION SUBMITTALS

- A. Product Data:
  - 1. Type EMT-S duct raceways and elbows.
  - 2. Type IMC duct raceways.
  - 3. Type LFMC duct raceways.
  - 4. Fittings for conduit, tubing, and cable.
  - 5. Electrically conductive corrosion-resistant compounds for threaded conduit.

## PART 2 - PRODUCTS

## 2.1 TYPE EMT-S DUCT RACEWAYS AND ELBOWS

- A. Performance Criteria:
  - 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
  - 2. Listing Criteria: UL CCN FJMX; including UL 797.
- B. Source Quality Control:
  - 1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
  - 2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.
- C. UL FJMX Steel Electrical Metal Tubing (EMT-S) and Elbows:
  - 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; Atkore International.
    - b. Calconduit; Atkore International.
    - c. Wheatland Tube; Zekelman Industries.
  - 2. Material: Steel.
  - 3. Options:
    - a. Minimum Trade Size: Metric designator 21 (trade size 3/4).
    - b. Colors: As indicated on Drawings.

### 2.2 TYPE IMC DUCT RACEWAYS

- A. Performance Criteria:
  - 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
  - 2. Listing Criteria: UL CCN DYBY; including UL 1242.
- B. Source Quality Control:
  - 1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.

- 2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.
- C. UL DYBY Steel Intermediate Metal Conduit (IMC):
  - 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; Atkore International.
    - b. Calconduit; Atkore International.
    - c. Wheatland Tube; Zekelman Industries.
  - 2. Options:
    - a. Minimum Trade Size: Metric designator 21 (trade size 3/4).
    - b. Colors: As indicated on Drawings.

# 2.3 TYPE LFMC DUCT RACEWAYS

- A. Performance Criteria:
  - 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
  - 2. Listing Criteria: UL CCN DXHR; including UL 360.
- B. Source Quality Control:
  - 1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
  - 2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.
- C. UL DXHR Steel Liquidtight Flexible Metal Conduit (LFMC-S):
  - 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. ABB, Electrification Business.
    - b. Electri-Flex Company.
    - c. International Metal Hose Co.
  - 2. Material: Steel.
  - 3. Options:
    - a. Minimum Trade Size: Metric designator 21 (trade size 3/4).

b. Colors: As indicated on Drawings.

## 2.4 FITTINGS FOR CONDUIT, TUBING, AND CABLE

- A. Performance Criteria:
  - 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
- B. Source Quality Control:
  - 1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
  - 2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.
- C. UL DWTT Fittings for Type ERMC, Type IMC, Type PVC, Type HDPE, Type EPEC, and Type RTRC Duct Raceways:
  - 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. Crouse-Hinds; brand of Eaton, Electrical Sector.
    - b. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
    - c. Southwire Company, LLC.
  - 2. Listing Criteria: UL CCN DWTT; including UL 514B.
  - 3. Options:
    - a. Material: Steel.
    - b. Coupling Method: Compression coupling Raintight compression coupling with distinctive color gland nut Setscrew coupling. Setscrew couplings with only single screw per conduit are unacceptable.
    - c. Expansion and Deflection Fittings: UL 651 with flexible bonding jumper.
- D. UL FKAV Fittings for Type EMT Duct Raceways:
  - 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; Atkore International.
    - b. Crouse-Hinds; brand of Eaton, Electrical Sector.
    - c. Southwire Company, LLC.
  - 2. Listing Criteria: UL CCN FKAV; including UL 514B.

- 3. Options:
  - a. Material: Steel.
  - b. Coupling Method: Compression coupling Raintight compression coupling with distinctive color gland nut Setscrew coupling. Setscrew couplings with only single screw per conduit are unacceptable.
  - c. Expansion and Deflection Fittings: UL 651 with flexible bonding jumper.
- E. UL DXAS Fittings for Type LFMC and Type LFNC Duct Raceways:
  - 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. Liquid Tight Connector Co.
  - 2. Listing Criteria: UL CCN DXAS; including UL 514B.
- 2.5 ELECTRICALLY CONDUCTIVE CORROSION-RESISTANT COMPOUNDS FOR THREADED CONDUIT
  - A. Performance Criteria:
    - 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
    - 2. Listing Criteria: UL CCN FOIZ; including UL Subject 2419.
  - B. Source Quality Control:
    - 1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
    - 2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.
  - C. UL FOIZ Electrically Conductive Corrosion-Resistant Compound for Threaded 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. ABB, Electrification Business.

## PART 3 - EXECUTION

## 3.1 SELECTION OF CONDUITS FOR ELECTRICAL SYSTEMS

- A. Unless more stringent requirements are specified in Contract Documents or manufacturers' published instructions, comply with NFPA 70 for selection of duct raceways. Consult Architect for resolution of conflicting requirements.
- B. Special Instructions Regarding HDPE Conduits: Although Article 353 of NFPA 70 permits use of HDPE conduits where encased in concrete aboveground, UL CCN EAZX listing requirements state that HDPE underground conduits are intended only for use where direct buried with or without being encased in concrete. Specified Type HDPE underground conduits are not permitted to be used aboveground on Project.
- C. Outdoors:
  - 1. Exposed and Subject to Severe Physical Damage: IMC.
  - 2. Exposed and Subject to Physical Damage: IMC.
    - a. Locations less than 2.5 m (8 ft) above finished floor.
  - 3. Exposed and Not Subject to Physical Damage: IMC.
  - 4. Concealed Aboveground: IMC.
  - 5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC .
- D. Indoors:
  - 1. Exposed and Subject to Physical Damage: IMC. Locations include the following:
    - a. Locations less than 2.5 m (8 ft) above finished floor.
    - b. Stub-ups to above suspended ceilings.
  - 2. Exposed and Not Subject to Physical Damage: EMT.
  - 3. Concealed in Ceilings and Interior Walls and Partitions: EMT.
  - 4. Damp or Wet Locations: IMC.
  - 5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
- E. Duct Fittings: Select fittings in accordance with NEMA FB 2.10 guidelines.
  - 1. ERMC and IMC: Provide threaded-type fittings unless otherwise indicated.

### 3.2 INSTALLATION OF CONDUITS FOR ELECTRICAL SYSTEMS

A. Comply with manufacturer's published instructions.

- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in Contract Documents or manufacturers' published instructions, comply with the following:
  - 1. Type EMT-S: Article 358 of NFPA 70 and NECA NEIS 101.
  - 2. Type IMC: Article 342 of NFPA 70 and NECA NEIS 101.
  - 3. Type LFMC: Article 350 of NFPA 70 and NECA NEIS 101.
  - 4. Expansion Fittings: NEMA FB 2.40.
  - 5. Consult Architect for resolution of conflicting requirements.
- C. Special Installation Techniques:
  - 1. General Requirements for Installation of Duct Raceways:
    - a. Complete duct raceway installation before starting conductor installation.
    - b. Provide stub-ups through floors with coupling threaded inside for plugs, set flush with finished floor. Plug coupling until conduit is extended above floor to final destination or a minimum of 2 ft above finished floor.
    - c. Install no more than equivalent of three 90-degree bends in conduit run except for control wiring conduits, for which no more than equivalent of two 90-degree fewer bends are permitted. Support within 12 inch of changes in direction.
    - d. Make bends in duct raceway using large-radius preformed ells except for parallel bends. Field bending must be in accordance with NFPA 70 minimum radii requirements. Provide only equipment specifically designed for material and size involved.
    - e. Conceal conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
    - f. Support conduit within 12 inch of enclosures to which attached.
    - g. Install duct sealing fittings at accessible locations in accordance with NFPA 70 and fill them with listed sealing compound. For concealed duct raceways, install fitting in flush steel box with blank cover plate having finish similar to that of adjacent plates or surfaces. Install duct sealing fittings in accordance with NFPA 70.
    - h. Install devices to seal duct raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal interior of duct 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 duct raceway enters a building or structure.
      - 3) Conduit extending from interior to exterior of building.
      - 4) Conduit extending into pressurized duct raceway 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.
    - i. Do not install duct raceways or electrical items on "explosion-relief" walls or rotating equipment.
    - j. Do not install conduits within 2 inch of the bottom side of a metal deck roof.

- k. Keep duct raceways at least 6 inch away from parallel runs of flues and steam or hot-water pipes. Install horizontal duct raceway runs above water and steam piping.
- I. Cut conduit perpendicular to the length. For conduits metric designator 53 (trade size 2) and larger, use roll cutter or a guide to make cut straight and perpendicular to the length. Ream inside of conduit to remove burrs.
- m. Install pull wires in empty duct raceways. Provide polypropylene or monofilament plastic line with not less than 200 lb tensile strength. Leave at least 12 inch of slack at both ends of pull wire. Cap underground duct raceways designated as spare above grade alongside duct raceways in use.
- n. Install duct raceways square to the enclosure and terminate at enclosures without hubs with locknuts on both sides of enclosure wall. Install locknuts hand tight, plus one-quarter turn more.
  - 1) Termination fittings with shoulders do not require two locknuts.
- Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to metric designator 35 (trade size 1-1/4) and insulated throat metal bushings on metric designator 41 (trade size 1-1/2) and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.
- 2. Types ERMC and IMC:
  - a. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound that maintains electrical conductivity to threads of duct raceway and fittings before making up joints. Follow compound manufacturer's published instructions.
- 3. Types FMC, LFMC, and LFNC:
  - a. Provide a maximum of 36 inch of flexible conduit for equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
- 4. Duct Raceways Embedded in Slabs:
  - a. Run duct raceways larger than metric designator 27 (trade size 1) below concrete slab.
  - b. Arrange duct raceways to cross building expansion joints with expansion fittings at right angles to the joint.
  - c. Arrange duct raceways to ensure that each is surrounded by minimum of 1 inch of concrete without voids.
  - d. Do not embed threadless fittings in concrete unless locations have been specifically approved by Architect.
  - e. Change from ENT to PVC-40 before rising above floor.
- 5. Stub-ups to Above Recessed Ceilings:
  - a. Provide EMT, IMC, or ERMC for duct raceways.

- b. Provide a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
- 6. Duct Raceway Terminations at Locations Subject to Moisture or Vibration:
  - a. Provide insulating bushings to protect conductors, including conductors smaller than 4 AWG. Install insulated throat metal grounding bushings on service conduits.
- 7. Duct Fittings: Install fittings in accordance with NEMA FB 2.10 guidelines.
  - a. ERMC-S-PVC: Provide only fittings listed for use with this type of conduit. Patch and seal joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Provide sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
  - b. EMT: Provide compression, steel fittings. Comply with NEMA FB 2.10.
  - c. Flexible Conduit: Provide only fittings listed for use with flexible conduit type. Comply with NEMA FB 2.20.
- 8. Expansion-Joint Fittings:
  - a. Install in runs of aboveground PVC that are located where environmental temperature change may exceed 30 deg F and that have straight-run length that exceeds 25 ft. Install in runs of aboveground ERMC and EMT conduit that are located where environmental temperature change may exceed 100 deg F and that have straight-run length that exceeds 100 ft.
  - b. Install type and quantity of fittings that accommodate temperature change listed for the following locations:
    - 1) Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F temperature change.
    - 2) Attics: 135 deg F temperature change.
  - 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.
  - d. Install expansion fittings at locations where conduits cross building or structure expansion joints.
  - e. Install expansion-joint fitting with position, mounting, and piston setting selected in accordance with manufacturer's published instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.
- 9. Duct Raceways Penetrating Rooms or Walls with Acoustical Requirements: Seal duct raceway openings on both sides of rooms or walls with acoustically rated putty or firestopping.

- 10. Identification: Provide labels for conduit assemblies, duct raceways, and associated electrical equipment.
  - a. Provide warning signs.

## 3.3 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 260533.13

## SECTION 260533.16 - BOXES AND COVERS FOR ELECTRICAL SYSTEMS

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section Includes:
  - 1. Metallic outlet boxes, device boxes, rings, and covers.
  - 2. Junction boxes and pull boxes.
  - 3. Cover plates for device boxes.
  - 4. Hoods for outlet boxes.
- B. Products Installed, but Not Furnished, under This Section:
  - 1. See Section 260553 "Identification for Electrical Systems" for electrical equipment labels.

### 1.2 ACTION SUBMITTALS

- A. Product Data:
  - 1. Metallic outlet boxes, device boxes, rings, and covers.
  - 2. Junction boxes and pull boxes.
  - 3. Cover plates for device boxes.
  - 4. Hoods for outlet boxes.

#### PART 2 - PRODUCTS

- 2.1 METALLIC OUTLET BOXES, DEVICE BOXES, RINGS, AND COVERS
  - A. Performance Criteria:
    - 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
    - 2. Listing Criteria: UL CCN QCIT; including UL 514A.
  - B. UL QCIT Metallic Outlet Boxes and Covers:
    - 1. Description: Box having pryout openings, knockouts, threaded entries, or hubs in either the sides of the back, or both, for entrance of conduit, conduit or cable fittings, or cables, with provisions for mounting outlet box cover, but without provisions for mounting wiring device directly to box.

BOXES AND COVERS FOR ELECTRICAL SYSTEMS

- 2. 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. Crouse-Hinds; brand of Eaton, Electrical Sector.
  - b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
  - c. Pass & Seymour; Legrand North America, LLC.
- 3. Options:
  - a. Material: Sheet steel.
  - b. Paddle Fan Outlet Boxes and Covers: Nonadjustable, designed for attachment of paddle fan weighing up to 70 lb.
- C. UL QCIT Metallic Conduit Bodies:
  - 1. Description: Means for providing access to interior of conduit or tubing system through one or more removable covers at junction or terminal point. In the United States, conduit bodies are listed in accordance with outlet box requirements.
  - 2. 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. Crouse-Hinds; brand of Eaton, Electrical Sector.
    - b. Pass & Seymour; Legrand North America, LLC.
    - c. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
- D. UL QCIT Metallic Device Boxes:
  - 1. Description: Box with provisions for mounting wiring device directly to box.
  - 2. 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. Crouse-Hinds; brand of Eaton, Electrical Sector.
    - b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
    - c. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
  - 3. Options:
    - a. Material: Sheet steel.
- E. UL QCIT Metallic Extension Rings:
  - 1. Description: Ring intended to extend sides of outlet box or device box to increase box depth, volume, or both.

- 2. 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. Crouse-Hinds; brand of Eaton, Electrical Sector.
  - b. Pass & Seymour; Legrand North America, LLC.
  - c. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

## 2.2 JUNCTION BOXES AND PULL BOXES

- A. Performance Criteria:
  - 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
  - 2. Listing Criteria: UL CCN BGUZ; including UL 50 and UL 50E.
- B. Source Quality Control:
  - 1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
  - 2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.
- C. UL BGUZ Indoor Sheet Metal Junction and Pull Boxes:
  - 1. Description: Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
  - 2. 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. Cooper B-line; brand of Eaton, Electrical Sector.
    - b. Milbank Manufacturing Co.
    - c. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
  - 3. Options:
    - a. Degree of Protection: Type 1.
- D. UL BGUZ Outdoor Sheet Metal Junction and Pull Boxes:
  - 1. Description: Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
  - 2. 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. Cooper B-line; brand of Eaton, Electrical Sector.
- b. Hoffman; brand of nVent Electrical plc.
- c. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
- 3. Options:
  - a. Degree of Protection: Type 3R.

## 2.3 COVER PLATES FOR DEVICES BOXES

- A. Performance Criteria:
  - 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
  - 2. Listing Criteria: UL CCN QCIT or UL CCN QCMZ; including UL 514D.
  - 3. Wallplate-Securing Screws: Metal with head color to match wallplate finish.
- B. Source Quality Control:
  - 1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
  - 2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.
- C. UL QCIT or QCMZ Metallic Cover Plates for Device Boxes:
  - 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. Crouse-Hinds; brand of Eaton, Electrical Sector.
    - b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
    - c. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
  - 2. Options:
    - a. Damp and Wet Locations: Listed, labeled, and marked for location and use. Provide gaskets and accessories necessary for compliance with listing.
    - b. Wallplate Material: 0.032 inch thick, Type 302/304 non-magnetic stainless steel with brushed finish.

### 2.4 HOODS FOR OUTLET BOXES

A. Performance Criteria:

- 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
- 2. Listing Criteria:
  - a. UL CCN QCIT or UL CCN QCMZ; including UL 514D.
  - b. Receptacle, Hood, Cover Plate, Gaskets, and Seals: UL 498 Supplement SA when mated with box or enclosure complying with UL 514A, UL 514C, or UL 50E.
- 3. Mounts to box using fasteners different from wiring device.
- B. Source Quality Control:
  - 1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
  - 2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.
- C. UL QCIT or QCMZ Extra-Duty, While-in-Use Hoods for Outlet Boxes:
  - 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. Arlington Industries, Inc.
    - b. Leviton Manufacturing Co., Inc.
    - c. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
  - 2. Additional Characteristics: Marked "Extra-Duty" in accordance with UL 514D.
  - 3. Options:
    - a. Provides clear, weatherproof, "while-in-use" cover.
    - b. Manufacturer may combine nonmetallic device box with hood as extra-duty rated assembly.

PART 3 - EXECUTION

#### 3.1 SELECTION OF BOXES AND COVERS FOR ELECTRICAL SYSTEMS

- A. Unless more stringent requirements are specified in Contract Documents or manufacturers' published instructions, comply with NFPA 70 for selection of boxes and enclosures. Consult Architect for resolution of conflicting requirements.
- B. Degree of Protection:
  - 1. Outdoors:
    - a. Type 3R unless otherwise indicated.

- b. Locations Exposed to Hosedown: Type 4.
- c. Locations Subject to Potential Flooding: Type 6P.
- d. Locations Aboveground Where Mechanism Must Operate When Ice Covered: Type 3S.
- e. Locations in-Ground or Exposed to Corrosive Agents: Type 4X.
- f. Locations in-Ground or Exposed to Corrosive Agents Where Mechanism Must Operate When Ice Covered: Type 3SX.
- 2. Indoors:
  - a. Type 1 unless otherwise indicated.
  - b. Damp or Dusty Locations: Type 12.
  - c. Surface Mounted in Kitchens and Other Locations Exposed to Oil or Coolants: Type 12.
  - d. Flush Mounted in Kitchens and Other Locations Exposed to Oil or Coolants: Type 12.
  - e. Locations Exposed to Airborne Dust, Lint, Fibers, or Flyings: Type 4.
  - f. Locations Exposed to Hosedown: Type 4.
  - g. Locations Exposed to Brief Submersion: Type 6.
  - h. Locations Exposed to Prolonged Submersion: Type 6P.
  - i. Locations Exposed to Corrosive Agents: Type 4X.
  - j. Locations Exposed to Spraying Oil or Coolants: Type 13.
- C. Exposed Boxes Installed Less Than 2.5 m (8 ft) Above Floor:
  - 1. Provide cast-metal boxes.
  - 2. Provide exposed cover. Flat covers with angled mounting slots or knockouts are prohibited.

## 3.2 INSTALLATION OF BOXES AND COVERS FOR ELECTRICAL SYSTEMS

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in Contract Documents or manufacturers' published instructions, comply with the following:
  - 1. Outlet, Device, Pull, and Junction Boxes: Article 314 of NFPA 70.
  - 2. Consult Architect for resolution of conflicting requirements.
- C. Special Installation Techniques:
  - 1. Provide boxes in wiring and raceway systems wherever required for pulling of wires, making connections, and mounting of devices or fixtures.
  - 2. 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.

- 3. 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, whether installed indoors or outdoors.
- 4. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.
- 5. Locate boxes so that cover or plate will not span different building finishes.
- 6. Support boxes in recessed ceilings independent of ceiling tiles and ceiling grid.
- 7. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for purpose.
- 8. Fasten junction and pull boxes to, or support from, building structure. Do not support boxes by conduits.
- 9. Set metal floor boxes level and flush with finished floor surface.
- 10. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.
- 11. Do not install aluminum boxes, enclosures, or fittings in contact with concrete or earth.
- 12. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to ensure a continuous ground path.
- 13. Boxes and Enclosures in Areas or Walls with Acoustical Requirements:
  - a. Seal openings and knockouts in back and sides of boxes and enclosures with acoustically rated putty.
  - b. Provide gaskets for wallplates and covers.
- 14. Identification: Provide labels for boxes and associated electrical equipment.
  - a. Identify field-installed conductors, interconnecting wiring, and components.
  - b. Provide warning signs.
  - c. Label each box with engraved metal or laminated-plastic nameplate.

## 3.3 PROTECTION

A. After installation, protect boxes from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 260533.16

## SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

### 1.1 SUMMARY

- A. Section Includes:
  - 1. Labels.
  - 2. Signs.
  - 3. Cable ties.

## 1.2 ACTION SUBMITTALS

- A. Product Data:
  - 1. Labels.
  - 2. Signs.
  - 3. Cable ties.

### PART 2 - PRODUCTS

#### 2.1 PERFORMANCE REQUIREMENTS

- A. Comply with ASME A13.1 and IEEE C2.
- B. Comply with 29 CFR 1910.144 for color identification of hazards; 29 CFR 1910.145 for danger, caution, warning, and safety instruction signs and tags; and the following:
  - 1. Fire-protection and fire-alarm equipment, including raceways, must be finished, painted, or suitably marked safety red.
  - 2. Ceiling-mounted hangers, supports, cable trays, and raceways must be finished, painted, or suitably marked safety yellow where less than 7.7 ftabove finished floor.
- C. Signs, labels, and tags required for personnel safety must comply with the following standards:
  - 1. Safety Colors: NEMA Z535.1.
  - 2. Facility Safety Signs: NEMA Z535.2.
  - 3. Safety Symbols: NEMA Z535.3.
  - 4. Product Safety Signs and Labels: NEMA Z535.4.
  - 5. Safety Tags and Barricade Tapes for Temporary Hazards: NEMA Z535.5.

D. Comply with NFPA 70E requirements for arc-flash warning labels.

IDENTIFICATION FOR ELECTRICAL SYSTEMS

- E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, must comply with UL 969.
- F. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.
  - 1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

## 2.2 COLOR AND LEGEND REQUIREMENTS

- A. Color-Coding for Phase- and Voltage-Level Identification, 1000 V or Less: Use colors listed below for ungrounded branch-circuit conductors.
  - 1. Color must be factory applied or field applied for sizes larger than 8 AWG if authorities having jurisdiction permit.
  - 2. Colors for 208Y/120 V Circuits:
    - a. Phase A: Black.
    - b. Phase B: Red.
    - c. Phase C: Blue.
  - 3. Colors for 480Y/277 V Circuits:
    - a. Phase A: Brown.
    - b. Phase B: Orange.
    - c. Phase C: Yellow.
  - 4. Color for Neutral: White or gray.
  - 5. Color for Equipment Grounds: Green.

## 2.3 LABELS

- A. Vinyl Wraparound Labels: Preprinted, flexible labels laminated with clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.
  - 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. Brady Corporation.
    - b. Panduit Corp.
- B. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameters sized to suit diameters and that stay in place by gripping action.

- 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. Brady Corporation.
  - b. Panduit Corp.
- C. Self-Adhesive Wraparound Labels: Preprinted, 3 mil thick, vinyl flexible label with acrylic pressure-sensitive adhesive.
  - 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. Brady Corporation.
    - b. Ideal Industries, Inc.
    - c. Panduit Corp.
  - 2. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating, protective shield over legend. Labels sized such that clear shield overlaps entire printed legend.
- D. Self-Adhesive Labels: Vinyl, thermal, transfer-printed, 3 mil thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.
  - 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. Brady Corporation.
    - b. Ideal Industries, Inc.
    - c. Panduit Corp.
  - 2. Minimum Nominal Size:
    - a. 1-1/2 by 6 inch for raceway and conductors.

## 2.4 SIGNS

- A. Laminated Acrylic or Melamine Plastic Signs:
  - 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. Brady Corporation.
    - b. Carlton Industries, LP.
  - 2. Engraved legend.

- 3. Thickness:
  - a. Engraved legend with black letters on white face.
  - b. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

### 2.5 CABLE TIES

- 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. Ideal Industries, Inc.
  - 2. Panduit Corp.
- B. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.
  - 1. Minimum Width: 3/16 inch.
  - 2. Tensile Strength at 73 deg F in accordance with ASTM D638: 12,000 psi.
  - 3. Temperature Range: Minus 40 to plus 185 deg F.
  - 4. Color: Black, except where used for color-coding.

#### PART 3 - EXECUTION

#### 3.1 PREPARATION

A. Self-Adhesive Identification Products: Before applying electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

#### 3.2 INSTALLATION

- A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.
- B. Install identifying devices before installing acoustical ceilings and similar concealment.
- C. Verify identity of item before installing identification products.
- D. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.

- E. Apply identification devices to surfaces that require finish after completing finish work.
- F. Install signs with approved legend to facilitate proper identification, operation, and maintenance of electrical systems and connected items.
- G. System Identification for Raceways and Cables under 1000 V: Identification must completely encircle cable or conduit. Place identification of two-color markings in contact, side by side.
  - 1. Secure tight to surface of conductor, cable, or raceway.
- H. System Identification for Raceways and Cables over 1000 V: Identification must completely encircle cable or conduit. Place adjacent identification of two-color markings in contact, side by side.
  - 1. Secure tight to surface of conductor, cable, or raceway.
- I. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.
- J. Emergency Operating Instruction Signs: Install instruction signs with white legend on red background with minimum 3/8 inch high letters for emergency instructions at equipment used for power transfer.
- K. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from floor.
- L. Accessible Fittings for Raceways: Identify cover of junction and pull box of the following systems with wiring system legend and system voltage. System legends must be as follows:
  - 1. "EMERGENCY POWER."
  - 2. "POWER."
  - 3. "UPS."
- M. Vinyl Wraparound Labels:
  - 1. Secure tight to surface of raceway or cable at location with high visibility and accessibility.
  - 2. Attach labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to location and substrate.
- N. Snap-Around Labels: Secure tight to surface at location with high visibility and accessibility.
- O. Self-Adhesive Wraparound Labels: Secure tight to surface at location with high visibility and accessibility.
- P. Self-Adhesive Labels:
  - 1. Install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual.

- 2. Unless otherwise indicated, provide single line of text with 1/2 inch high letters on 1-1/2 inch high label; where two lines of text are required, use labels 2 inch high.
- Q. Laminated Acrylic or Melamine Plastic Signs:
  - 1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to location and substrate.
  - 2. Unless otherwise indicated, provide single line of text with 1/2 inch high letters on 1-1/2 inch high sign; where two lines of text are required, use labels 2 inch high.

END OF SECTION 260553

## SECTION 262726 - WIRING DEVICES

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section Includes:
  - 1. General-grade duplex straight-blade receptacles.
  - 2. Receptacles with arc-fault and ground-fault protective devices.
  - 3. Connectors, cords, and plugs.

#### 1.2 DEFINITIONS

- A. Commercial/Industrial-Use Cord Reel: A cord reel subject to severe use in factories, commercial garages, construction sites, and similar locations requiring a harder service-type cord.
- B. UL 1472 Type I Dimmer: Dimmer in which air-gap switch is used to energize preset lighting levels.

#### 1.3 ACTION SUBMITTALS

- A. Product Data:
  - 1. Toggle switches.
  - 2. Duplex straight-blade receptacles.
  - 3. Receptacles with GFCI device.

## 1.4 WARRANTY FOR DEVICES

- A. Special Manufacturer Extended Warranty: Manufacturer warrants that devices perform in accordance with specified requirements and agrees to provide repair or replacement of devices that fail to perform as specified within extended warranty period.
  - 1. Initial Extended Warranty Period: Three years from date of Substantial Completion; full coverage for labor, materials, and equipment.
  - 2. Follow-On Extended Warranty Period: Eight years from date of Substantial Completion; full coverage for materials that failed because of transient voltage surges only, free on board origin, freight prepaid.

### PART 2 - PRODUCTS

### 2.1 GENERAL-GRADE DUPLEX STRAIGHT-BLADE RECEPTACLES

- A. Duplex Straight-Blade Receptacle :
  - 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. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
    - b. Leviton Manufacturing Co., Inc.
    - c. Pass & Seymour; Legrand North America, LLC.
  - 2. Regulatory Requirements:
    - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
  - 3. General Characteristics:
    - a. Reference Standards: UL CCN RTRT and UL 498.
  - 4. Options:
    - a. Device Color: White.
    - b. Configuration:
      - 1) Heavy-duty, NEMA 5-20R.
  - 5. Accessories:
    - a. Cover Plate: 0.060 inch thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
    - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

#### 2.2 RECEPTACLES WITH ARC-FAULT AND GROUND-FAULT PROTECTIVE DEVICES

- A. General-Grade, Weather-Resistant, Tamper-Resistant Duplex Straight-Blade Receptacle with GFCI Device :
  - 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. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.

- b. Leviton Manufacturing Co., Inc.
- c. Pass & Seymour; Legrand North America, LLC.
- 2. Regulatory Requirements:
  - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
- 3. General Characteristics:
  - a. Reference Standards: UL CCN KCXS, UL 498, and UL 943.
- 4. Options:
  - a. Device Color: White.
  - b. Configuration: Heavy-duty, NEMA 5-20R.
- 5. Accessories:
  - a. Cover Plate: 0.060 inch thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
  - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

### 2.3 CONNECTORS, CORDS, AND PLUGS

- A. Outdoor-Use, Watertight, Sealed Cord Connector :
  - 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. Ericson Manufacturing Company.
  - 2. Regulatory Requirements:
    - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
  - 3. General Characteristics:
    - a. Reference Standards: UL CCN AXUT and UL 498.

## PART 3 - EXECUTION

## 3.1 EXAMINATION

- A. Receptacles:
  - 1. Verify that receptacles to be procured and installed for Owner-furnished equipment are compatible with mating attachment plugs on equipment.
- B. Cord Reels:
  - 1. Examine roughing-in for cord reel mounting and power connections to verify actual locations of mounts and power connections before cord reel installation.
  - 2. Examine walls, floors, and ceilings for suitable conditions where cord reel will be installed.
  - 3. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 SELECTION OF CONTROLLED AND UNCONTROLLED RECEPTACLES

- A. Private and Open Office Spaces:
  - 1. Uncontrolled Receptacles at Workstations: Coordinate final locations of receptacles with furniture plan such that at least one uncontrolled receptacle is selected for installation not greater than 6 ft from each workstation.
  - 2. Controlled Receptacles at Workstations: Coordinate final locations of receptacles with furniture plan such that at least one controlled receptacle is selected for installation not greater than 6 ft from each workstation.
  - 3. Contact Architect for resolution of discrepancies between these requirements and Drawings.

#### 3.3 SELECTION OF GFCI RECEPTACLES

A. Healthcare Facilities: Unless protection of downstream branch-circuit wiring, cord sets, and power-supply cords is required by NFPA 70 or NFPA 99, provide non-feed-through GFCI receptacles.

## 3.4 INSTALLATION OF SWITCHES

- A. Comply with manufacturer's instructions.
- B. Reference Standards:
  - 1. Unless more stringent requirements are specified in Contract Documents or manufacturers' instructions, comply with installation instructions in NECA NEIS 130.

- 2. Mounting Heights: Unless otherwise indicated in Contract Documents, comply with mounting heights recommended in NECA NEIS 1.
- 3. Consult Architect for resolution of conflicting requirements.
- C. Identification:
  - 1. Identify cover or cover plate for device with panelboard identification and circuit number in accordance with Section 260553 "Identification for Electrical Systems."
    - a. Mark cover or cover plate using hot, stamped, or engraved machine printing with black -filled lettering, and provide durable wire markers or tags inside device box or outlet box.
    - b. Healthcare Facilities: Distinctively identify covers or cover plates of device boxes and outlet boxes that are supplied from life safety and critical branch power supplies following facility's standard practice.

### 3.5 INSTALLATION OF STRAIGHT-BLADE RECEPTACLES

- A. Comply with manufacturer's instructions.
- B. Reference Standards:
  - 1. Unless more stringent requirements are specified in Contract Documents or manufacturers' instructions, comply with installation instructions in NECA NEIS 130.
  - 2. Mounting Heights: Unless otherwise indicated in Contract Documents, comply with mounting heights recommended in NECA NEIS 1.
  - 3. Receptacle Orientation: Unless otherwise indicated in Contract Documents, orient receptacle to match configuration diagram in NEMA WD 6.
    - a. Hospital-Grade Receptacle Orientation: Orient receptacle with ground pin or neutral pin at top.
  - 4. Consult Architect for resolution of conflicting requirements.
- C. Identification:
  - 1. Identify cover or cover plate for device with panelboard identification and circuit number in accordance with Section 260553 "Identification for Electrical Systems."
    - a. Mark cover or cover plate using hot, stamped, or engraved machine printing with black -filled lettering, and provide durable wire markers or tags inside device box or outlet box.
- D. Interfaces with Other Work:
  - 1. Do not install Type 3 SPD, including surge-protected relocatable taps and power strips, on branch circuit downstream of GFCI device.
  - 2. Coordinate installation of new products for with existing conditions.

## 3.6 FIELD QUALITY CONTROL OF STRAIGHT-BLADE RECEPTACLES

- A. Field tests and inspections must be witnessed by authorities having jurisdiction.
- B. Tests and Inspections:
  - 1. Insert and remove test plug to verify that device is securely mounted.
  - 2. Verify polarity of hot and neutral pins.
  - 3. Measure line voltage.
  - 4. Measure percent voltage drop.
  - 5. Measure grounding circuit continuity; impedance must be not greater than 2 ohms.
  - 6. Healthcare Facilities: Test straight-blade receptacles in patient care spaces with receptacle pin tension test instrument in accordance with NFPA 99. Retention force of ground pin must be not less than 115 g (4 oz).
  - 7. Perform additional installation and maintenance inspections and diagnostic tests in accordance with NECA NEIS 130 and manufacturers' instructions.
  - 8.
- C. Nonconforming Work:
  - 1. Device will be considered defective if it does not pass tests and inspections.
  - 2. Remove and replace defective units and retest.
- D. Assemble and submit test and inspection reports.
- E. Manufacturer Services:
  - 1. Engage factory-authorized service representative to support field tests and inspections.

#### 3.7 PROTECTION

- A. Devices:
  - 1. Schedule and sequence installation to minimize risk of contamination of wires and cables, devices, device boxes, outlet boxes, covers, and cover plates by plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other materials.
  - 2. After installation, protect wires and cables, devices, device boxes, outlet boxes, covers, and cover plates from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

### END OF SECTION 262726

## SECTION 262816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

#### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section Includes:
  - 1. Fusible switches.
  - 2. Nonfusible switches.
  - 3. Molded-case circuit breakers (MCCBs).
  - 4. Enclosures.

## 1.2 DEFINITIONS

- A. GFEP: Ground-fault circuit-interrupter for equipment protection.
- B. GFLS: Ground-fault circuit-interrupter for life safety.
- C. SPDT: Single pole, double throw.

#### 1.3 ACTION SUBMITTALS

- A. Product Data:
  - 1. For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include nameplate ratings, dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
  - 2. Enclosure types and details for types other than UL 50E, Type 1.
  - 3. Current and voltage ratings.
  - 4. Short-circuit current ratings (interrupting and withstand, as appropriate).
  - 5. Include evidence of qualified electrical testing laboratory listing for series rating of installed devices.
  - 6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
  - 7. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device. Provide in PDF electronic format.

### 1.4 WARRANTY

- A. Special Installer Extended Warranty: Installer warrants that fabricated and installed enclosed switches and circuit breakers perform in accordance with specified requirements and agrees to repair or replace components or products that fail to perform as specified within extended-warranty period.
  - 1. Extended-Warranty Period: Two years from date of Substantial Completion; full coverage for labor, materials, and equipment.
- B. Special Manufacturer Extended Warranty: Manufacturer warrants that enclosed switches and circuit breakers perform in accordance with specified requirements and agrees to provide repair or replacement of components or products that fail to perform as specified within extended-warranty period.
  - 1. Extended-Warranty Period: Three years from date of Substantial Completion; full coverage for labor, materials, and equipment.

## PART 2 - PRODUCTS

## 2.1 GENERAL REQUIREMENTS

- A. Source Limitations: Obtain products from single manufacturer.
- B. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA
  70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

#### 2.2 FUSIBLE SWITCHES

- 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. ABB, Electrification Business.
  - 2. Eaton.
  - 3. Siemens Industry, Inc., Energy Management Division.
  - 4. Square D; Schneider Electric USA.
- B. Type HD, Heavy Duty:
  - 1. Single throw.
  - 2. Three pole.
  - 3. 600 V(ac).
  - 4. 1200 A and smaller.

- 5. UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses.
- 6. Lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- C. Accessories:
  - 1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
  - 2. Lugs: Mechanical type, suitable for number, size, and conductor material.

# 2.3 NONFUSIBLE SWITCHES

- 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. ABB, Electrification Business.
  - 2. Eaton.
  - 3. Siemens Industry, Inc., Energy Management Division.
  - 4. Square D; Schneider Electric USA.
- B. Type HD, Heavy Duty, Three Pole, Single Throw, 600 V(ac), 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- C. Accessories:
  - 1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
  - 2. Lugs: Mechanical type, suitable for number, size, and conductor material.

# 2.4 MOLDED-CASE CIRCUIT BREAKERS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
  - 1. Square D; Schneider Electric USA.
- B. Maximum ampere rating and UL, IEC, or other certification standards with applicable voltage systems and corresponding interrupting ratings must be clearly marked on face of circuit breaker. Circuit breakers must be 100 percent rated. Circuit breaker/circuit breaker combinations for series connected interrupting ratings must be listed by UL as recognized component combinations. Series rated combination used must be marked on end-use equipment along with statement "Caution Series Rated System. \_\_\_\_\_ Amps Available. Identical Replacement Component Required."
- C. MCCBs must be equipped with device for locking in isolated position.

## ENCLOSED SWITCHES AND CIRCUIT BREAKERS
- D. Lugs must be suitable for 75 deg C rated wire.
- E. Standard: Comply with UL 489 with required interrupting capacity for available fault currents.
- F. Thermal-Magnetic Circuit Breakers: Inverse time-current thermal element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
- G. Features and Accessories:
  - 1. Standard frame sizes, trip ratings, and number of poles.

#### 2.5 ENCLOSURES

- A. Enclosure Finish: Enclosure must be gray baked enamel paint, electrodeposited on cleaned, phosphatized steel (UL 50E Type 1).
- B. Conduit Entry: UL 50E Types 4, 4X, and 12 enclosures may not contain knockouts. UL 50E
  Types 7 and 9 enclosures must be provided with threaded conduit openings in both endwalls.
- C. Operating Mechanism: Circuit-breaker operating handle must be externally operable with operating mechanism being integral part of box, not cover. Cover interlock mechanism must have externally operated override. Override may not permanently disable interlock mechanism, which must return to locked position once override is released. Tool used to override cover interlock mechanism must not be required to enter enclosure in order to override interlock.
- D. Enclosures designated as UL 50E Type 4, 4X stainless steel, 12, or 12K must have dual cover interlock mechanism to prevent unintentional opening of enclosure cover when circuit breaker is ON and to prevent turning circuit breaker ON when enclosure cover is open.
- E. UL 50E Type 7/9 enclosures must be furnished with breather and drain kit to allow their use in outdoor and wet location applications.

#### PART 3 - EXECUTION

#### 3.1 EXAMINATION

- A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.
  - 1. Commencement of work will indicate Installer's acceptance of areas and conditions as satisfactory.

# 3.2 SELECTION OF ENCLOSURES

- A. Indoor, Dry and Clean Locations: UL 50E, Type 1.
- B. Outdoor Locations: UL 50E, Type 3R.
- C. Kitchen Areas: UL 50E, Type 4X, stainless steel.
- D. Other Wet or Damp, Indoor Locations: UL 50E, Type 4.
- E. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: UL 50E, Type 12.
- F. Hazardous Areas Indicated on Drawings: UL 50E, Type 7.

## 3.3 INSTALLATION

- A. Comply with manufacturer's published instructions.
- B. Special Techniques:
  - 1. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
  - 2. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.
  - 3. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."
  - 4. Temporary Lifting Provisions: Remove temporary lifting of eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
  - 5. Install fuses in fusible devices.

## 3.4 IDENTIFICATION

- A. Comply with requirements in Section 260553 "Identification for Electrical Systems."
  - 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
  - 2. Label each enclosure with engraved metal or laminated-plastic nameplate.

## 3.5 FIELD QUALITY CONTROL

- A. Field tests and inspections must be witnessed by Architect authorities having jurisdiction.
- B. Tests and Inspections for Switches:
  - 1. Visual and Mechanical Inspection:

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- a. Inspect physical and mechanical condition.
- b. Inspect anchorage, alignment, grounding, and clearances.
- c. Verify that unit is clean.
- d. Verify blade alignment, blade penetration, travel stops, and mechanical operation.
- e. Verify that fuse sizes and types match the Specifications and Drawings.
- f. Verify that each fuse has adequate mechanical support and contact integrity.
- g. Inspect bolted electrical connections for high resistance using one of the following methods:
  - 1) Use low-resistance ohmmeter.
    - a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of lowest value.
  - 2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.
    - a) Bolt-torque levels must be in accordance with manufacturer's published data. In absence of manufacturer's published data, use NETA ATS Table 100.12.
- h. Verify that operation and sequencing of interlocking systems is as described in the Specifications and shown on Drawings.
- i. Verify correct phase barrier installation.
- j. Verify lubrication of moving current-carrying parts and moving and sliding surfaces.
- 2. Electrical Tests:
  - a. Perform resistance measurements through bolted connections with lowresistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of lowest value.
  - b. Measure contact resistance across each switchblade fuseholder. Drop values may not exceed high level of manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of lowest value.
  - c. 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. Apply voltage in accordance with manufacturer's published data. In absence of manufacturer's published data, use Table 100.1 from NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.
  - d. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.

- e. Perform ground fault test in accordance with NETA ATS Section 7.14 "Ground Fault Protection Systems, Low-Voltage."
- C. Tests and Inspections for Molded-Case Circuit Breakers:
  - 1. Visual and Mechanical Inspection:
    - a. Verify that equipment nameplate data are as described in the Specifications and shown on Drawings.
    - b. Inspect physical and mechanical condition.
    - c. Inspect anchorage, alignment, grounding, and clearances.
    - d. Verify that unit is clean.
    - e. Operate circuit breaker to ensure smooth operation.
    - f. Inspect bolted electrical connections for high resistance using one of the following methods:
      - 1) Use low-resistance ohmmeter.
        - a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of lowest value.
      - 2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.
        - a) Bolt-torque levels must be in accordance with manufacturer's published data. In absence of manufacturer's published data, use NETA ATS Table 100.12.
    - g. Inspect operating mechanism, contacts, and chutes in unsealed units.
    - h. Perform adjustments for final protective device settings in accordance with coordination study.
  - 2. Electrical Tests:
    - a. Perform resistance measurements through bolted connections with lowresistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of lowest value.
    - Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with circuit breaker closed, and across each open pole.
       Apply voltage in accordance with manufacturer's published data. In absence of manufacturer's published data, use Table 100.1 from NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.

- c. Perform contact/pole resistance test. Drop values may not exceed high level of manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of lowest value.
- Perform insulation resistance tests on control wiring with respect to ground. Applied potential must be 500 V(dc) for 300 V rated cable and 1000 V(dc) for 600 V rated cable. Test duration must be one minute. For units with solid state components, follow manufacturer's recommendation. Insulation resistance values may be no less than 2 M <sup>1</sup>/<sub>1</sub>?.
- e. Determine the following by primary current injection:
  - 1) Long-time pickup and delay. Pickup values must be as specified. Trip characteristics may not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
  - 2) Short-time pickup and delay. Short-time pickup values must be as specified. Trip characteristics may not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
  - Ground-fault pickup and time delay. Ground-fault pickup values must be as specified. Trip characteristics may not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
  - 4) Instantaneous pickup. Instantaneous pickup values must be as specified and within manufacturer's published tolerances.
- f. Test functionality of trip unit by means of primary current injection. Pickup values and trip characteristics must be as specified and within manufacturer's published tolerances.
- g. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data. Minimum pickup voltage of shunt trip and close coils must be as indicated by manufacturer.
- h. Verify correct operation of auxiliary features such as trip and pickup indicators; zone interlocking; electrical close and trip operation; trip-free, anti-pump function; and trip unit battery condition. Reset trip logs and indicators. Investigate units that do not function as designed.
- i. Verify operation of charging mechanism. Investigate units that do not function as designed.
- 3. Test and adjust controls, remote monitoring, and safeties.
- D. Nonconforming Work:
  - 1. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.
  - 2. Remove and replace defective units and retest.
- E. Collect, assemble, and submit test and inspection reports.
  - 1. Test procedures used.

- 2. Include identification of each enclosed switch and circuit breaker tested and describe test results.
- 3. List deficiencies detected, remedial action taken, and observations after remedial action.
- F. Manufacturer Services:
  - 1. Engage factory-authorized service representative to support field tests and inspections.

## 3.6 ADJUSTING

A. Adjust moving parts and operable components to function smoothly and lubricate as recommended by manufacturer.

# 3.7 PROTECTION

A. After installation, protect enclosed switches and circuit breakers from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

## 3.8 MAINTENANCE

- A. Infrared Scanning of Enclosed Switches and Breakers: Two months after Substantial Completion, perform infrared scan of joints and connections. Remove covers so joints and connections are accessible to portable scanner. Take visible light photographs at same locations and orientations as infrared scans for documentation to ensure follow-on scans match same conditions for valid comparison.
  - 1. Instruments and Equipment: Use infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
  - 2. Follow-up Infrared Scanning: Perform two follow-up infrared scans of enclosed switches and breakers, one at four months and another at 11 months after Substantial Completion.
  - 3. Instrument: Use infrared-scanning device designed to measure temperature or to detect significant deviations from normal values. Provide documentation of device calibration.
  - 4. Report: Prepare certified report that identifies units checked and that describes scanning results. Include notation of deficiencies detected, remedial actions taken, and scanning observations after remedial action.

## END OF SECTION 262816