

1 **SECTION 23 01 00 - GENERAL PROVISIONS FOR HVAC**

2 **PART 1 - GENERAL**

3 **1.1 RELATED DOCUMENTS**

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

6 B. Provisions of this Section apply to all Division 23 Specification Sections.

7 **1.2 SUMMARY**

8 A. Section includes basic requirements for heating, ventilation, and air-conditioning systems.

9 B. Related Work:

10 1. Division 02 – Existing Conditions

11 a. Refer to Division 02 for demolition and for abatement of hazardous materials.

12 b. Comply with the requirements of Division 02 for selective demolition.

13 2. Division 03 – Concrete

14 a. Refer to Division 03 for rough grouting in and around work, patching concrete cut
15 to accommodate work, and sumps for work.

16 b. Comply with the requirements of Division 03 for curbs, foundations, inertia bases,
17 and equipment pads for equipment.

18 3. Division 05 – Metals

19 a. Refer to Division 05 for framed openings for equipment.

20 b. Comply with the requirements of Division 05 for supports for work.

21 4. Division 06 – Wood, Plastics, and Composites

22 a. Refer to Division 06 for framed openings for equipment.

23 5. Division 07 – Thermal and Moisture Protection

24 a. Refer to Division 07 for installation of roof curbs and roof supports and for caulking
25 and waterproofing of wall- and roof-mounted work.

26 b. Comply with the requirements of Division 07 for penetration firestopping and
27 furnishing roof curbs and roof supports for equipment and piping.

28 6. Division 08 – Openings

29 a. Refer to Division 08 for installation of access doors and frames and for louvers and
30 vents.

31 b. Comply with the requirements of Division 08 for access doors and frames and for
32 louvers and vents, unless otherwise included in the Contract Documents.

33 7. Division 09 – Finishes

34 a. Refer to Division 09 for paint products and applications in finished spaces.

35 b. Comply with the requirements of Division 09 for paint products and applications
36 identified in the Contract Documents.

- 1 8. Division 10 – Specialties
- 2 a. Refer to Division 10 for fire protection cabinets and fire extinguishers.

- 3 9. Division 11 – Equipment
- 4 a. Refer to Division 11 for food service equipment to be provided.
- 5 b. Comply with the requirements of Division 11 for connections and related devices to
- 6 make these systems operational.

- 7 10. Division 21 – Fire Suppression
- 8 a. Refer to Division 21 for all suppression work.

- 9 11. Division 22 – Plumbing
- 10 a. Refer to Division 22 for all plumbing work.
- 11 b. Comply with requirements of Division 22 for related equipment and components
- 12 and for connections to systems.

- 13 12. Division 25 – Instrumentation and Control
- 14 a. Refer to Division 25 for instrumentation and control systems.
- 15 b. Comply with the requirements of Division 25 for installation of and integration with
- 16 instrumentation and control components.

- 17 13. Division 26 – Electrical
- 18 a. Refer to Division 26 for all electrical work.

- 19 14. Division 27 – Communications
- 20 a. Refer to Division 27 for all communications work.

- 21 15. Division 28 – Electronic Safety and Security
- 22 a. Refer to Division 28 for all electronic safety and security work.
- 23 b. Coordinate with Division 28 for integration with fire-alarm systems.

- 24 16. Division 31 – Earthwork
- 25 a. Refer to Division 31 for all site related work greater than five feet outside the
- 26 building, unless noted otherwise in the Contract Documents.
- 27 b. Comply with the requirements of Division 31 for site clearing, earth moving, and
- 28 dewatering within five feet outside the building and otherwise as indicated in the
- 29 Contract Documents.

- 30 17. Division 33 – Utilities
- 31 a. Refer to Division 33 for all utility related work greater than five feet outside the
- 32 building, unless noted otherwise in the Contract Documents.
- 33 b. Comply with the requirements of Division 33 for utility work within five feet outside
- 34 the building and otherwise as indicated in the Contract Documents.

35 **1.3 DEFINITIONS**

- 36 A. Experienced: When used with an entity or individual, “experienced” unless otherwise further
- 37 described means having successfully completed a minimum of five previous projects similar in
- 38 nature, size, and extent to this Project; being familiar with special requirements indicated; and
- 39 having complied with requirements of authorities having jurisdiction.

- 40 B. Furnish: Supply and deliver to project site, ready for subsequent requirements.

- 1 C. Install: Operations at project site, including unloading, unpacking, assembly, erection, placing,
2 anchoring, applying, working to dimension, finishing, curing, protecting, cleaning, and similar
3 requirements.
- 4 D. Provide: Furnish and install, complete and ready for intended use.
- 5 E. Cutting: Removal of in-place construction necessary to permit installation or performance of
6 subsequent work.
- 7 F. Patching: Fitting and repair work required to restore construction to original conditions after
8 installation of subsequent work.
- 9 G. Concealed Work: Work hidden from view, including inside chases, furred spaces, or above
10 ceilings.
- 11 H. Exposed Work: Work open to view, including inside mechanical and equipment rooms and on
12 mezzanines.

13 **1.4 QUALITY ASSURANCE**

- 14 A. General:
 - 15 1. It is the intent of the plans and specifications to obtain a complete, operable and
16 satisfactory installation.
 - 17 2. All materials shall be new, be properly labeled and/or identified and be in full compliance
18 with the contract documents.
 - 19 3. All work shall comply with applicable Codes and Standards.
 - 20 4. Manufacturer's model names and numbers used in these specifications are subject to
21 change per manufacturer's action. Contractor shall therefore verify them with
22 manufacturer's representative before ordering any product or equipment
- 23 B. Furnish new and unused materials and equipment manufactured in the U.S.A. Where two or
24 more units of the same type or class of equipment are required provide units of a single
25 manufacturer.

26 **1.5 CODES AND STANDARDS**

- 27 A. Perform work in accordance with the following codes and any applicable statutes, ordinances,
28 codes, and regulations of governmental authorities having jurisdiction.
 - 29 1. ASHRAE
 - 30 a. Standard 15 Safety Standard for Refrigeration Systems - 2019
 - 31 b. Standard 55 Thermal Environmental Conditions for Human Occupancy
 - 32 c. Standard 62.1 Ventilation Standard for Acceptable Indoor air Quality - 2016
 - 33 d. Standard 90.1 Energy Standard for Buildings Except Low Rise Residential
34 Buildings
 - 35 2. ASME
 - 36 a. Boiler and Pressure Vessel Code - 2013
 - 37 1) Section I Rules for Construction of Power Boilers

- 1 2) Section IV Rules for Construction of Heating Boilers
 2 3) Section VIII Rules for Construction of Pressure Vessels
- 3 b. ASME A17.1 Safety Code for Elevators and Escalators - 2016
 4 c. ASME A17.3 Safety Code for Existing Elevators and Escalators - 2015
- 5 3. Occupational Safety and Health Regulations (OSHA).
 6 4. National Fire Codes
- 7 a. NFPA 1 Uniform Fire Code – 2018 (Florida Edition)
 8 b. NFPA 54 National Fuel Gas Code – 2018
 9 c. NFPA 70 National Electrical Code – 2017
 10 d. NFPA 72 National Fire Alarm and Signaling Code - 2016
 11 e. NFPA 90A Standard for the Installation of Air Conditioning and Ventilation
 12 Systems - 2018
 13 f. NFPA 90B Standard for the Installation of Warm Air Heating and Air
 14 Conditioning Systems - 2018
 15 g. NFPA 91 Standard for the Installation of Blower and Exhaust Systems - 2015
 16 h. NFPA 96 Standard for Ventilation Control and Fire Protection of Commercial
 17 Cooking Operations – 2017
 18 i. NFPA 101 Life Safety Code – 2018 (Florida Edition)
- 19 5. Florida Building Code, 2020 Edition
- 20 a. Building Code
 21 b. Existing Building Code
 22 c. Energy Conservation Code
 23 d. Mechanical Code
 24 e. Plumbing Code
 25 f. Fuel Gas Code
 26 g. Accessibility Code
- 27 6. Florida Statutes
- 28 a. Chapter 471 Engineering
 29 b. Chapter 533.80 Building Construction Standards; Florida Building Code -
 30 Enforcement
- 31 7. Florida Administrative Code
- 32 a. Chapter 9B-7 Florida Building Commission Handicapped Accessibility
 33 Standards
 34 b. Chapter 61C-5 Florida Elevator Safety Code
 35 c. Chapter 61G15-34 Responsibility Rules of Professional Engineers Concerning
 36 the Design of Mechanical Systems
 37 d. Chapter 69A-3 Fire Prevention – General Provisions
 38 e. Chapter 69A-47 Uniform Fire Safety Standards for Elevators
 39 f. Chapter 69A-60 The Florida Fire Prevention Code
- 40 B. Resolve, in writing, any code violation discovered in contract documents with the Engineer prior
 41 to bidding. After award of the contract, make any correction or addition necessary for
 42 compliance with applicable codes at no additional cost to Owner.
- 43 C. The Contractor shall include in the Work, without extra cost to the Owner, any labor, materials,
 44 services, apparatus, and drawings required to comply with all applicable laws, ordinances,
 45 rules, and regulations.

1 D. Where there is conflict between the Contract Documents and the applicable Codes, the Codes
2 shall govern, except where the requirements of the Contract Documents are more stringent.

3 **1.6 REFERENCE SPECIFICATIONS AND STANDARDS**

4 A. Materials which are specified by reference to Federal Specifications; ASTM, ASME, ANSI, or
5 AWWA Specifications; Federal Standards; or other standard specifications must comply with
6 latest editions, revisions, amendments, or supplements in effect on date bids are received.
7 Specifications and standards are minimum requirements for all equipment, material and work.
8 In instances where capacities, size or other feature of equipment, devices or materials exceed
9 these minimums, meet listed or shown capacities.

10 B. Whenever a reference is made to a standard, installation and materials shall comply with the
11 latest published edition of the standard at the time project is bid unless otherwise specified
12 herein

13 **1.7 DELEGATED-DESIGN SERVICES**

14 A. Performance and Design Criteria: Where professional design services or certifications by a
15 design professional are specifically required of Contractor by the Contract Documents, provide
16 products and systems complying with specific performance and design criteria indicated.

17 **1.8 PERMITS FEES AND INSPECTIONS**

18 A. Obtain and pay for all permits, fees, tap fees, connection charges, demand charges, systems
19 charges, impact fees, and inspections.

20 B. Deliver all certificates of inspection issued by authorities having jurisdiction to the Engineer.

21 **1.9 CONFLICTING REQUIREMENTS**

22 A. Conflicting Standards and Other Requirements: If compliance with two or more standards or
23 requirements are specified and the standards or requirements establish different or conflicting
24 requirements for minimum quantities or quality levels, comply with the most stringent
25 requirement. Refer conflicting requirements that are different, but apparently equal, to Engineer
26 for direction before proceeding.

27 1. If discrepancies or conflicts occur between drawings, or between drawings and
28 specifications, notify the Engineer in writing prior to bid date; however, the most stringent
29 requirement shall govern.

30 B. Minimum Quantity or Quality Levels: The quantity or quality level shown or specified shall be the
31 minimum provided or performed. The actual installation may comply exactly with the minimum
32 quantity or quality specified, or it may exceed the minimum within reasonable limits. To comply
33 with these requirements, indicated numeric values are minimum or maximum, as appropriate,
34 for the context of requirements. Refer uncertainties to Engineer for a decision before
35 proceeding.

36 **1.10 SUBMITTALS**

- 1 A. Submittals (including Product Data, Shop Drawings, and any other Action Submittal or
2 Information Submittal) will only be reviewed if they are submitted in full accordance with the
3 General and Supplementary Conditions, Division 01, and the following:
- 4 1. Prepare and submit submittals required by individual Specification Sections. Types of
5 submittals are indicated in individual Specification Sections.
 - 6 2. Submit all submittal items required for each Specification Section concurrently unless
7 partial submittals for portions of the Work are approved by the Engineer.
 - 8 3. Submittals shall only contain relevant product data. Remove or strikeout irrelevant
9 product data.
 - 10 4. Prepare submittals as PDF electronic files and electronically transmit to Engineer through
11 email or web-based project software site, in accordance with Division 01 Specification
12 Sections. Submittals shall be in searchable PDF format and not a scanned copy.
 - 13 5. Options: Identify options requiring selection by Engineer.
 - 14 6. Deviations: Clearly identify deviations from requirements in the Contract Documents,
15 including minor variations and limitations.
 - 16 7. Revisions: Include relevant additional information and revisions, other than those
17 specifically requested by Engineer on previous submittals. Indicate by highlighting on
18 each submittal or noting on attached submittal sheet.
 - 19 8. Contractor's Review:
 - 20 a. Submittals shall have been reviewed and approved by the General Contractor /
21 Construction Manager. Include approval stamp, name of reviewer, date of
22 Contractor's approval, and statement certifying that submittal has been reviewed,
23 checked, and approved for compliance with the Contract Documents.
 - 24 b. Engineer will not review submittals received from Contractor that do not have
25 Contractor's review and approval.
 - 26 9. Electrical Modifications:
 - 27 a. The electrical design indicated on the plans supports the Basis of Design
28 specifications for the HVAC systems at the time of design.
 - 29 b. If HVAC equipment is submitted with different electrical requirements, it is the
30 responsibility of the Contractor to resolve all required electrical design changes,
31 including, but not limited to: wire and conduit size, type or size of disconnect or
32 overload protection, breaker coordination, point(s) of connection, etc. Any
33 corrections required shall be provided at no additional cost.
 - 34 c. Submittal shall clearly show the electrical design revisions with a written statement
35 that this change will be provided at no additional cost. Submittals made with no
36 written reference to the electrical design revisions will be presumed to work with
37 the electrical design.
- 38 B. Processing Time: Allow 15 days for submittal review. Time of review shall commence on
39 Engineer's receipt of submittal. No extension of the Contract Time will be authorized because
40 of the failure to transmit submittals enough in advance of the Work to permit processing,
41 including resubmittals.
- 42 1. Allow additional time if coordination with subsequent submittals is required. Engineer will
43 advise Contractor when a submittal being processed must be delayed for coordination.
 - 44 2. Engineer reserves the right to withhold action on a submittal requiring coordination with
45 other submittals until related submittals are received.
- 46 C. The Contractor shall not be relieved of responsibility for deviations from requirements of the
47 contract documents by the Engineer's approval of shop drawings, product data, samples, or
48 similar submittals unless the Contractor has specifically informed the Engineer in writing of such
49 deviation at the time of submittal, and the Engineer has given written approval to the specific

1 deviation. The Contractor shall not be relieved of responsibility for errors or omissions in shop
2 drawings, product data, samples, or similar submittals by the Engineer's approval thereof.

3 D. Submittals on any particular phase of Work will receive only one review and one re-review (if
4 required). If additional reviews are required beyond these two, the Contractor will be charged
5 \$120.00 per hour for review time. This fee shall be paid to the Engineer prior to Submittal
6 release.

7 1.11 SUBSTITUTIONS

8 A. By submitting a bid, the Bidder represents that its bid is based on materials and equipment
9 described in the Procurement and Contracting Documents, including Addenda. Bidders are
10 encouraged to request approval of qualifying substitute materials and equipment when the
11 Specifications Sections list materials and equipment by product or manufacturer name.

12 B. Substitution Requests shall include, at a minimum:

- 13 1. Statement indicating why specified material, equipment, or installation method cannot be
14 provided, if applicable.
- 15 2. Coordination of information, including a list of changes and revisions needed to other
16 parts of the Work and to construction performed by Owner and separate contractors that
17 will be necessary to accommodate proposed substitution.
- 18 3. Detailed comparison of significant qualities of proposed substitutions with those of the
19 Work specified. Include an annotated copy of applicable Specification Section. Significant
20 qualities may include attributes, such as performance, weight, size, durability, visual
21 effect, sustainable design characteristics, warranties, and specific features and
22 requirements indicated. Indicate deviations, if any, from the Work specified.
- 23 4. Product Data, including drawings and descriptions of products and fabrication and
24 installation procedures.
- 25 5. Detailed comparison of Contractor's construction schedule using proposed substitutions
26 with products specified for the Work, including effect on the overall Contract Time. If
27 specified product or method of construction cannot be provided within the Contract Time,
28 include letter from manufacturer, on manufacturer's letterhead, stating date of receipt of
29 purchase order, lack of availability, or delays in delivery.
- 30 6. Cost information, including a proposal of change, if any, in the Contract Sum.
- 31 7. Contractor's certification that proposed substitution complies with requirements in the
32 Contract Documents, except as indicated in substitution request, is compatible with
33 related materials and is appropriate for applications indicated.
- 34 8. Contractor's waiver of rights to additional payment or time that may subsequently become
35 necessary because of failure of proposed substitution to produce indicated results.

36 C. Procurement Substitution Requests submitted prior to receipt of bids will be received and
37 considered by Owner when the following conditions are satisfied, as determined by Engineer;
38 otherwise, requests will be returned without action:

- 39 1. Requests for substitution of materials and equipment are received no later than 10 days
40 prior to date of bid opening.
- 41 2. Extensive revisions to the Contract Documents are not required.
- 42 3. Proposed changes are in keeping with the general intent of the Contract Documents,
43 including the level of quality of the Work represented by the requirements therein.
- 44 4. The request is fully documented and properly submitted.

45 D. Substitutions for Cause, as required due to changed Project conditions, such as unavailability of
46 product, regulatory changes, or unavailability of required warranty terms will be received and

1 considered by Engineer, only when the following conditions are satisfied; otherwise, requests
2 will be returned without action, except to record noncompliance with these requirements:

- 3 1. Requested substitution is consistent with the Contract Documents and will produce
4 indicated results.
- 5 2. Substitution request is fully documented and properly submitted.
- 6 3. Requested substitution has received necessary approvals of authorities having
7 jurisdiction.
- 8 4. Requested substitution is compatible with other portions of the Work.
- 9 5. Requested substitution has been coordinated with other portions of the Work.
- 10 6. Requested substitution provides specified warranty.
- 11 7. If requested substitution involves more than one contractor, requested substitution has
12 been coordinated with other portions of the Work, is uniform and consistent, is compatible
13 with other products, and is acceptable to all contractors involved.

14 E. Substitutions for Convenience, not required in order to meet other Project requirements but may
15 offer advantage to Contractor or Owner, will be received and considered by Owner, as
16 determined by Engineer, only when the following conditions are satisfied; otherwise, requests
17 will be returned without action, except to record noncompliance with these requirements:

- 18 1. Requested substitution is received within 60 days after the Notice of Award.
- 19 2. Requested substitution offers Owner a substantial advantage in cost, time, energy
20 conservation, or other considerations, after deducting additional responsibilities Owner
21 must assume. Owner's additional responsibilities may include compensation to Engineer
22 for redesign and evaluation services, increased cost of other construction by Owner, and
23 similar considerations.
- 24 3. Requested substitution does not require extensive revisions to the Contract Documents.
- 25 4. Requested substitution is consistent with the Contract Documents and will produce
26 indicated results.
- 27 5. Substitution request is fully documented and properly submitted.
- 28 6. Requested substitution has received necessary approvals of authorities having
29 jurisdiction.
- 30 7. Requested substitution is compatible with other portions of the Work.
- 31 8. Requested substitution has been coordinated with other portions of the Work.
- 32 9. Requested substitution provides specified warranty.
- 33 10. If requested substitution involves more than one contractor, requested substitution has
34 been coordinated with other portions of the Work, is uniform and consistent, is compatible
35 with other products, and is acceptable to all contractors involved.

36 F. If a requested substitution is approved but contains differences or omissions not specifically
37 identified to the attention of the Engineer in the substitution request, the Owner reserves the
38 right to require equal or similar features to be added to the substituted products or to have the
39 substituted products replaced at the Contractor's expense.

40 1.12 PROJECT RECORD DOCUMENTS

41 A. Recording: Maintain one copy of the Contract Documents and Shop Drawings during the
42 construction period for project record document purposes. Post changes and revisions to
43 project record documents as they occur; do not wait until end of Project.

44 B. Preparation:

- 45 1. Contract Drawings and Shop Drawings:

- 1 a. Mark revisions to show where the actual installation varies from that shown
- 2 originally.
- 3 b. Mark record sets completely and accurately, including important information that
- 4 was either shown schematically or omitted from original Drawings.
- 5 c. Mark record sets with erasable, red-colored pencil. Use other colors to distinguish
- 6 between changes for different categories of the Work at same location.
- 7 d. Record underground and under-slab piping installed, dimensioning exact location
- 8 and elevation of piping.

- 9 2. Mark Specifications to indicate the actual product installation where installation varies
- 10 from that indicated in Specifications, addenda, and contract modifications.
- 11 3. Mark Product Data to indicate the actual product installation where installation varies
- 12 substantially from that indicated in Product Data submittal.

- 13 C. Deliver: Prior to Final Completion, provide record documents to Owner as indicated below:

- 14 1. Record Drawings: Submit PDF electronic files of scanned record prints and one set of
- 15 prints.
- 16 2. Record Specifications: Submit annotated PDF electronic files of Project's Specifications,
- 17 including addenda and contract modifications.
- 18 3. Record Product Data: Submit annotated PDF electronic files and directories of each
- 19 submittal.
- 20 4. Miscellaneous Record Submittals: Submit annotated PDF electronic files directories of
- 21 each submittal.

22 1.13 OPERATION AND MAINTENANCE MANUALS

- 23 A. Prepare and submit a comprehensive manual of emergency, operation, and maintenance data
- 24 and materials in full accordance with the General and Supplementary Conditions, Division 01,
- 25 and the following:
 - 26 1. Operations and Maintenance Manuals: Assemble a complete set of data indicating
 - 27 operation and maintenance of each system, subsystem, and piece of equipment not part
 - 28 of a system, including:
 - 29 a. Information required for daily operation and management, operating standards,
 - 30 and routine and special operating procedures.
 - 31 b. Manufacturers' maintenance documentation, preventative maintenance
 - 32 procedures and frequency, repair procedures, wiring and systems diagrams, list of
 - 33 spare parts, and warranty information.
 - 34 2. Submit manuals as PDF electronic files and electronically transmit to Engineer through
 - 35 email or web-based project software site, in accordance with Division 01 Specification
 - 36 Sections. Submittals shall be in searchable PDF format and not a scanned copy.

37 1.14 DEMONSTRATION AND TRAINING

- 38 A. Prepare and provide services of qualified instructors to instruct Owner's personnel to adjust,
- 39 operate, and maintain systems, subsystems, and equipment not a part of a system in
- 40 accordance with the General and Supplementary Conditions, Division 01, individual
- 41 Specification Sections, and the following:

- 1 1. Demonstration and training shall occur upon completion of the Work and at a time
- 2 designated by the Owner's representative.
- 3 2. Provide a high-resolution, digital video recording of each training session to the Owner.

4 **1.15 DELIVERY, STORAGE, AND HANDLING**

- 5 A. Deliver, store, and handle products using means and methods that will prevent damage,
- 6 deterioration, and loss, including theft and vandalism. Comply with manufacturer's written
- 7 instructions.
- 8 B. Inspect products on delivery to determine compliance with the Contract Documents and to
- 9 determine that products are undamaged and properly protected.

10 **1.16 WARRANTY**

- 11 A. Warranty work and equipment within specified warranty period. During the warranty period,
- 12 provide labor and materials to make good any faults or imperfections that may arise due to
- 13 defects or omissions in materials or workmanship without expense to the Owner.
- 14 1. Warranty Period: One year from date of Substantial Completion.
- 15 B. Warranties specified in other Sections shall be in addition to, and run concurrent with, other
- 16 warranties required by the Contract Documents. Manufacturer's disclaimers and limitations on
- 17 product warranties do not relieve Contractor of obligations under requirements of Contract
- 18 Documents.
- 19 C. Owner reserves the right to make emergency repairs as required to keep equipment in
- 20 operation without voiding Contractor's Guarantee Bond nor relieving the Contractor of
- 21 responsibilities during the warranty period.

22 **PART 2 - PRODUCTS (NONE)**

23 **PART 3 - EXECUTION**

24 **3.1 CONTRACT DOCUMENTS**

- 25 A. Examine all drawings and specifications carefully before submitting a bid. Architectural
- 26 drawings take precedence over mechanical or electrical drawings with reference to building
- 27 construction.
- 28 B. For purposes of clearness and legibility, drawings are essentially diagrammatic and, although
- 29 size and location of equipment are drawn to scale wherever possible, Contractor shall make
- 30 use of all data in all of the contract documents and shall verify this information at the building
- 31 site.
- 32 C. The drawings indicate required size and points of termination of pipes, conduits, and ducts and
- 33 suggest proper routes to conform to structure avoid obstructions and preserve clearances.
- 34 However, it is not intended that drawings indicate all necessary offsets, and it shall be the
- 35 responsibility of the Contractor to make the installation in such a manner as to conform to
- 36 structure, avoid obstructions, preserve headroom and keep openings and passageways clear,

- 1 without further instructions or cost to the Owner.
- 2 D. Furnish, install and/or connect with appropriate services all items shown on any drawing without
3 additional compensation.
- 4 E. Any and all questions about a subcontractor's scope of work responsibility shall be addressed
5 to and answered by the General Contractor / Construction Manager.
- 6 F. Questions About Construction Documents: Any and all questions shall be submitted through
7 the proper channels IN WRITING and, in turn, shall be answered by the Engineer in writing. All
8 telephone conversations shall be considered unofficial and, as such, shall not be considered
9 official or binding responses to Contractor's questions.
- 10 G. Drawings, specifications, or other documents issued by the Engineer in electronic format and/or
11 electronic media are provided for convenience only and are not intended for use as Contract
12 Documents.
- 13 1. The electronic files are provided merely as a convenience to the Recipient.
14 2. The electronic files do not replace or supplement the paper copies of any drawings,
15 specifications, or other documents included in the Contract Documents for use on the
16 project.
17 3. The Engineer makes no representation, warranty, or guarantee that electronic files:
- 18 a. Are suitable for any other usage or purpose.
19 b. Have any particular durability.
20 c. Will not damage or impair the Recipient's computer or software.
21 d. Contain no errors or mechanical flaws or other discrepancies that may render them
22 unsuitable for the purpose intended by the Recipient.
- 23 4. Due to the unsecured nature of the electronic files and the inability of Engineer or the
24 Recipient to establish controls over their use, the Engineer assumes no responsibility for
25 any consequences arising out of the use of the data. It is the sole responsibility of the
26 Recipient to check the validity of all information contained therein. The Recipient shall at
27 all times refer to the signed and sealed drawings, specification or other documents for the
28 project during all phases of the project. The Recipient shall assume all risks and liabilities
29 resulting from the use of the electronic files.

30 3.2 SUPERVISION OF WORK

- 31 A. Perform all work under the direct supervision of an experienced, qualified superintendent. The
32 Engineer has the right to remove a superintendent who, in the Engineer's opinion, is not
33 satisfactory.

34 3.3 EXAMINATION

- 35 A. Existing Conditions: The existence and location of underground and other utilities and
36 construction indicated as existing are not guaranteed. Before beginning sitework, investigate
37 and verify the existence and location of underground utilities, mechanical and electrical
38 systems, and other construction affecting the Work.
- 39 B. Examination and Acceptance of Conditions: Before proceeding with each component of the
40 Work, examine substrates, areas, and conditions, with Installer or Applicator present where

1 indicated, for compliance with requirements for installation tolerances and other conditions
 2 affecting performance.

- 3 1. Examine roughing-in for mechanical and electrical systems to verify actual locations of
 4 connections before equipment and fixture installation.
- 5 2. Examine walls, floors, and roofs for suitable conditions where products and systems are
 6 to be installed.
- 7 3. Verify compatibility with and suitability of substrates, including compatibility with existing
 8 finishes or primers.

9 C. Proceed with installation only after unsatisfactory conditions have been corrected. Proceeding
 10 with the Work indicates acceptance of surfaces and conditions.

11 **3.4 PREPARATION**

12 A. Existing Utility Information: Furnish information to Owner that is necessary to adjust, move, or
 13 relocate existing utility structures, lines, services, or other utility appurtenances located in or
 14 affected by construction. Coordinate with authorities having jurisdiction.

15 B. Field Measurements: Take field measurements as required to fit the Work properly. Recheck
 16 measurements before installing each product. Where portions of the Work are indicated to fit to
 17 other construction, verify dimensions of other construction by field measurements before
 18 fabrication. Coordinate fabrication schedule with construction progress to avoid delaying the
 19 Work.

20 C. Space Requirements: Verify space requirements and dimensions of items shown
 21 diagrammatically on Drawings.

22 D. Review of Contract Documents and Field Conditions: Immediately on discovery of the need for
 23 clarification of the Contract Documents caused by differing field conditions outside the control of
 24 Contractor, submit a request for information to Engineer.

25 E. Interruption of Service: Before any existing equipment or system is shut down for disconnecting
 26 or tie-ins, coordinate with Engineer and Owner regarding acceptable dates and times for this
 27 Work to be performed. Work shall be performed at the time best suited for the Owner, which
 28 typically is either on weekends, holidays, and/or after normal working hours. Services shall be
 29 restored the same day unless prior arrangements are made. All overtime or premium costs
 30 associated with this Work shall be included in the Contractor's bid.

31 **3.5 INSTALLATION**

32 A. Install materials and equipment in a professional manner. The Engineer may direct
 33 replacement of items which, in the Engineer's opinion, do not present a professional
 34 appearance or do not allow adequate space for maintenance. Replace or reinstall items at the
 35 expense of the Contractor.

36 B. General: Locate the Work and components of the Work accurately, in correct alignment and
 37 elevation, as indicated.

- 38 1. Make vertical work plumb and make horizontal work level.
- 39 2. Where space is limited, install components to maximize space available for maintenance
 40 and ease of removal for replacement.
- 41 3. Conceal pipes, ducts, and wiring in finished areas unless otherwise indicated.

- 1 4. Maintain minimum headroom clearance of 96 inches (2440 mm) in occupied spaces and
2 90 inches (2300 mm) in unoccupied spaces.
- 3 C. Comply with manufacturer's written instructions and recommendations for installing products in
4 applications indicated.
- 5 D. Install products at the time and under conditions that will ensure the best possible results.
6 Maintain conditions required for product performance until Substantial Completion.
- 7 E. Conduct construction operations so no part of the Work is subjected to damaging operations or
8 loading in excess of that expected during normal conditions of occupancy.
- 9 F. Sequence the Work and allow adequate clearances to accommodate movement of construction
10 items on site and placement in permanent locations.
- 11 G. Obstructions
- 12 1. The drawings indicate certain information pertaining to surface and subsurface
13 obstructions which has been taken from available drawings. Such information is not
14 guaranteed, however, as to accuracy of location or complete information.
- 15 2. Before any cutting or trenching operations are begun, verify with Owner's representative,
16 utility companies, municipalities, and other interested parties that all available information
17 has been provided. Verify locations given.
- 18 3. Should obstruction be encountered, whether shown or not, alter routing of new work,
19 reroute existing lines, remove obstruction where permitted, or otherwise perform
20 whatever work is necessary to satisfy the purpose of the new work and leave existing
21 services and structures in a satisfactory and serviceable condition.
- 22 4. Assume total responsibility for and repair any damage to existing utilities or construction,
23 whether or not such existing facilities are shown.
- 24 H. Where "rated" walls, floor, roofs and ceilings are penetrated or cut to install equipment,
25 materials, devices, etc. the Contractor shall provide and install all materials required to re-
26 establish the rating of the wall, floor, roof, or ceiling to the satisfaction of the authority having
27 jurisdiction.
- 28 I. Structural Elements: Do not cut structural elements without written approval from Engineer.
29 Notify Engineer of locations and details of cutting and await directions from Engineer before
30 proceeding. If approved by Engineer:
- 31 1. Shore, brace, and support structural elements during cutting and patching.
- 32 2. Do not cut and patch structural elements in a manner that could change their load-
33 carrying capacity or increase deflection.
- 34 J. Space Requirements: Consider space limitations imposed by contiguous work in selection and
35 location of equipment and material. Do not provide equipment or material which is not suitable
36 in this respect.
- 37 K. Tools and Equipment: Select equipment to operate with minimum noise and vibration. If
38 objectionable noise or vibration is produced or transmitted to or through the building structure by
39 equipment, piping, ducts or other parts of work, rectify such conditions without cost to the
40 Owner.
- 41 L. Phasing: Provide all temporary valves, piping, ductwork, equipment, and devices as required.
42 Maintain temporary services to areas as required. Remove all temporary material and

1 equipment on completion of work unless Engineer concurs that such material and equipment
2 would be beneficial to the Owner on a permanent basis.

3 **3.6 OWNER-INSTALLED PRODUCTS**

4 A. Coordination: Coordinate construction and operations of the Work with work performed by
5 Owner's construction personnel.

6 **3.7 PROTECTION OF EXISTING FINISHES, CARPET, AND FURNISHING**

7 A. Protect existing finishes, carpet, casework, furnishing, and other building components against
8 damage and soiling throughout construction activities. Take care during construction not to
9 damage existing items. Contractor shall be responsible for replacing damaged material or
10 restoring damaged materials to the Owner's satisfaction.

11 B. When permitted by Engineer, items may be removed to a suitable, protected storage location
12 during construction and cleaned and reinstalled in their original locations after construction
13 operations are complete.

14 C. Furniture may be relocated during construction and reinstalled in their original locations after
15 construction operations are complete.

16 D. Means and methods for protection are the responsibility of the Contractor. Utilize plywood,
17 polyethylene sheeting, dust cloths, and other means as required.

18 **3.8 UTILITY SERVICES AND MECHANICAL SYSTEMS**

19 A. Existing Services/Systems to Remain: Maintain services/systems indicated to remain and
20 protect them against damage.

21 B. Existing Services/Systems to Be Removed, Relocated, or Abandoned: Locate, identify,
22 disconnect, and seal or cap off utility services and mechanical/electrical systems serving areas
23 to be selectively demolished.

- 24 1. Owner will arrange to shut off indicated services/systems when requested by Contractor.
25 2. Arrange to shut off utilities with utility companies.
26 3. If services/systems are required to be removed, relocated, or abandoned, provide
27 temporary services/systems that bypass area of selective demolition and that maintain
28 continuity of services/systems to other parts of building.
29 4. Disconnect, demolish, and remove HVAC systems, equipment, and components
30 indicated on Drawings to be removed.

- 31 a. Piping to Be Removed: Remove portion of piping indicated to be removed and cap
32 or plug remaining piping with same or compatible piping material.
33 b. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or
34 compatible piping material and leave in place.
35 c. Equipment to Be Removed: Disconnect and cap services and remove equipment.
36 d. Equipment to Be Removed and Reinstalled: Disconnect and cap services and
37 remove, clean, and store equipment; when appropriate, reinstall, reconnect, and
38 make equipment operational.
39 e. Equipment to Be Removed and Salvaged: Disconnect and cap services and
40 remove equipment and deliver to Owner.

- 1 f. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug
- 2 remaining ducts with same or compatible ductwork material.
- 3 g. Ducts to Be Abandoned in Place: Cap or plug ducts with same or compatible
- 4 ductwork material and leave in place.

5 **3.9 CUTTING AND PATCHING**

- 6 A. Cutting and Patching, General: Employ skilled workers to perform cutting and patching. Proceed
- 7 with cutting and patching at the earliest feasible time, and complete without delay.
- 8 1. Cut in-place construction to provide for installation of other components or performance
- 9 of other construction, and subsequently patch as required to restore surfaces to their
- 10 original condition.
- 11 B. Existing Warranties: Remove, replace, patch, and repair materials and surfaces cut or damaged
- 12 during installation or cutting and patching operations, by methods and with materials so as not
- 13 to void existing warranties.
- 14 C. Temporary Support: Provide temporary support of work to be cut.
- 15 D. Protection: Protect in-place construction during cutting and patching to prevent damage.
- 16 Provide protection from adverse weather conditions for portions of Project that might be
- 17 exposed during cutting and patching operations.
- 18 E. Structural Elements: When cutting and patching structural elements, notify Engineer of locations
- 19 and details of cutting and await directions from Engineer before proceeding. Shore, brace, and
- 20 support structural elements during cutting and patching. Do not cut and patch structural
- 21 elements in a manner that could change their load-carrying capacity or increase deflection.
- 22 F. Operational Elements: Do not cut and patch operating elements and related components in a
- 23 manner that results in reducing their capacity to perform as intended or that results in increased
- 24 maintenance or decreased operational life or safety.
- 25 G. Other Construction Elements: Do not cut and patch other construction elements or components
- 26 in a manner that could change their load-carrying capacity, that results in reducing their capacity
- 27 to perform as intended, or that result in increased maintenance or decreased operational life or
- 28 safety.
- 29 H. Visual Elements: Do not cut and patch construction in a manner that results in visual evidence
- 30 of cutting and patching. Do not cut and patch exposed construction in a manner that would, in
- 31 Engineer's opinion, reduce the building's aesthetic qualities. Remove and replace construction
- 32 that has been cut and patched in a visually unsatisfactory manner.
- 33 I. Cutting: Cut in-place construction by sawing, drilling, breaking, chipping, grinding, and similar
- 34 operations, including excavation, using methods least likely to damage elements retained or
- 35 adjoining construction. If possible, review proposed procedures with original Installer; comply
- 36 with original Installer's written recommendations.
- 37 1. In general, use hand or small power tools designed for sawing and grinding, not
- 38 hammering and chopping. Cut holes and slots neatly to minimum size required, and with
- 39 minimum disturbance of adjacent surfaces. Temporarily cover openings when not in use.
- 40 2. Finished Surfaces: Cut or drill from the exposed or finished side into concealed surfaces.
- 41 3. Concrete and Masonry: Cut using a cutting machine, such as an abrasive saw or a
- 42 diamond-core drill.

- 1 4. Excavating and Backfilling: Comply with requirements in applicable Sections where
 2 required by cutting and patching operations.
- 3 5. Mechanical and Electrical Services: Cut off pipe or conduit in walls or partitions to be
 4 removed. Cap, valve, or plug and seal remaining portion of pipe or conduit to prevent
 5 entrance of moisture or other foreign matter after cutting.
- 6 6. Proceed with patching after construction operations requiring cutting are complete.
- 7 J. Patching: Patch construction by filling, repairing, refinishing, closing up, and similar operations
 8 following performance of other work. Patch with durable seams that are as invisible as
 9 practicable. Provide materials and comply with installation requirements specified in other
 10 Sections, where applicable or with in-place materials.
- 11 1. For exposed surfaces, use materials that visually match in-place adjacent surfaces to the
 12 fullest extent possible.
- 13 2. If identical materials are unavailable or cannot be used, use materials that, when
 14 installed, will provide a match acceptable to Engineer for the visual and functional
 15 performance of in-place materials.
- 16 K. Cleaning: Clean areas and spaces where cutting and patching are performed. Remove paint,
 17 mortar, oils, putty, and similar materials from adjacent finished surfaces.
- 18 **3.10 PAINTING**
- 19 A. Comply with requirements with General and Supplementary Conditions, Division 01, Division
 20 09, and individual Specification Sections.
- 21 B. Touch-up factory finishes on equipment provided under Division 23. Obtain matched color
 22 coatings from the manufacturer and apply as directed. If corrosion is found during inspection on
 23 the surface of any equipment, clean, prime, and paint, as required.
- 24 C. Paint the following work where exposed to view:
- 25 1. Uninsulated Metal Piping (bare copper piping not required to be painted unless noted
 26 otherwise):
- 27 a. Natural or LP Gas: Yellow
- 28 b. Other: To be determined by Engineer
- 29 2. Uninsulated plastic piping
- 30 3. Tanks that do not have factory-applied final finishes.
- 31 4. Duct, equipment, and pipe insulation having a cotton or canvas insulation covering or
 32 other paintable jacket material, as outlined in individual Specification Sections.
- 33 D. Paint the following work where exposed in occupied spaces:
- 34 1. Duct, equipment, and pipe insulation having a cotton or canvas insulation covering or
 35 other paintable jacket material, as outlined in individual Specification Sections.
- 36 2. Other items as directed by Engineer.
- 37 E. Paint portions of internal surfaces of metal ducts, without liner, behind air inlets and outlets that
 38 are visible from occupied spaces.

1 **3.11 REPAIR OF WORK**

- 2 A. Complete repair and restoration operations before requesting inspection for determination of
3 Substantial Completion.
- 4 B. Repair or remove and replace defective construction. Repairing includes replacing defective
5 parts, refinishing damaged surfaces, touching up with matching materials, and properly
6 adjusting operating equipment. Where damaged or worn items cannot be repaired or restored,
7 provide replacements. Remove and replace operating components that cannot be repaired.
8 Restore damaged construction and permanent facilities used during construction to specified
9 condition.
- 10 1. Touch up and otherwise repair and restore marred or exposed finishes and surfaces.
11 Replace finishes and surfaces that that already show evidence of repair or restoration.
- 12 a. Do not paint over "UL" and other required labels and identification, including
13 mechanical and electrical nameplates. Remove paint applied to required labels
14 and identification.
- 15 2. Replace parts subject to operating conditions during construction that may impede
16 operation or reduce longevity.

17 **3.12 FIELD QUALITY CONTROL**

- 18 A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and
19 inspect components, assemblies, and equipment installations, including connections.
- 20 B. Furnish a letter from the control manufacturer stating that all controls have been checked for
21 operation and calibration, and the system is operating as designed.
- 22 C. Furnish a letter from an authorized factory representative of the air conditioning unit
23 manufacturer stating that the complete refrigeration installation including pipe sizing and routing
24 and operating and safety controls has been checked and is operating properly.
- 25 D. Tests
- 26 1. Include all tests specified and/or required under laws, rules and regulations of all
27 departments having jurisdiction. Tests shall also be performed as indicated herein and
28 other sections of the specifications.
- 29 2. After all systems have been completed and put into operation, subject each system to an
30 operating test under design conditions to ensure proper sequence and operation
31 throughout the range of operation. Make adjustments as required to ensure proper
32 functioning of all systems.
- 33 3. All parts of the work and associated equipment shall be tested and adjusted to work
34 properly and be left in perfect operating condition.
- 35 4. Correct defects disclosed by these tests without any additional cost to the Owner.
36 Repeat tests on repaired or replaced work.
- 37 5. Maintain a log of all tests being conducted and have it available for review by the
38 Engineer. Log to indicate date, type of tests, duration, and defects noted and when
39 corrected.
- 40 6. Special tests on individual systems are specified under individual Specification Sections.

1 E. Retesting/Reinspecting: Regardless of whether original tests or inspections were Contractor's
2 responsibility, provide quality-control services, including retesting and reinspecting, for
3 construction that replaced Work that failed to comply with the Contract Documents.

4 **3.13 CLEANING**

5 A. Progress Cleaning: Clean Project site and work areas daily, including common areas. Enforce
6 requirements strictly. Dispose of materials lawfully.

- 7 1. Comply with requirements in NFPA 241 for removal of combustible waste materials and
8 debris.
9 2. Do not hold waste materials more than seven days during normal weather or three days if
10 the temperature is expected to rise above 80 deg F (27 deg C).
11 3. Containerize hazardous and unsanitary waste materials separately from other waste.
12 Mark containers appropriately and dispose of legally, according to regulations.

13 B. Final Cleaning: Employ experienced workers or professional cleaners for final cleaning. Clean
14 each surface or unit to condition expected in an average commercial building cleaning and
15 maintenance program. Comply with manufacturer's written instructions.

16 1. Complete the following cleaning operations before requesting inspection for certification
17 of Substantial Completion for entire Project or for a designated portion of Project:

- 18 a. Remove tools, construction equipment, machinery, and surplus material from
19 Project site.
20 b. Remove labels that are not permanent.
21 c. Wipe surfaces of equipment. Remove excess lubrication, paint and mortar
22 droppings, and other foreign substances.

23 **3.14 MAINTENANCE SERVICE**

24 A. Maintenance Service: Beginning at Substantial Completion, maintenance service shall include
25 12 months' full maintenance by skilled employees of systems and equipment Installer. Include
26 quarterly preventive maintenance, repair or replacement of worn or defective components,
27 lubrication, cleaning, and adjusting as required for proper operation. Parts and supplies shall be
28 manufacture's authorized replacement parts and supplies.

29 **END OF SECTION 23 01 00**

1 **SECTION 23 05 13 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT**

2 **PART 1 - GENERAL**

3 **1.1 RELATED DOCUMENTS**

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

6 **1.2 SUMMARY**

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

11 **1.3 COORDINATION**

- 12 A. Coordinate features of motors, installed units, and accessory devices to be compatible with the
13 following:
- 14 1. Motor controllers.
 - 15 2. Torque, speed, and horsepower requirements of the load.
 - 16 3. Ratings and characteristics of supply circuit and required control sequence.
 - 17 4. Ambient and environmental conditions of installation location.

18 **PART 2 - PRODUCTS**

19 **2.1 GENERAL MOTOR REQUIREMENTS**

- 20 A. Comply with NEMA MG 1 unless otherwise indicated.
- 21 B. Comply with IEEE 841 for severe-duty motors.

22 **2.2 MOTOR CHARACTERISTICS**

- 23 A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet (1000 m)
24 above sea level.
- 25 B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected
26 loads at designated speeds, at installed altitude and environment, with indicated operating
27 sequence, and without exceeding nameplate ratings or considering service factor.

28 **2.3 POLYPHASE MOTORS**

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

- 1 B. Efficiency: Premium efficient, as defined in NEMA MG 1.
- 2 C. Service Factor: 1.15.
- 3 D. Power factor: 0.80.
- 4 E. Rotor: Random-wound, squirrel cage.
- 5 F. Bearings: Re-greasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
- 6 G. Temperature Rise: Match insulation rating.
- 7 H. Insulation: Class F.
- 8 I. Code Letter Designation:
 - 9 1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
 - 10 2. Motors Smaller Than 15 HP: Manufacturer's standard starting characteristic.
- 11 J. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame
- 12 sizes smaller than 324T

13 **2.4 ADDITIONAL REQUIREMENTS FOR POLYPHASE MOTORS**

- 14 A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection
- 15 requirements for controller with required motor leads. Provide terminals in motor terminal box,
- 16 suited to control method.
- 17 B. Motors Used with Variable-Frequency Controllers:
 - 18 1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and
 - 19 tested to resist transient spikes, high frequencies, and short time rise pulses produced by
 - 20 pulse-width-modulated inverters.
- 21 C. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

22 **2.5 SINGLE-PHASE MOTORS**

- 23 A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements
- 24 of specific motor application:
 - 25 1. Permanent-split capacitor.
- 26 B. Bearings: Pre-lubricated, antifriction ball bearings or sleeve bearings suitable for radial and
- 27 thrust loading.
- 28 C. Motors 1/20 HP and Smaller: Shaded-pole type.
- 29 D. Thermal Protection: Internal protection to automatically open power supply circuit to motor when
- 30 winding temperature exceeds a safe value calibrated to temperature rating of motor insulation.
- 31 Thermal-protection device shall automatically reset when motor temperature returns to normal
- 32 range.

1 **PART 3 - EXECUTION (Not Applicable)**

2 **END OF SECTION 23 05 13**

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1 **SECTION 23 05 16 - EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING**

2 **PART 1 - GENERAL**

3 **1.1 RELATED DOCUMENTS**

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

6 **1.2 SUMMARY**

- 7 A. Section Includes:
- 8 1. Metal, compensator packless expansion joints.
9 2. Flexible-hose packless expansion joints.

10 **1.3 ACTION SUBMITTALS**

- 11 A. Product Data: For each type of product.

12 **1.4 CLOSEOUT SUBMITTALS**

- 13 A. Maintenance Data: For expansion joints to include in maintenance manuals.

14 **PART 2 - PRODUCTS**

15 **2.1 PERFORMANCE REQUIREMENTS**

- 16 A. Compatibility: Products shall be suitable for piping service fluids, materials, working pressures,
17 and temperatures.
- 18 B. Capability: Products to absorb 200 percent of maximum axial movement between anchors.

19 **2.2 PACKLESS EXPANSION JOINTS**

- 20 A. Metal, Compensator Packless Expansion Joints:
- 21 1. Basis-of-Design Product: Subject to compliance with requirements, provide Twin City
22 Hose, Inc.; TCHS (steel pipe), TCHB (copper pipe) or comparable product by one of the
23 following:
- 24 a. Flex-Hose Co., Inc.
25 b. Metraflex, Inc.; SST / MLP (steel), BBS (copper).
- 26 2. Minimum Pressure Rating: 175 psig (1200 kPa), unless otherwise indicated.

- 1 3. Description: Totally enclosed, externally pressurized, multi-ply bellows isolated from fluid
- 2 flow by an internal pipe sleeve and external housing.
- 3 4. Joint Axial Movement: 2 inches (50 mm) of compression and 1/2 inch (12 mm) of
- 4 extension.
- 5 5. Configuration for Copper Tubing: Multi-ply, phosphor-bronze bellows with copper pipe
- 6 ends.

- 7 a. End Connections for Copper Tubing NPS 2 (DN 50) and Smaller: Solder joint.
- 8 b. End Connections for Copper Tubing NPS 2-1/2 to NPS 4 (DN 65 to DN 100):
- 9 Threaded.

- 10 6. Configuration for Steel Piping: Multi-ply, stainless-steel bellows; steel-pipe end
- 11 connections; and carbon-steel shroud.

- 12 a. End Connections for Steel Pipe NPS 2 (DN 50) and Smaller: Threaded.
- 13 b. End Connections for Steel Pipe NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged.

- 14 B. Flexible-Hose Packless Expansion Joints:

- 15 1. Basis-of-Design Product: Subject to compliance with requirements, provide Metraflex
- 16 Company; Superflex or comparable product by one of the following:

- 17 a. Mason Industries, Inc.; Mercer Rubber Co.
- 18 b. Metraflex, Inc.

- 19 2. Flexible Hose: Corrugated-metal inner hoses and braided outer sheaths.
- 20 3. Expansion Joints for Steel Piping NPS 2 (DN 50) and Smaller: Carbon-steel fittings with
- 21 threaded end connections.

22 **PART 3 - EXECUTION**

23 **3.1 EXPANSION JOINT INSTALLATION**

- 24 A. Install expansion joints of sizes matching sizes of piping in which they are installed.

25 **3.2 EXPANSION-JOINT SCHEDULE**

- 26 A. Chiller Evaporator and Condenser Connections: Metal compensator packless expansion joints.
- 27 B. Water Cooled Condenser: Metal compensator packless expansion expansion joints.
- 28 C. Boiler Connections: Metal compensator packless expansion joints..
- 29 D. Hydronic Pump Suction and Discharge: Metal compensator packless expansion joint..
- 30 E. Air Handling Unit Hydronic Coil Connections: Metal compensator packless expansion joints..
- 31 F. Fan Coil Unit Hydronic Coil Connections: Flexible hose packless expansion joints.
- 32 G. Terminal Unit Hydronic Coil Connections: Flexible hose packless expansion joints.
- 33 H. Chiller Refrigerant Pressure Relief Valves: Metal compensator packless expansion joints.

1 **END OF SECTION 23 05 16**

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1 **SECTION 23 05 17 - SLEEVES AND SLEEVE SEALS FOR HVAC PIPING**

2 **PART 1 - GENERAL**

3 **1.1 RELATED DOCUMENTS**

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

6 **1.2 SUMMARY**

- 7 A. Section Includes:

- 8 1. Sleeves.
9 2. Grout.
10 3. Silicone sealants.

- 11 B. Related Requirements:

- 12 1. Section 07 84 13 "Penetration Firestopping" for penetration Firestopping installed in fire-
13 resistance-rated walls, horizontal assemblies, and smoke barriers, with and without
14 penetrating items.

15 **1.3 ACTION SUBMITTALS**

- 16 A. Product Data: For each type of product.

17 **1.4 INFORMATIONAL SUBMITTALS**

- 18 A. Field quality-control reports.

19 **PART 2 - PRODUCTS**

20 **2.1 SLEEVES**

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

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

25 **2.2 GROUT**

- 26 A. Description: Non-shrink, recommended for interior and exterior sealing openings in nonfire-rated
27 walls or floors.

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

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

4 D. Packaging: Premixed and factory packaged.

5 **2.3 SILICONE SEALANTS**

6 A. Silicone, S, NS, 25, NT: Single-component, non-sag, plus 25 percent and minus 25 percent
7 movement capability, non-traffic-use, neutral-curing silicone joint sealant, ASTM C 920, Type S,
8 Grade NS, Class 25, use NT.

9 1. Sealant shall have a VOC content of 250 g/L or less.

10 B. Silicone, S, P, 25, T, NT: Single-component, pourable, plus 25 percent and minus 25 percent
11 movement capability, traffic- and non-traffic-use, neutral-curing silicone joint sealant;
12 ASTM C 920, Type S, Grade P, Class 25, Uses T and NT. Grade P Pourable (self-leveling)
13 formulation is for opening in floors and other horizontal surfaces that are not fire rated.

14 1. Sealant shall have a VOC content of 250 g/L or less.

15 C. Silicone Foam: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and
16 cure in place to produce a flexible, non-shrinking foam.

17 1. Sealant shall have a VOC content of 250 g/L or less.

18 **PART 3 - EXECUTION**

19 **3.1 SLEEVE INSTALLATION**

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

21 B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to
22 provide 12-inch (50-mm) annular clear space between piping and concrete slabs and walls.

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

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

26 1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP
27 sleeves.

28 2. Cut sleeves to length for mounting flush with both surfaces.

29 a. Exception: Extend sleeves installed in floors of mechanical equipment areas or
30 other wet areas 2 inches (50 mm) above finished floor level.

31 3. Using groutorsilicone sealant, seal space outside of sleeves in slabs and walls without
32 sleeve-seal system.

33 D. Install sleeves for pipes passing through interior partitions.

- 1 1. Cut sleeves to length for mounting flush with both surfaces.
- 2 2. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space
- 3 between sleeve and pipe or pipe insulation.
- 4 3. Seal annular space between sleeve and piping or piping insulation; use sealants
- 5 appropriate for size, depth, and location of joint.

6 E. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke-Barrier
 7 Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at
 8 pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with
 9 requirements for Firestopping and fill materials specified in Section 07 84 13 "Penetration
 10 Firestopping."

11 **3.2 FIELD QUALITY CONTROL**

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

16 **3.3 SLEEVE AND SLEEVE-SEAL SCHEDULE**

- 17 A. Use sleeves and sleeve seals for the following piping-penetration applications:
- 18 1. Exterior Concrete Walls Above Grade:
- 19 a. Piping Smaller Than NPS 6 (DN 150): Steel pipe sleeves.
- 20 b. Piping NPS 6 (DN 150) and Larger: Steel pipe sleeves.
- 21 2. Concrete Slabs Above Grade:
- 22 a. Piping Smaller Than NPS 6 (DN 150): Steel pipe sleeves.
- 23 b. Piping NPS 6 (DN 150) and Larger: Steel pipe sleeves.
- 24 3. Interior Partitions:
- 25 a. Piping Smaller Than NPS 6 (DN 150): Steel pipe sleeves .
- 26 b. Piping NPS 6 (DN 150) and Larger: Galvanized-steel sheet sleeves.

27 **END OF SECTION 23 05 17**

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1 **SECTION 23 05 18 - ESCUTCHEONS FOR HVAC PIPING**

2 **PART 1 - GENERAL**

3 **1.1 RELATED DOCUMENTS**

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

6 **1.2 SUMMARY**

- 7 A. Section Includes:

- 8 1. Escutcheons.
9 2. Floor plates.

10 **1.3 DEFINITIONS**

- 11 A. Existing Piping to Remain: Existing piping that is not to be removed and that is not otherwise
12 indicated to be removed, removed and salvaged, or removed and reinstalled.

13 **1.4 ACTION SUBMITTALS**

- 14 A. Product Data: For each type of product.

15 **PART 2 - PRODUCTS**

16 **2.1 ESCUTCHEONS**

- 17 A. One-Piece, Steel Type: With polished, chrome-plated and finish and setscrew fastener.
18 B. One-Piece, Stainless-Steel Type: With polished stainless-steel finish.
19 C. One-Piece, Cast-Brass Type: With polished, chrome-plated and polished brass finish and
20 setscrew fastener.
21 D. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished, chrome-plated
22 finish and spring-clip fasteners.
23 E. One-Piece, Stamped-Steel Type: With polished, chrome-plated finish and spring-clip fasteners.

24 **2.2 FLOOR PLATES**

- 25 A. .
26 B. One-Piece Floor Plates: Cast-iron flange.

1 **PART 3 - EXECUTION**

2 **3.1 INSTALLATION**

- 3 A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.
- 4 B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD
5 that completely covers opening.
- 6 1. Escutcheons for New Piping
- 7 a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep pattern.
- 8 b. Insulated Piping: One-piece stamped steel with polished, chrome-plated finish.
- 9 c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece cast
10 brass with polished, chrome-plated finish.
- 11 d. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece cast brass with
12 polished, chrome-plated finish.
- 13 e. Bare Piping in Unfinished Service Spaces: One-piece cast brass with rough-brass
14 finish.
- 15 f. Bare Piping in Equipment Rooms: One-piece cast brass with rough-brass finish.
- 16 C. Install floor plates for piping penetrations of equipment-room floors.
- 17 D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD
18 that completely covers opening.
- 19 1. New Piping One piece floor plate.

20 **3.2 FIELD QUALITY CONTROL**

- 21 A. Using new materials, replace broken and damaged escutcheons and floor plates.

22 **END OF SECTION 23 05 18**

1 **SECTION 23 05 19 - METERS AND GAGES FOR HVAC PIPING**

2 **PART 1 - GENERAL**

3 **1.1 RELATED DOCUMENTS**

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

6 **1.2 SUMMARY**

- 7 A. Section Includes:

- 8 1. Liquid-in-glass thermometers.
9 2. Thermowells.
10 3. Dial-type pressure gages.
11 4. Gage attachments.
12 5. Test plugs.

- 13 B. Related Requirements:

- 14 1. Section 231123 "Facility Natural-Gas Piping" for gas meters.

15 **1.3 ACTION SUBMITTALS**

- 16 A. Product Data: For each type of product.

17 **1.4 INFORMATIONAL SUBMITTALS**

- 18 A. Product Certificates: For each type of meter and gage, from manufacturer

19 **1.5 CLOSEOUT SUBMITTALS**

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

22 **PART 2 - PRODUCTS**

23 **2.1 FILLED-SYSTEM THERMOMETERS**

- 24 A. Remote-Mounted, Metal-Case, Vapor-Actuated Thermometers:

- 25 1. Basis-of-Design Product: Subject to compliance with requirements, provide Trerice H.O.
26 Co.; V803 or comparable product by one of the following:

- 27 a. Ashcroft Inc.
28 b. Miljoco Corporation.

- 1 c. Weiss Instruments, Inc.
- 2 2. Standard: ASME B40.200.
- 3 3. Case: Sealed type, cast aluminum or drawn steel; 4-1/2-inch (114-mm) nominal diameter
- 4 with back flange and holes for panel mounting.
- 5 4. Element: Bourdon tube or other type of pressure element.
- 6 5. Movement: Mechanical, with link to pressure element and connection to pointer.
- 7 6. Dial: Non-reflective aluminum with permanently etched scale markings graduated in
- 8 deg F (deg C).
- 9 7. Pointer: Dark-colored metal.
- 10 8. Window: Glass.
- 11 9. Ring: Stainless steel.
- 12 10. Connector Type(s): Union joint, back for panel mount applications, bottom otherwise; with
- 13 ASME B1.1 screw threads.
- 14 11. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of
- 15 length to suit installation.
- 16 a. Design for Air-Duct Installation: Helical bulb with 3-inch outside diameter reversible
- 17 aluminum flange.
- 18 b. Design for Thermowell Installation: Bare stem.
- 19 12. Accuracy: Plus or minus 1 percent of scale range.

20 2.2 LIQUID-IN-GLASS THERMOMETERS

- 21 A. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:
- 22 1. Basis-of-Design Product: Subject to compliance with requirements, provide Terrice, H.O.
- 23 Co.; BX9 or comparable product by one of the following:
- 24 a. Miljoco Corporation.
- 25 b. Weiss Instruments, Inc.
- 26 c. Winters Instruments - U.S.
- 27 2. Standard: ASME B40.200.
- 28 3. Case: Cast aluminum; 9-inch (229-mm) nominal size unless otherwise indicated.
- 29 4. Case Form: Adjustable angle unless otherwise indicated.
- 30 5. Tube: Glass with magnifying lens and blue or red organic liquid.
- 31 6. Tube Background: Non-reflective aluminum with permanently etched scale markings
- 32 graduated in deg F (deg C).
- 33 7. Window: Glass.
- 34 8. Stem: Brass and of length to suit installation.
- 35 a. Design for Air-Duct Installation: With 6-inch (152-mm) aluminum ventilated air-duct
- 36 stem and 3-inch (76-mm) outside diameter reversible aluminum flange and
- 37 perforated aluminum guard.
- 38 b. Design for Thermowell Installation: Bare stem.
- 39 9. Connector: 1-1/4 inches (32 mm), with ASME B1.1 screw threads.
- 40 10. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of
- 41 1.5 percent of scale range.

1 **2.3 DUCT-THERMOMETER MOUNTING BRACKETS**

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

4 **2.4 THERMOWELLS**

5 A. Thermowells:

- 6 1. Standard: ASME B40.200.
- 7 2. Description: Pressure-tight, socket-type fitting made for insertion in piping tee fitting.
- 8 3. Material for Use with Copper Tubing: CNR (copper nickel 90-10).
- 9 4. Material for Use with Steel Piping: CRES (stainless steel).
- 10 5. Type: Stepped shank unless straight or tapered shank is indicated.
- 11 6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, (DN 15, DN 20, or NPS 25,) ASME B1.20.1 pipe threads.
- 12 7. Internal Threads: 1/2, 3/4, and 1 inch (13, 19, and 25 mm), with ASME B1.1 screw threads.
- 13 8. Bore: Diameter required to match thermometer bulb or stem.
- 14 9. Insertion Length: Length required to match thermometer bulb or stem.
- 15 10. Lagging Extension: Include on thermowells for insulated piping and tubing.
- 16 11. Bushings: For converting size of thermowell's internal screw thread to size of
17 thermometer connection.
- 18 19

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

21 **2.5 PRESSURE GAGES**

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

- 23 1. Basis-of-Design Product: Subject to compliance with requirements, provide Trerice, H.O.
24 Co.; 600CB or comparable product by one of the following:
 - 25 a. Ashcroft Inc.
 - 26 b. Miljoco Corporation.
 - 27 c. Weiss Instruments, Inc.
 - 28 d. Winters Instruments - U.S.
- 29 2. Standard: ASME B40.100.
- 30 3. Case: Solid-front, pressure relief type(s); cast aluminum; 4-1/2-inch (114-mm) nominal
31 diameter.
- 32 4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
- 33 5. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2 (DN 8 or DN 15), ASME B1.20.1
34 pipe threads and bottom-outlet type unless back-outlet type is indicated.
- 35 6. Movement: Mechanical, with link to pressure element and connection to pointer.
- 36 7. Dial: Non-reflective aluminum with permanently etched scale markings graduated in psi
37 (kPa).
- 38 8. Pointer: Dark-colored metal.
- 39 9. Window: Glass.
- 40 10. Ring: Stainless steel.
- 41 11. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

42 B. Remote-Mounted, Metal-Case, Dial-Type Pressure Gages:

- 1 1. Basis-of-Design Product: Subject to compliance with requirements, provide Trerice, H.O.
 2 Co.; 600CB w/ threaded diaphragm and capillary tubing kit or comparable product by one
 3 of the following:
- 4 a. Ashcroft Inc.
 5 b. Miljoco Corporation.
 6 c. Weiss Instruments, Inc.
 7 d. Winters Instruments - U.S.
- 8 2. Standard: ASME B40.100.
 9 3. Case: Solid-front, pressure relief type; cast aluminum; 4-1/2-inch (114-mm) nominal
 10 diameter with back flange and holes for panel mounting.
 11 4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
 12 5. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2 (DN 8 or DN 15), ASME B1.20.1
 13 pipe threads and bottom-outlet type unless back-outlet type is indicated.
 14 6. Movement: Mechanical, with link to pressure element and connection to pointer.
 15 7. Dial: Non-reflective aluminum with permanently etched scale markings graduated in psi
 16 (kPa).
 17 8. Pointer: Dark-colored metal.
 18 9. Window: Glass.
 19 10. Ring: Stainless steel.
 20 11. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

21 **2.6 GAGE ATTACHMENTS**

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

26 **2.7 TEST PLUGS**

- 27 A. Basis-of-Design Product: Subject to compliance with requirements, provide Petersen Equipment
 28 Co., Inc.; Model 310-110-XL or comparable product by one of the following:
- 29 1. Sisco Manufacturing Company, Inc.
 30 2. Trerice, H. O. Co.
 31 3. Weiss Instruments, Inc.
- 32 B. Description: Test-station fitting made for insertion in piping tee fitting.
- 33 C. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include
 34 extended stem on units to be installed in insulated piping.
- 35 D. Thread Size: NPS 1/4 (DN 8), ASME B1.20.1 pipe thread.
- 36 E. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F (3450 kPa at 93 deg C).
- 37 F. Core Inserts: EPDM self-sealing rubber.

1 **PART 3 - EXECUTION**

2 **3.1 INSTALLATION**

- 3 A. Install thermowells with socket extending a minimum of 2 inches (51 mm) into fluid and in
4 vertical position in piping tees.
- 5 B. Install thermowells of sizes required to match thermometer connectors. Include bushings if
6 required to match sizes.
- 7 C. Install thermowells with extension on insulated piping.
- 8 D. Fill thermowells with heat-transfer medium.
- 9 E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.
- 10 F. Install duct-thermometer mounting brackets in walls of ducts. Attach to duct with screws.
- 11 G. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the
12 most readable position.
- 13 H. Install remote-mounted pressure gages on panel.
- 14 I. Install valve and snubber in piping for each pressure gage for fluids (except steam).
- 15 J. Install test plugs in piping tees.
- 16 K. Assemble and install connections, tubing, and accessories between flow-measuring elements
17 and flowmeters according to manufacturer's written instructions.
- 18 L. Install flowmeter elements in accessible positions in piping systems.
- 19 M. Install flowmeter elements, with at least minimum straight lengths of pipe, upstream and
20 downstream from element according to manufacturer's written instructions.
- 21 N. Install Venturi flowmeter downstream of electromagnetic flowmeters, with at least minimum
22 straight lengths of pipe, upstream and downstream from meter according to manufacturer's
23 written instructions. Straight lengths of pipe required downstream of electromagnetic flowmeter
24 and upstream of Venturi flowmeter may be shared.
- 25 O. Install permanent indicators on walls or brackets in accessible and readable positions.
- 26 P. Install connection fittings in accessible locations for attachment to portable indicators.
- 27 Q. Mount thermal-energy meters on wall if accessible; if not, provide brackets to support meters.
- 28 R. Install thermometers in the following locations:
 - 29 1. Inlet and outlet of each hydronic zone.
 - 30 2. Inlet and outlet of each hydronic boiler.
 - 31 3. Inlets and outlets of each chiller.
 - 32 4. Inlet and outlet of each hydronic coil in air-handling units.
 - 33 5. Inlet and outlet of each storage tank.
 - 34 6. Air handler supply air ducts with an airflow of 2000 cfm or greater.

- 1 S. Install pressure gages in the following locations:
- 2 1. Discharge of each pressure-reducing valve.
- 3 2. Inlet and outlet of each chiller chilled-water and condenser-water connection.
- 4 3. Suction and discharge of each pump.
- 5 4. Inlet and outlet of each air handling unit hydronic coil.

- 6 T. Install test plugs in the following locations:
- 7 1. Inlet and outlet of each hydronic coil.
- 8 2. Inlet and outlet of each control valve.

9 **3.2 CONNECTIONS**

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

15 **3.3 ADJUSTING**

- 16 A. After installation, calibrate meters according to manufacturer's written instructions.
- 17 B. Adjust faces of meters and gages to proper angle for best visibility.

18 **3.4 THERMOMETER SCHEDULE**

- 19 A. Thermometers at inlet and outlet of each hydronic zone shall be the following:
- 20 1. Remote-.
- 21 2. Industrial-style, liquid-in-glass type.
- 22 B. Thermometers at inlet and outlet of each hydronic boiler shall be the following:
- 23 1. where indicated.
- 24 2. Industrial-style, liquid-in-glass type.
- 25 3. Test plug with EPDM self-sealing rubber inserts shall be provided in addition to industrial
- 26 or remote mounted thermometers.
- 27 C. Thermometers at inlets and outlets of each chiller shall be the following:
- 28 1. Remote-mounted, metal-case, vapor-actuated type where indicated.
- 29 2. Industrial-style, liquid-in-glass type.
- 30 3. Test plug with EPDM self-sealing rubber inserts shall be provided in addition to industrial
- 31 or remote mounted thermometers.
- 32 D. Thermometers at inlet and outlet of each hydronic coil in air-handling units and built-up central
- 33 systems shall be the following:

- 1 1. Remote-mounted, metal-case, vapor-actuated type where indicated.
 2 2. Industrial-style, liquid-in-glass type.
 3 3. Test plug with EPDM self-sealing rubber inserts shall be provided in addition to industrial
 4 or remote mounted thermometers.
- 5 E. Thermometers at inlet and outlet of each hydronic heat-recovery unit shall be the following:
- 6 1. Remote-mounted, metal-case, vapor-actuated type where indicated.
 7 2. Industrial-style, liquid-in-glass type.
 8 3. Test plug with EPDM self-sealing rubber inserts shall be provided in addition to industrial
 9 or remote mounted thermometers.
- 10 F. Thermometers at inlet and outlet of each thermal-storage tank shall be the following:
- 11 1. Industrial-style, liquid-in-glass type.
 12 2. Test plug with EPDM self-sealing rubber inserts shall be provided in addition to industrial
 13 or remote mounted thermometers.
- 14 G. Thermometers at supply-, -air ducts shall be the following:
- 15 1. Remote]-mounted, case, vapor-actuated type where indicatedIndustrial-style, liquid-in-
 16 glass type.
- 17 H. Thermometer stems shall be of length to match thermowell insertion length.

18 **3.5 THERMOMETER SCALE-RANGE SCHEDULE**

- 19 A. Scale Range for Chilled-Water Piping: 0 to 100 deg F (Minus 20 to plus 50 deg C).
 20 B. Scale Range for Process Cooling-Water Piping: 0 to 150 deg F (Minus 20 to plus 70 deg C).
 21 C. Scale Range for Heat Recovery-Water Piping: 0 to 150 deg F (Minus 20 to plus 70 deg C).
 22 D. Scale Range for Heating, Hot-Water Piping: 20 to 240 deg F (0 to 150 deg C).
 23 E. Scale Range for Air Ducts: 0 to 150 deg F (Minus 20 to plus 70 deg C).

24 **3.6 PRESSURE-GAGE SCHEDULE**

- 25 A. Pressure gages at discharge of each pressure-reducing valve shall be the following:
- 26 1. Solid-front, pressure-relief,-remote mounted where indicated on plans, direct mounted
 27 otherwise, metal case.
- 28 B. Pressure gages at inlet and outlet of each chiller chilled-water and condenser-water connection
 29 shall be the following:
- 30 1. Solid-front, pressure-relief,-remote mounted where indicated on plans, direct mounted
 31 otherwise, metal case.
 32 2. Test plug with EPDM self-sealing rubber inserts shall be provided in addition to direct or
 33 remote mounted gages.
- 34 C. Pressure gages at suction and discharge of each pump shall be the following:

- 1 1. Solid-front, pressure-relief, remote mounted where indicated on plans, direct mounted
- 2 otherwise, metal case.
- 3 2. Test plug with self-sealing rubber inserts shall be provided in addition to direct or remote
- 4 mounted gages.

5 **3.7 PRESSURE-GAGE SCALE-RANGE SCHEDULE**

- 6 A. Scale Range for Chilled-Water Piping: 0 to 160 psi (0 to 1100 kPa).
- 7 B. Scale Range for Process Cooling-Water Piping: 0 to 160 psi (0 to 1100 kPa).
- 8 C. Scale Range for Heat Recovery-Water Piping: 0 to 160 psi (0 to 1100 kPa).
- 9 D. Scale Range for Heating, Hot-Water Piping: 0 to 160 psi (0 to 1100 kPa).

10 **3.8 FLOWMETER SCHEDULE**

- 11 A. Flowmeters for Chilled-Water Piping: Venturi type.
- 12 B. Flowmeters for Process Cooling-Water Piping: Venturi type.
- 13 C. Flowmeters for Heat Recovery-Water Piping: Venturi type.
- 14 D. Flowmeters for Heating, Hot-Water Piping: Venturi type.

15 **END OF SECTION 23 05 19**

1 **SECTION 23 05 23.12 - BALL VALVES FOR HVAC PIPING**

2 **PART 1 - GENERAL**

3 **1.1 RELATED DOCUMENTS**

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

6 **1.2 SUMMARY**

- 7 A. Section Includes:
8 1. Bronze ball valves.
9 2.

10 **1.3 DEFINITIONS**

- 11 A. CWP: Cold working pressure.
12 B. SWP: Steam working pressure.

13 **1.4 ACTION SUBMITTALS**

- 14 A. Product Data: For each type of valve.

15 **1.5 DELIVERY, STORAGE, AND HANDLING**

- 16 A. Prepare valves for shipping as follows:
17 1. Protect internal parts against rust and corrosion.
18 2. Protect threads, flange faces, and weld ends.
19 3. Set ball valves open to minimize exposure of functional surfaces.
20 B. Use the following precautions during storage:
21 1. Maintain valve end protection.
22 2. Store valves indoors and maintain at higher-than-ambient-dew-point temperature. If
23 outdoor storage is necessary, store valves off the ground in watertight enclosures.

24 **PART 2 - PRODUCTS**

25 **2.1 GENERAL REQUIREMENTS FOR VALVES**

- 26 A. Source Limitations for Valves: Obtain each type of valve from single source from single
27 manufacturer.

- 1 B. ASME Compliance:
- 2 1. ASME B1.20.1 for threads for threaded-end valves.
- 3 2. ASME B31.9 for building services piping valves.
- 4 C. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with
- 5 copper alloy (brass) containing more than 15 percent zinc are not permitted.
- 6 D. Refer to HVAC valve schedule articles for applications of valves.
- 7 E. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system
- 8 pressures and temperatures.
- 9 F. Valve Sizes: Same as upstream piping unless otherwise indicated.
- 10 G. Valve Actuator Types:
- 11 1. Handlever
- 12 H. Valves in Insulated Piping:
- 13 1. Include 2-inch (50-mm) stem extensions.
- 14 2. Extended operating handle of non-thermal-conductive material, and protective sleeves
- 15 that allow operation of valves without breaking the vapor seals or disturbing insulation.
- 16 3. Memory stops that are fully adjustable after insulation is applied.
- 17 I. Valve Bypass and Drain Connections: MSS SP-45.

18 **2.2 BRONZE BALL VALVES**

- 19 A. Bronze Ball Valves, Two-Piece with Full Port and Stainless-Steel Trim:
- 20 1. Description:
- 21 a. Standard: MSS SP-110.
- 22 b. SWP Rating: 150 psig (1035 kPa).
- 23 c. CWP Rating: 600 psig (4140 kPa).
- 24 d. Body Design: Two piece.
- 25 e. Body Material: Bronze.
- 26 f. Ends: Threaded.
- 27 g. Seats: PTFE.
- 28 h. Stem: Stainless steel.
- 29 i. Ball: Stainless steel, vented.
- 30 j. Port: Full.

31 **PART 3 - EXECUTION**

32 **3.1 EXAMINATION**

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

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

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

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

5 **3.2 VALVE INSTALLATION**

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

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

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

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

11 E. Install valve tags. Comply with requirements in Section 23 05 53 "Identification for HVAC Piping
12 and Equipment" for valve tags and schedules.

13 **3.3 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS**

14 A. If valves with specified SWP classes or CWP ratings are unavailable, the same types of valves
15 with higher SWP classes or CWP ratings may be substituted.

16 B. Select valves with the following end connections:

- 17 1. For Copper Tubing, NPS 2 (DN 50) and Smaller: Threaded
- 18 2. For Steel Piping, NPS 2 (DN 50) and Smaller: Threaded ends.

19 **3.4 CHILLED-WATER VALVE SCHEDULE**

20 A. Pipe NPS 2 (DN 50) and Smaller: Bronze ball valves, two piece, with stainless-steel trim, and
21 full port.

22 **3.5 PROCESS COOLING-WATER VALVE SCHEDULE**

23 A. Pipe NPS 2 (DN 50) and Smaller: Bronze ball valves, two piece with stainless-steel trim, and
24 full port.

25 **3.6 HEAT RECOVERY-WATER VALVE SCHEDULE**

26 A. Pipe NPS 2 (DN 50) and Smaller: Bronze ball valves, two piece with stainless-steel trim, and
27 full port.

1 **3.7 HEATING-WATER VALVE SCHEDULE**

2 A. Pipe NPS 2 (DN 50) and Smaller: Bronze ball valves, two piece with stainless-steel trim, and full
3 port.

4 **END OF SECTION 23 05 23.12**

1 **SECTION 23 05 23.13 - BUTTERFLY VALVES FOR HVAC PIPING**

2 **PART 1 - GENERAL**

3 **1.1 RELATED DOCUMENTS**

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

6 **1.2 SUMMARY**

- 7 A. Section Includes:
- 8 1. Iron, single-flange butterfly valves.
 - 9 2. Chainwheels.

10 **1.3 DEFINITIONS**

- 11 A. CWP: Cold working pressure.
- 12 B. EPDM: Ethylene propylene copolymer rubber.
- 13 C. SWP: Steam working pressure.

14 **1.4 ACTION SUBMITTALS**

- 15 A. Product Data: For each type of valve.

16 **1.5 DELIVERY, STORAGE, AND HANDLING**

- 17 A. Prepare valves for shipping as follows:
- 18 1. Protect internal parts against rust and corrosion.
 - 19 2. Protect threads, flange faces, grooves, and weld ends.
 - 20 3. Set butterfly valves closed or slightly open.
- 21 B. Use the following precautions during storage:
- 22 1. Maintain valve end protection.
 - 23 2. Store valves indoors and maintain at higher-than-ambient-dew-point temperature. If
24 outdoor storage is necessary, store valves off the ground in watertight enclosures.
- 25 C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use
26 handwheels or stems as lifting or rigging points.

1 **PART 2 - PRODUCTS**

2 **2.1 GENERAL REQUIREMENTS FOR VALVES**

- 3 A. Source Limitations for Valves: Obtain each type of valve from single source from single
4 manufacturer.
- 5 B. ASME Compliance:
- 6 1. ASME B16.1 for flanges on iron valves.
7 2. ASME B16.5 for pipe flanges and flanged fittings, NPS 1/2 through NPS 24.
8 3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
9 4. ASME B31.9 for building services piping valves.
- 10 C. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.
- 11 D. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system
12 pressures and temperatures.
- 13 E. Valve Sizes: Same as upstream piping unless otherwise indicated.
- 14 F. Valve Actuator Types:
- 15 1. Gear Actuator: For valves NPS 8 (DN 200) and larger.
16 2. Handlever: For valves NPS 6 (DN 150) and smaller.
17 3. Chainwheel: Device for attachment to gear, stem, or other actuator of size and with chain
18 for mounting height, according to "Valve Installation" Article.
- 19 G. Valves in Insulated Piping: With 2-inch (50-mm) stem extensions with extended necks.

20 **2.2 IRON, SINGLE-FLANGE BUTTERFLY VALVES**

- 21 A. Iron, Single-Flange Butterfly Valves with Aluminum-Bronze Disc:
22
23 1. Description:
- 24 a. Standard: MSS SP-67, Type I.
25 b. CWP Rating: 150 psig (1035 kPa)
26 c. Body Design: Lug type; suitable for bidirectional dead-end service at rated
27 pressure without use of downstream flange.
28 d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
29 e. Seat: EPDM.
30 f. Stem: One- or two-piece stainless steel.
31 g. Disc: Aluminum bronze.

32 **2.3 CHAINWHEELS**

- 33 A. Description: Valve actuation assembly with sprocket rim, chain guides, chain.
- 34 1. Sprocket Rim with Chain Guides: Ductile iron, of type and size required for valve. Include
35 zinc or epoxy coating.
36 2. Chain: Hot-dip, galvanized steel, of size required to fit sprocket rim.

1 **PART 3 - EXECUTION**

2 **3.1 EXAMINATION**

- 3 A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove
4 special packing materials, such as blocks, used to prevent disc movement during shipping and
5 handling.
- 6 B. Operate valves in positions from fully open to fully closed. Examine guides and seats made
7 accessible by such operations.
- 8 C. Examine mating flange faces for damage. Check bolting for proper size, length, and material.
9 Verify that gasket is of proper size, that its material composition is suitable for service, and that
10 it is free from defects and damage.
- 11 D. Do not attempt to repair defective valves; replace with new valves.

12 **3.2 VALVE INSTALLATION**

- 13 A. Install valves with unions or flanges at each piece of equipment arranged to allow service,
14 maintenance, and equipment removal without system shutdown.
- 15 B. Locate valves for easy access and provide separate support where necessary.
- 16 C. Install valves in horizontal piping with stem at or above center of pipe.
- 17 D. Install valves in position to allow full stem movement.
- 18 E. Install chainwheels on operators for butterfly valves NPS 4 (DN 100) and larger and more than
19 96 inches (2400 mm) above floor. Extend chains to 60 inches (1520 mm) above finished floor.
- 20 F. Install valve tags. Comply with requirements in Section 23 05 53 "Identification for HVAC Piping
21 and Equipment" for valve tags and schedules.

22 **3.3 ADJUSTING**

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

25 **3.4 CHILLED-WATER VALVE SCHEDULE**

- 26 A. Pipe NPS 2-1/2 (DN 65) and Larger:
 - 27 1. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): Aluminum-
28 bronze disc, 200 CWP, and EPDM seat.

29 **3.5 PROCESS COOLING-WATER VALVE SCHEDULE**

- 30 A. Pipe NPS 2-1/2 (DN 65) and Larger:

- 1 1. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): Aluminum-
2 bronze disc, 200 CWP, and EPDM seat.

3 **3.6 HEAT RECOVERY-WATER VALVE SCHEDULE**

- 4 A. Pipe NPS 2-1/2 (DN 65) and Larger:

- 5 1. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): Aluminum-
6 bronze disc, 200 CWP, and EPDM seat.

7 **3.7 HEATING-WATER VALVE SCHEDULE**

- 8 A. Pipe NPS 2-1/2 (DN 65) and Larger:

- 9 1. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): Aluminum-
10 bronze disc, 200 CWP, and EPDM seat.

11 **END OF SECTION 23 05 23.13**

1 **SECTION 23 05 23.14 - CHECK VALVES FOR HVAC PIPING**

2 **PART 1 - GENERAL**

3 **1.1 RELATED DOCUMENTS**

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

6 **1.2 SUMMARY**

- 7 A. Section Includes:

- 8 1. Bronze swing check valves.
9 2. Iron swing check valves.
10 3. Iron, center-guided check valves.

11 **1.3 DEFINITIONS**

- 12 A. CWP: Cold working pressure.
13 B. EPDM: Ethylene propylene copolymer rubber.
14 C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.
15 D. SWP: Steam working pressure.

16 **1.4 ACTION SUBMITTALS**

- 17 A. Product Data: For each type of valve.

18 **1.5 DELIVERY, STORAGE, AND HANDLING**

- 19 A. Prepare valves for shipping as follows:

- 20 1. Protect internal parts against rust and corrosion.
21 2. Protect threads, flange faces, grooves, and weld ends.
22 3. Block check valves in either closed or open position.

- 23 B. Use the following precautions during storage:

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

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

1 **PART 2 - PRODUCTS**

2 **2.1 GENERAL REQUIREMENTS FOR VALVES**

- 3 A. Source Limitations for Valves: Obtain each type of valve from single source from single
4 manufacturer.
- 5 B. ASME Compliance:
- 6 1. ASME B1.20.1 for threads for threaded-end valves.
 - 7 2. ASME B16.1 for flanges on iron valves.
 - 8 3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
 - 9 4. ASME B16.18 for solder joint.
 - 10 5. ASME B31.1 for power piping valves.
 - 11 6. ASME B31.9 for building services piping valves.
- 12 C. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with
13 copper alloy (brass) containing more than 15 percent zinc are not permitted.
- 14 D. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system
15 pressures and temperatures.
- 16 E. Valve Sizes: Same as upstream piping unless otherwise indicated.
- 17 F. Valve Bypass and Drain Connections: MSS SP-45.

18 **2.2 BRONZE SWING CHECK VALVES**

- 19 A. Bronze Swing Check Valves with Nonmetallic Disc, Class 150:
- 20 1. Manufacturers: Subject to compliance with requirements, provide products by one of the
21 following:
 - 22 a. Crane Co.; Crane Valve Group; Crane Valves.
 - 23 b. Hammond Valve.
 - 24 c. Milwaukee Valve Company.
 - 25 d. NIBCO INC.
 - 26 e. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
 - 27 2. Description:
 - 28 a. Standard: MSS SP-80, Type 4.
 - 29 b. CWP Rating: 300 psig (2070 kPa).
 - 30 c. Body Design: Horizontal flow.
 - 31 d. Body Material: ASTM B 62, bronze.
 - 32 e. Ends: Threaded.
 - 33 f. Disc: PTFE.

34 **2.3 IRON SWING CHECK VALVES**

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

- 1 1. Manufacturers: Subject to compliance with requirements, provide products by one of the
 2 following:
- 3 a. Crane Co.; Crane Valve Group; Stockham Division.
 4 b. Hammond Valve.
 5 c. Milwaukee Valve Company.
 6 d. NIBCO INC.
 7 e. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
- 8 2. Description:
- 9 a. Standard: MSS SP-71, Type I.
 10 b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
 11 c. NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
 12 d. Body Design: Clear or full waterway.
 13 e. Body Material: ASTM A 126, gray iron with bolted bonnet.
 14 f. Ends: Flanged.
 15 g. Trim: Bronze.
 16 h. Gasket: Asbestos free.
- 17 B. Iron Swing Check Valves with Metal Seats, Class 250:
- 18 1. Manufacturers: Subject to compliance with requirements, provide products by one of the
 19 following:
- 20 a. Crane Co.; Crane Valve Group; Stockham Division.
 21 b. Hammond Valve.
 22 c. Milwaukee Valve Company.
 23 d. NIBCO INC.
 24 e. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
- 25 2. Description:
- 26 a. Standard: MSS SP-71, Type I.
 27 b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 500 psig (3450 kPa).
 28 c. NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 300 psig (2070 kPa).
 29 d. Body Design: Clear or full waterway.
 30 e. Body Material: ASTM A 126, gray iron with bolted bonnet.
 31 f. Ends: Flanged.
 32 g. Trim: Bronze.
 33 h. Gasket: Asbestos free.

34 2.4 IRON, CENTER-GUIDED CHECK VALVES

- 35 A. Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat, Class 125:
- 36 1. Manufacturers: Subject to compliance with requirements, provide products by one of the
 37 following:
- 38 a. Crispin Valve.
 39 b. Hammond Valve.
 40 c. Milwaukee Valve Company.
 41 d. Mueller Steam Specialty; a division of SPX Corporation.
 42 e. NIBCO INC.

- 1 f. Spence Strainers International; a division of CIRCOR International.
 2 g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
- 3 2. Description:
- 4 a. Standard: MSS SP-125.
 5 b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
 6 c. NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
 7 d. Body Material: ASTM A 126, gray iron.
 8 e. Style: Compact wafer.
 9 f. Seat: Bronze.
- 10 B. Iron, Globe, Center-Guided Check Valves with Metal Seat, Class 125:
- 11 1. Manufacturers: Subject to compliance with requirements, provide products by one of the
 12 following:
- 13 a. Crispin Valve.
 14 b. Hammond Valve.
 15 c. Milwaukee Valve Company.
 16 d. Mueller Steam Specialty; a division of SPX Corporation.
 17 e. NIBCO INC.
 18 f. Spence Strainers International; a division of CIRCOR International.
 19 g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
- 20 2. Description:
- 21 a. Standard: MSS SP-125.
 22 b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
 23 c. NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
 24 d. Body Material: ASTM A 126, gray iron.
 25 e. Style: Globe, spring loaded.
 26 f. Ends: Flanged.
 27 g. Seat: Bronze.
- 28 C. Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat, Class 250:
- 29 1. Manufacturers: Subject to compliance with requirements, provide products by one of the
 30 following:
- 31 a. Crispin Valve.
 32 b. Hammond Valve.
 33 c. Milwaukee Valve Company.
 34 d. Mueller Steam Specialty; a division of SPX Corporation.
 35 e. NIBCO INC.
 36 f. Spence Strainers International; a division of CIRCOR International.
 37 g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
- 38 2. Description:
- 39 a. Standard: MSS SP-125.
 40 b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 400 psig (2760 kPa).
 41 c. NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 300 psig (2070 kPa).
 42 d. Body Material: ASTM A 126, gray iron.
 43 e. Style: Compact wafer, spring loaded.

- 1 f. Seat: Bronze.
- 2 D. Iron, Globe, Center-Guided Check Valves with Metal Seat, Class 250:
- 3 1. Manufacturers: Subject to compliance with requirements, provide products by one of the
- 4 following:
- 5 a. Crispin Valve.
- 6 b. Hammond Valve.
- 7 c. Milwaukee Valve Company.
- 8 d. Mueller Steam Specialty; a division of SPX Corporation.
- 9 e. NIBCO INC.
- 10 f. Spence Strainers International; a division of CIRCOR International.
- 11 g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
- 12 2. Description:
- 13 a. Standard: MSS SP-125.
- 14 b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 400 psig (2760 kPa).
- 15 c. NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 300 psig (2070 kPa).
- 16 d. Body Material: ASTM A 126, gray iron.
- 17 e. Style: Globe, spring loaded.
- 18 f. Ends: Flanged.
- 19 g. Seat: Bronze.

20 PART 3 - EXECUTION

21 3.1 EXAMINATION

- 22 A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove
- 23 special packing materials, such as blocks, used to prevent disc movement during shipping and
- 24 handling.
- 25 B. Operate valves in positions from fully open to fully closed. Examine guides and seats made
- 26 accessible by such operations.
- 27 C. Examine threads on valve and mating pipe for form and cleanliness.
- 28 D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper
- 29 size, length, and material. Verify that gasket is of proper size, that its material composition is
- 30 suitable for service, and that it is free from defects and damage.
- 31 E. Do not attempt to repair defective valves; replace with new valves.

32 3.2 VALVE INSTALLATION

- 33 A. Install valves with unions or flanges at each piece of equipment arranged to allow service,
- 34 maintenance, and equipment removal without system shutdown.
- 35 B. Locate valves for easy access and provide separate support where necessary.
- 36 C. Install valves in horizontal piping with stem at or above center of pipe.

- 1 D. Install valves in position to allow full stem movement.
- 2 E. Install check valves for proper direction of flow and as follows:
 - 3 1. Swing Check Valves: In horizontal position with hinge pin level.
 - 4 2. Center-Guided Check Valves: In horizontal or vertical position, between flanges.
- 5 F. Install valve tags. Comply with requirements for valve tags and schedules in Section 23 05 53
- 6 "Identification for HVAC Piping and Equipment."

7 **3.3 ADJUSTING**

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

10 **3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS**

- 11 A. If valve applications are not indicated, use the following:
 - 12 1. Pump-Discharge Check Valves:
 - 13 a. NPS 2 (DN 50) and Smaller: Bronze swing check valves with nonmetallic disc.
 - 14 b. NPS 2-1/2 (DN 65) and Larger: Iron swing check valves with lever and weight or
 - 15 with spring or iron, center-guided, metal -seat check valves.
 - 16 B. If valves with specified SWP classes or CWP ratings are unavailable, the same types of valves
 - 17 with higher SWP classes or CWP ratings may be substituted.
 - 18 C. Select valves, except wafer types, with the following end connections:
 - 19 1. For Copper Tubing, NPS 2 (DN 50) and Smaller: Threaded ends.
 - 20 2. For Copper Tubing, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends.
 - 21 3. For Copper Tubing, NPS 5 (DN 125) and Larger: Flanged ends.
 - 22 4. For Steel Piping, NPS 2 (DN 50) and Smaller: Threaded ends.
 - 23 5. For Steel Piping, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends.
 - 24 6. For Steel Piping, NPS 5 (DN 125) and Larger: Flanged ends.

25 **3.5 CHILLED-WATER VALVE SCHEDULE**

- 26 A. Pipe NPS 2 (DN 50) and Smaller:
 - 27 1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
 - 28 2. Bronze swing check valves with nonmetallic disc, Class 150.
- 29 B. Pipe NPS 2-1/2 (DN 65) and Larger:
 - 30 1. Iron, compact-wafer or globe, center-guided check valves metal seat, Class 125 (see
 - 31 plans for type).

32 **3.6 PROCESS COOLING-WATER VALVE SCHEDULE**

- 33 A. Pipe NPS 2 (DN 50) and Smaller:

- 1 1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
- 2 2. Bronze swing check valves with nonmetallic disc, Class 150.

- 3 B. Pipe NPS 2-1/2 (DN 65) and Larger:
- 4 1. Iron, compact-wafer or globe, center-guided check valves with metal seat, Class 125 (see
- 5 plans for type).

6 **3.7 HEAT RECOVERY-WATER VALVE SCHEDULE**

- 7 A. Pipe NPS 2 (DN 50) and Smaller:

- 8 1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
- 9 2. Bronze swing check valves with nonmetallic disc, Class 150.

- 10 B. Pipe NPS 2-1/2 (DN 65) and Larger:
- 11 1. Iron, compact-wafer or globe, center-guided check valves with metal seat, Class 125 (see
- 12 plans for type).

13 **3.8 HEATING-WATER VALVE SCHEDULE**

- 14 A. Pipe NPS 2 (DN 50) and Smaller:

- 15 1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
- 16 2. Bronze swing check valves with nonmetallic disc, Class 150.

- 17 B. Pipe NPS 2-1/2 (DN 65) and Larger:
- 18 1. Iron, compact-wafer or globe, center-guided check valves with metal seat, Class 125 (see
- 19 plans for type).

20 **END OF SECTION 23 05 23.14**

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1 **SECTION 23 05 29 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT**

2 **PART 1 - GENERAL**

3 **1.1 RELATED DOCUMENTS**

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

6 **1.2 SUMMARY**

7 A. Section Includes:

- 8 1. Metal pipe hangers and supports.
9 2. Trapeze pipe hangers.
10 3. Metal framing systems.
11 4. Fastener systems.
12 5. Equipment supports.

13 **1.3 DEFINITIONS**

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

15 **1.4 ACTION SUBMITTALS**

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

17 B. Shop Drawings: Show fabrication and installation details and include calculations for the
18 following; include Product Data for components:

- 19 1. Trapeze pipe hangers.
20 2. Metal framing systems.
21 3. Pipe stands.
22 4. Equipment supports.

23 **PART 2 - PRODUCTS**

24 **2.1 PERFORMANCE REQUIREMENTS**

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

- 28 1. Design supports for multiple pipes, including pipe stands, capable of supporting
29 combined weight of supported systems, system contents, and test water.
30 2. Design equipment supports capable of supporting combined operating weight of
31 supported equipment and connected systems and components.

1 **2.2 METAL PIPE HANGERS AND SUPPORTS**

2 A. Carbon-Steel Pipe Hangers and Supports:

- 3 1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
- 4 2. Galvanized Metallic Coatings: Pre-galvanized, hot-dip galvanized, or electro-galvanized.
- 5 3. Nonmetallic Coatings: Plastic coated, or epoxy powder-coated.
- 6 4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
- 7 4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
- 8 5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

9 B. Stainless-Steel Pipe Hangers and Supports:

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

14 C. Copper Pipe and Tube Hangers:

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

18 **2.3 TRAPEZE PIPE HANGERS**

- 19 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.
- 20 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.
- 21 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.

22 **2.4 METAL FRAMING SYSTEMS**

23 A. MFMA Manufacturer Metal Framing Systems:

- 24 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- 25 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- 26 a. Cooper B-Line, Inc.
- 27 b. Flex-Strut Inc.
- 28 c. Unistrut Corporation; Tyco International, Ltd.
- 29 2. Description: Shop- or field-fabricated, pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
- 30 2. Description: Shop- or field-fabricated, pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
- 31 3. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
- 32 4. Channels: Continuous slotted carbon-steel channel with inturned lips.
- 33 5. Channel Width: Selected for applicable load criteria.
- 34 6. Channel Nuts: Formed or stamped nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
- 35 6. Channel Nuts: Formed or stamped nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
- 36 7. Hanger Rods: Continuous-thread rod, nuts, and washer made of electroplated zinc indoors and stainless steel outdoors..
- 37 7. Hanger Rods: Continuous-thread rod, nuts, and washer made of electroplated zinc indoors and stainless steel outdoors..
- 38 8. Metallic Coating: Electroplated zinc indoors and Hot-dip galvanized outdoors.

39 B. Non-MFMA Manufacturer Metal Framing Systems:

- 1 1. Description: Shop- or field-fabricated, pipe-support assembly made of steel channels,
- 2 accessories, fittings, and other components for supporting multiple parallel pipes.
- 3 2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
- 4 3. Channels: Continuous slotted carbon-steel channel with inturned lips.
- 5 4. Channel Width: Select for applicable load criteria.
- 6 5. Channel Nuts: Formed or stamped nuts or other devices designed to fit into channel slot
- 7 and, when tightened, prevent slipping along channel.
- 8 6. Hanger Rods: Continuous-thread rod, nuts, and washer made of electroplated zinc
- 9 indoors and stainless steel outdoors..
- 10 7. Metallic Coating: Hot-dip galvanized.

11 2.5 FASTENER SYSTEMS

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

18 2.6 EQUIPMENT SUPPORTS

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

21 2.7 MATERIALS

- 22 A. Aluminum: ASTM B 221 (ASTM B 221M).
- 23 B. Carbon Steel: ASTM A 1011 / A 1011M.
- 24 C. Structural Steel: ASTM A 36 / A 36M, carbon-steel plates, shapes, and bars; galvanized.
- 25 D. Stainless Steel: ASTM A 240 / A 240M.
- 26 E. Threaded Rods: Continuously threaded. Zinc-plated or galvanized steel for indoor applications
- 27 and stainless steel for outdoor applications. Mating nuts and washers of similar materials as
- 28 rods.
- 29 F. Grout: ASTM C 1107 / C 1107M, factory-mixed and -packaged, dry, hydraulic-cement, non-
- 30 shrink and nonmetallic grout; suitable for interior and exterior applications.
- 31 1. Properties: Non-staining, noncorrosive, and nongaseous.
- 32 2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

1 **PART 3 - EXECUTION**

2 **3.1 APPLICATION**

- 3 A. Comply with requirements in Section 07 84 13 "Penetration Firestopping" for Firestopping
4 materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.
- 5 B. Strength of Support Assemblies: Where not indicated, select sizes of components so strength
6 will be adequate to carry present and future static loads within specified loading limits. Minimum
7 static design load used for strength determination shall be weight of supported components plus
8 200 lb (90 kg).

9 **3.2 HANGER AND SUPPORT INSTALLATION**

- 10 A. Metal Pipe-Hanger Installation: Comply with MSS SP-58. Install hangers, supports, clamps, and
11 attachments as required to properly support piping from the building structure.
- 12 B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-58. Arrange for grouping of
13 parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.
- 14 1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or
15 install intermediate supports for smaller diameter pipes as specified for individual pipe
16 hangers.
- 17 2. Field fabricate from ASTM A 36 / A 36M, carbon-steel shapes selected for loads being
18 supported. Weld steel according to AWS D1.1 / D1.1M.
- 19 C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support
20 together on field-assembled strut systems.
- 21 D. Fastener System Installation:
- 22 1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less
23 than 4 inches (100 mm) thick in concrete after concrete is placed and completely cured.
24 Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners
25 according to powder-actuated tool manufacturer's operating manual.
- 26 2. Install mechanical-expansion anchors in concrete after concrete is placed and completely
27 cured. Install fasteners according to manufacturer's written instructions.
- 28 E. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts,
29 washers, and other accessories.
- 30 F. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
- 31 G. Install hangers and supports to allow controlled thermal movement of piping systems, to permit
32 freedom of movement between pipe anchors, and to facilitate action of expansion joints,
33 expansion loops, expansion bends, and similar units.
- 34 H. Install lateral bracing with pipe hangers and supports to prevent swaying.
- 35 I. Install building attachments within concrete slabs or attach to structural steel. Install additional
36 attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 (DN 65)
37 and larger and at changes in direction of piping. Install concrete inserts before concrete is
38 placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

- 1 J. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses
2 from movement will not be transmitted to connected equipment.
- 3 K. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed
4 maximum pipe deflections allowed by ASME B31.9 for building services piping.
- 5 L. Insulated Piping:
- 6 1. Install MSS SP-58, Type 40, protective shields on piping. Shields shall span an arc of
7 180 degrees. Secure shield to pipe on both ends with stainless steel bands.
- 8 2. Shield Dimensions for Pipe: Not less than the following:
- 9 a. NPS 1/4 to NPS 3-1/2 (DN 8 to DN 90): 12 inches (305 mm) long and 0.048 inch
10 (1.22 mm) thick.
- 11 b. NPS 4 (DN 100): 12 inches (305 mm) long and 0.06 inch (1.52 mm) thick.
- 12 c. NPS 5 and NPS 6 (DN 125 and DN 150): 18 inches (457 mm) long and 0.06 inch
13 (1.52 mm) thick.
- 14 d. NPS 8 to NPS 14 (DN 200 to DN 350): 24 inches (610 mm) long and 0.075 inch
15 (1.91 mm) thick.
- 16 e. NPS 16 to NPS 24 (DN 400 to DN 600): 24 inches (610 mm) long and 0.105 inch
17 (2.67 mm) thick.

18 3.3 EQUIPMENT SUPPORTS

- 19 A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support
20 equipment above floor.
- 21 B. Grouting: Place grout under supports for equipment and make bearing surface smooth.
- 22 C. Provide lateral bracing, to prevent swaying, for equipment supports.

23 3.4 METAL FABRICATIONS

- 24 A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment
25 supports.
- 26 B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be
27 shop welded because of shipping size limitations.
- 28 C. Field Welding: Comply with AWS D1.1 / D1.1M procedures for shielded, metal arc welding;
29 appearance and quality of welds; and methods used in correcting welding work; and with the
30 following:
- 31 1. Use materials and methods that minimize distortion and develop strength and corrosion
32 resistance of base metals.
- 33 2. Obtain fusion without undercut or overlap.
- 34 3. Remove welding flux immediately.
- 35 4. Finish welds at exposed connections so no roughness shows after finishing and so
36 contours of welded surfaces match adjacent contours.

1 **3.5 ADJUSTING**

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

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

5 **3.6 PAINTING**

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

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

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

13 **3.7 HANGER AND SUPPORT SCHEDULE**

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

16 B. Comply with MSS SP-58 for pipe-hanger selections and applications that are not specified in
17 piping system Sections.

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

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

22 E. Use carbon-steel pipe hangers and supports, metal trapeze pipe hangers, and metal framing
23 systems and attachments for general service applications.

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

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

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

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

30 1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of non-insulated or
31 insulated, stationary pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).

32 2. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to
33 NPS 24 (DN 15 to DN 600) if little or no insulation is required.

34 3. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36 (DN 100 to
35 DN 900), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel
36 plate.

- 1 4. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24
 2 (DN 65 to DN 600), from single rod if horizontal movement caused by expansion and
 3 contraction might occur.
 4 5. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 (DN 50 to
 5 DN 1050) if longitudinal movement caused by expansion and contraction might occur but
 6 vertical adjustment is unnecessary.
- 7 J. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system
 8 Sections, install the following types:
- 9 1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to
 10 NPS 24 (DN 24 to DN 600).
- 11 K. Saddles and Shields: Unless otherwise indicated and except as specified in piping system
 12 Sections, install the following types:
- 13 1. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to
 14 prevent crushing insulation.
- 15 L. Comply with MSS SP-58 for trapeze pipe-hanger selections and applications that are not
 16 specified in piping system Sections.
- 17 M. Comply with MFMA-103 for metal framing system selections and applications that are not
 18 specified in piping system Sections.
- 19 N. Use powder-actuated fasteners or mechanical-expansion anchors instead of building
 20 attachments where required in concrete construction.

21 **END OF SECTION 23 05 29**

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SECTION 23 05 48.13 - VIBRATION CONTROLS FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Elastomeric isolation pads.
 - 2. Elastomeric isolation mounts.
 - 3. Open-spring isolators.
 - 4. Housed-spring isolators.
 - 5. Restrained-spring isolators.
 - 6. Elastomeric hangers.
 - 7. Spring hangers.
 - 8. Vibration isolation equipment bases.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
 - 2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device type required.
- B. Shop Drawings:
 - 1. Detail fabrication and assembly of equipment bases. Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
 - 2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
- C. Delegated-Design Submittal: For each vibration isolation device.
 - 1. Include design calculations for designing vibration isolation bases.
 - 2. Design Calculations: Calculate static and dynamic loading due to equipment weight, operation and for designing vibration isolation bases.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For professional engineer.

PART 2 - PRODUCTS

2.1 ELASTOMERIC ISOLATION PADS

- A. Elastomeric Isolation Pads:
1. Basis-of-Design Product: Subject to compliance with requirements, provide Mason Industries, Inc.; Mason Super W or comparable product by one of the following:
 - a. Kinetics Noise Control, Inc.
 - b. Vibration Mountings & Controls, Inc.
 2. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
 3. Size: Factory or field cut to match requirements of supported equipment.
 4. Pad Material: Oil and water resistant with elastomeric properties.
 5. Surface Pattern: Waffle pattern.

2.2 ELASTOMERIC ISOLATION MOUNTS

- A. Double-Deflection, Elastomeric Isolation Mounts:
1. Basis-of-Design Product: Subject to compliance with requirements, provide Mason Industries, Inc.; Mason ND or comparable product by one of the following:
 - a. Kinetics Noise Control, Inc.
 - b. Vibration Mountings & Controls, Inc.
 2. Mounting Plates:
 - a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded with threaded studs or bolts.
 - b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.
 3. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.3 OPEN-SPRING ISOLATORS

- A. Freestanding, Laterally Stable, Open-Spring Isolators: .
1. Basis-of-Design Product: Subject to compliance with requirements, provide Mason Industries, Inc.; Mason SLFH or comparable product by one of the following:
 - a. Kinetics Noise Control, Inc.
 - b. Vibration Mountings & Controls, Inc.
 2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.

5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Baseplates: Factory-drilled steel plate for bolting to structure with an elastomeric isolator pad attached to the underside. Baseplates shall limit floor load to 500 psig (3447 kPa).
7. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

2.4 HOUSED-SPRING ISOLATORS

- A. Freestanding, Laterally Stable, Open-Spring Isolators in Two-Part Telescoping Housing:
1. Basis-of-Design Product: Subject to compliance with requirements, provide Mason Industries, Inc.; Mason C or comparable product by one of the following:
 - a. Kinetics Noise Control, Inc.
 - b. Vibration Mountings & Controls, Inc.
 2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 6. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators.
 - a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig (3447 kPa).
 - b. Top housing with attachment and leveling bolt.

2.5 RESTRAINED-SPRING ISOLATORS

- A. Freestanding, Laterally Stable, Open-Spring Isolators with Vertical-Limit Stop Restraint:
1. Basis-of-Design Product: Subject to compliance with requirements, provide Mason Industries, Inc.; Mason SLR or a comparable product by one of the following:
 - a. Kinetics Noise Control, Inc.
 - b. Vibration Mountings & Controls, Inc.
 2. Housing: Steel housing with vertical-limit stops to prevent spring extension due to weight being removed.
 - a. Base with holes for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig (3447 kPa).
 - b. Top plate with threaded mounting holes.
 - c. Internal leveling bolt that acts as blocking during installation.
 3. Restraint: Limit stop as required for equipment and authorities having jurisdiction.
 4. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 5. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 6. Lateral Stiffness: More than 80 percent of rated vertical stiffness.

7. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.6 ELASTOMERIC HANGERS

- A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods: .
 1. Basis-of-Design Product: Subject to compliance with requirements, provide Mason Industries, Inc.; Mason HD or comparable product by one of the following:
 - a. Kinetics Noise Control, Inc.
 - b. Vibration Mountings & Controls, Inc.
 2. Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.
 3. Dampening Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel to steel contact.

2.7 SPRING HANGERS

- A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression:
 1. Basis-of-Design Product: Subject to compliance with requirements, provide Mason Industries, Inc.; HS-B or comparable product by one of the following:
 - a. Kinetics Noise Control, Inc.
 - b. Vibration Mountings & Controls, Inc.
 2. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
 3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 7. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
 8. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
 9. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

2.8 VIBRATION ISOLATION EQUIPMENT BASES

- A. Basis-of-Design Product: Subject to compliance with requirements, provide Mason Industries, Inc.; Type K (Fans) or BMK/KSL-6 (Pumps) or comparable product by one of the following:
 1. Kinetics Noise Control.

2. Vibration Mountings & Controls, Inc.
- B. Concrete Inertia Base: Factory-fabricated, welded, structural-steel bases and rails ready for placement of cast-in-place concrete.
1. Design Requirements: Lowest possible mounting height with not less than 1-inch (25-mm) clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
 - a. Include supports for suction and discharge elbows for pumps.
 2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
 3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
 4. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and equipment to receive vibration isolation control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 VIBRATION CONTROL DEVICE INSTALLATION

- A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Division 03.
- B. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.

3.3 VIBRATION ISOLATION EQUIPMENT BASES INSTALLATION

- A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Division 03.

END OF SECTION 23 05 48.13

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1 **SECTION 23 05 53 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT**

2 **PART 1 - GENERAL**

3 **1.1 RELATED DOCUMENTS**

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

6 **1.2 SUMMARY**

- 7 A. Section Includes:

- 8 1. Equipment labels.
9 2. Warning signs and labels.
10 3. Pipe labels.
11 4. Stencils.
12 5. Valve tags.
13 6. Warning tags.

14 **1.3 ACTION SUBMITTALS**

- 15 A. Product Data: For each type of product.
16 B. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed
17 content for each label.
18 C. Valve numbering scheme.
19 D. Valve Schedules: For each piping system to include in maintenance manuals.

20 **1.4 CLOSEOUT SUBMITTALS**

- 21 A. Maintenance Data: For each piping system to include in maintenance manuals.

22 **PART 2 - PRODUCTS**

23 **2.1 EQUIPMENT LABELS**

- 24 A. Plastic Labels for Equipment:
25 1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving,
26 1/8 inch (3.2 mm) thick, and having predrilled holes for attachment hardware.
27 2. Letter Color: White.
28 3. Background Color: Black.
29 4. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).

- 1 5. Minimum Label Size: Length and width vary for required label content, but not less than
- 2 2-1/2 by 3/4 inch (64 by 19 mm).
- 3 6. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than
- 4 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm),
- 5 and proportionately larger lettering for greater viewing distances. Include secondary
- 6 lettering two-thirds to three-quarters the size of principal lettering.
- 7 7. Fasteners: Stainless-steel rivets or self-tapping screws.
- 8 8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- 9 B. Label Content: Include equipment's Drawing designation or unique equipment number.
- 10 C. Equipment Label Schedule: For each item of equipment to be labeled, tabulate equipment label
- 11 information. Equipment schedule shall be included in operation and maintenance data.

12 2.2 WARNING SIGNS AND LABELS

- 13 A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch
- 14 (3.2 mm) thick, and having predrilled holes for attachment hardware.
- 15 B. Letter Color: White.
- 16 C. Background Color: Red.
- 17 D. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).
- 18 E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by
- 19 3/4 inch (64 by 19 mm).
- 20 F. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24
- 21 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and
- 22 proportionately larger lettering for greater viewing distances. Include secondary lettering two-
- 23 thirds to three-quarters the size of principal lettering.
- 24 G. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- 25 H. Label Content: Include caution and warning information plus emergency notification instructions.

26 2.3 PIPE LABELS

- 27 A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering
- 28 indicating service, and showing flow direction.
- 29 B. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
- 30 C. Pipe Label Contents: Include identification of piping service using same designations or
- 31 abbreviations as used on Drawings; also include pipe size and an arrow indicating flow
- 32 direction.
- 33 1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both
- 34 directions or as separate unit on each pipe label to indicate flow direction.
- 35 2. Lettering Size: Size letters according to ASME A13.1 for piping.

1 **2.4 STENCILS**

2 A. Stencils for Ducts:

- 3 1. Lettering Size: Minimum letter height of 1-1/4 inches (32 mm) for viewing distances up to
 4 15 feet (4-1/2 m) and proportionately larger lettering for greater viewing distances.
 5 2. Stencil Material: Fiberboard or metal.
 6 3. Stencil Paint: Exterior, gloss, acrylic enamel. Paint may be in pressurized spray-can form.

7 **2.5 VALVE TAGS**

8 A.

9 B. Description: Stamped or engraved with 1/4-inch (6.4-mm) letters for piping system abbreviation
 10 and 1/2-inch (13-mm) numbers.

- 11 1. Tag Material: Brass, 0.032-inch (0.8-mm) minimum thickness, and having predrilled or
 12 stamped holes for attachment hardware.
 13 2. Fasteners: Brass wire-link chain

14 C. Valve Schedules: For each piping system, on 8-1/2-by-11-inch (A4) bond paper. Tabulate valve
 15 number, piping system, system abbreviation (as shown on valve tag), location of valve (room or
 16 space), normal-operating position (open, closed, or modulating), and variations for identification.
 17 Mark valves for emergency shutoff and similar special uses.

- 18 1. Valve-tag schedule shall be included in operation and maintenance data.

19 **2.6 WARNING TAGS**

20 A. Description: Preprinted or partially preprinted accident-prevention tags of plasticized card stock
 21 with matte finish suitable for writing.

- 22 1. Size: 3 by 5-1/4 inches (75 by 133 mm) minimum.
 23 2. Fasteners: Brass grommet and wire.
 24 3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT
 25 OPERATE."
 26 4. Color: Safety-yellow background with black lettering.

27 **PART 3 - EXECUTION**

28 **3.1 PREPARATION**

29 A. Clean piping and equipment surfaces of substances that could impair bond of identification
 30 devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and
 31 encapsulants.

32 **3.2 GENERAL INSTALLATION REQUIREMENTS**

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

- 1 B. Coordinate installation of identifying devices with locations of access panels and doors.
- 2 C. Install identifying devices before installing acoustical ceilings and similar concealment.

3 **3.3 EQUIPMENT LABEL INSTALLATION**

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

6 **3.4 PIPE LABEL INSTALLATION**

- 7 A. Pipe Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings
- 8 in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels,
- 9 and plenums; and exterior exposed locations as follows:

- 10 1. Near each valve and control device.
- 11 2. Near each branch connection, excluding short takeoffs for fixtures and terminal units.
- 12 Where flow pattern is not obvious, mark each pipe at branch.
- 13 3. Near penetrations and on both sides of through walls, floors, ceilings, and inaccessible
- 14 enclosures.
- 15 4. At access doors, manholes, and similar access points that permit view of concealed
- 16 piping.
- 17 5. Near major equipment items and other points of origination and termination.
- 18 6. Spaced at maximum intervals of 50 feet (15 m) along each run. Reduce intervals to 25
- 19 feet (7.6 m) in areas of congested piping and equipment.
- 20 7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

- 21 B. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including
- 22 pipes where flow is allowed in both directions. Install marker tape with arrows around the entire
- 23 circumference of the pipe at the beginning and end of the pipe-label content.

- 24 C. Pipe Label Color Schedule:

- 25 1. Chilled-Water Piping: White letters on a safety-green background.
- 26 2. Heating Water Piping: White letters on a safety-green background.
- 27 3. Refrigerant Piping: Black letters on a safety-orange background.
- 28 4. Fuel Gas Piping: Black letters on a safety-yellow background.

29 **3.5 DUCT LABEL INSTALLATION**

- 30 A. Stenciled Duct Label: Stenciled labels showing service and flow direction.
- 31 B. Locate labels near points where ducts enter into and exit from concealed spaces and at
- 32 maximum intervals of 50 feet (15 m) in each space where ducts are exposed or concealed by
- 33 removable ceiling system.

34 **3.6 VALVE-TAG INSTALLATION**

- 35 A. Install tags on valves and control devices in piping systems, except check valves, valves within
- 36 factory-fabricated equipment units, shutoff valves, faucets, convenience and lawn-watering

1 hose connections, and HVAC terminal devices and similar roughing-in connections of end-use
2 fixtures and units. List tagged valves in a valve schedule.

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

5 1. Valve-Tag Size and Shape: 1-1/2 inches (38 mm), round

6 2. Valve-Tag Colors:

- 7 a. Toxic and Corrosive Fluids: Black letters on a safety-orange background.
- 8 b. Flammable Fluids: Black letters on a safety-yellow background.
- 9 c. Combustible Fluids: White letters on a safety-brown background.
- 10 d. Potable and Other Water: White letters on a safety-green background.
- 11 e. Compressed Air: White letters on a safety-blue background.
- 12 f. Defined by User: White letters on a safety-purple background, black letters on a
13 safety-white background, white letters on a safety-gray background, and white
14 letters on a safety-black background

15 3.7 WARNING-TAG INSTALLATION

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

18 **END OF SECTION 23 05 53**

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1 **SECTION 23 05 93 - TESTING, ADJUSTING, AND BALANCING FOR HVAC**

2 **PART 1 - GENERAL**

3 **1.1 RELATED DOCUMENTS**

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

6 **1.2 SUMMARY**

- 7 A. Section Includes:

8 1. Balancing Air Systems:

- 9 a. Constant-volume air systems.
10 b. Variable-air-volume systems.
11 c. Multizone systems.

12 2. Balancing Hydronic Piping Systems:

- 13 a. Constant-flow hydronic systems.
14 b. Variable-flow hydronic systems.
15 c. Primary-secondary hydronic systems.

16 3. Balancing steam systems.

17 4. Testing, Adjusting, and Balancing Equipment:

- 18 a. Heat exchangers.
19 b. Motors.
20 c. Chillers.
21 d. Condensing units.
22 e. Boilers.
23 f. Heat-transfer coils.

24 g. .

25 5. Duct leakage tests.

26 6. Control system verification.

- 27 B. Related Sections:

- 28 1. Section 019113 "General Commissioning Requirements" for general commissioning
29 process requirements.

30 **1.3 DEFINITIONS**

- 31 A. AABC: Associated Air Balance Council.

- 32 B. BAS: Building automation systems.

- 1 C. NEBB: National Environmental Balancing Bureau.
- 2 D. TAB: Testing, adjusting, and balancing.
- 3 E. TABB: Testing, Adjusting, and Balancing Bureau.
- 4 F. TAB Specialist: An independent entity meeting qualifications to perform TAB work.
- 5 G. TDH: Total dynamic head.
- 6 H. Special Inspector: An entity engaged to inspect smoke control systems.

7 **1.4 PREINSTALLATION MEETINGS**

- 8 A. TAB Conference: Conduct a TAB conference at Project site after approval of the TAB strategies
- 9 and procedures plan to develop a mutual understanding of the details. Provide a minimum of 14
- 10 days' advance notice of scheduled meeting time and location.
- 11 1. Minimum Agenda Items:
- 12 a. The Contract Documents examination report.
- 13 b. The TAB plan.
- 14 c. Needs for coordination and cooperation of trades and subcontractors.
- 15 d. Proposed procedures for documentation and communication flow.

16 **1.5 ACTION SUBMITTALS**

- 17 A. Sustainable Design Submittals:
- 18 1. Air-Balance Report: Documentation indicating that Work complies with ASHRAE 62.1,
- 19 Section 7.2.2 - "Air Balancing."
- 20 2. TAB Report: Documentation indicating that Work complies with ASHRAE/IES 90.1,
- 21 Section 6.7.2.3 - "System Balancing."
- 22 B. Qualification Data: Within 30 days of Contractor's Notice to Proceed, submit documentation that
- 23 the TAB specialist and this Project's TAB team members meet the qualifications specified in
- 24 "Quality Assurance" Article.
- 25 C. Report Format Submittals: Within 60 days of Contractor's Notice to Proceed, submit the
- 26 following as specified in "Preparation" Article.
- 27 1. TAB strategies and step-by-step procedures.
- 28 2. System readiness checklists.

29 **1.6 INFORMATIONAL SUBMITTALS**

- 30 A. Contract Documents Examination Report: Within 60 days of Contractor's Notice to Proceed,
- 31 submit the Contract Documents review report as specified in Part 3.
- 32 B. Examination Report: Submit a summary report of the examination review required in
- 33 "Examination" Article.

- 1 C. Certified TAB reports.
- 2 D. Sample report forms.
- 3 E. Instrument calibration reports, to include the following:
- 4 1. Instrument type and make.
- 5 2. Serial number.
- 6 3. Application.
- 7 4. Dates of use.
- 8 5. Dates of calibration.

9 **1.7 QUALITY ASSURANCE**

- 10 A. TAB Specialists Qualifications: Certified by AABC or NEBB.
- 11 1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC or NEBB. A
- 12 TAB Field Supervisor shall be on the project site at all times during TAB work and shall
- 13 have a minimum three years' of TAB experience with air, water, sound, and vibration
- 14 testing.
- 15 a. NEBB: Certified Professional (TAB-CP) or Certified Technician (TAB-CT).
- 16 b. AABC: Certified Test and Balance Engineer (TBE) or Certified Technician.
- 17 2. TAB Technician: Employee of the TAB specialist and certified by AABC or NEBB as a
- 18 TAB technician.
- 19 a. NEBB: Certified Technician (TAB-CT).
- 20 b. AABC: Certified Technician.
- 21
- 22 B. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in
- 23 ASHRAE 111, Section 4, "Instrumentation."
- 24 C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air
- 25 Balancing."
- 26 D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.7.2.3 -
- 27 "System Balancing."
- 28 E. Warranty: Comply with the program requirements of either:
- 29 1. AABC National Performance Guaranty.
- 30 2. NEBB Conformance Certification.

31 **1.8 TAB CONTRACTOR'S RESPONSIBILITIES**

- 32 A. Attend testing, adjusting, and balancing review and coordination meeting.
- 33 B. Participate in verification of the TAB report by the CxA or Engineer for verification and
- 34 diagnostic purposes.

1 **PART 2 - PRODUCTS (Not Applicable)**

2 **PART 3 - EXECUTION**

3 **3.1 TAB SPECIALISTS**

4 A. Subject to compliance with requirements, engage one of the following:

- 5 1. FTS Test and Balance
 - 6 a. Location: Tallahassee, Florida
 - 7 b. Contact: Heath Allbaugh, CP
 - 8 c. Phone Number: (850) 727-5391
- 9 2. HVAC Testing Services, Inc.
 - 10 a. Location: Thomasville, Georgia
 - 11 b. Contact: Greg Lang, CP / Pete Lang
 - 12 c. Phone Number: (229) 227-0255
- 13 3. Indoor Air Professionals, Inc.
 - 14 a. Location: Fort Myers, Florida
 - 15 b. Contact: Joseph Molloy, III, CP
 - 16 c. Phone Number: (239) 707-9732

17 **3.2 EXAMINATION**

- 18 A. Examine the Contract Documents to become familiar with Project requirements and to discover
 - 19 conditions in systems designs that may preclude proper TAB of systems and equipment.
- 20 B. Examine installed systems for balancing devices, such as test ports, gage cocks, thermometer
 - 21 wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify
 - 22 that locations of these balancing devices are applicable for intended purpose and are
 - 23 accessible.
- 24 C. Examine the approved submittals for HVAC systems and equipment.
- 25 D. Examine design data including HVAC system descriptions, statements of design assumptions
 - 26 for environmental conditions and systems output, and statements of philosophies and
 - 27 assumptions about HVAC system and equipment controls.
- 28 E. Examine equipment performance data including fan and pump curves.
 - 29 1. Relate performance data to Project conditions and requirements, including system effects
 - 30 that can create undesired or unpredicted conditions that cause reduced capacities in all
 - 31 or part of a system.
- 32 F. Examine system and equipment installations and verify that field quality-control testing,
 - 33 cleaning, and adjusting specified in individual Sections have been performed.
- 34 G. Examine test reports specified in individual system and equipment Sections.
- 35 H. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight,
 - 36 filters are clean, and equipment with functioning controls is ready for operation.

- 1 I. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible
2 and their controls are connected and functioning.
- 3 J. Examine strainers. Verify that startup screens have been replaced by permanent screens with
4 indicated perforations.
- 5 K. Examine control valves for proper installation for their intended function of throttling, diverting, or
6 mixing fluid flows.
- 7 L. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- 8 M. Examine system pumps to ensure absence of entrained air in the suction piping.
- 9 N. Examine operating safety interlocks and controls on HVAC equipment.
- 10 O. Report deficiencies discovered before and during performance of TAB procedures. Observe
11 and record system reactions to changes in conditions. Record default set points if different from
12 indicated values.

13 3.3 PREPARATION

- 14 A. Prepare a TAB plan that includes the following:
 - 15 1. Equipment and systems to be tested.
 - 16 2. Strategies and step-by-step procedures for balancing the systems.
 - 17 3. Instrumentation to be used.
 - 18 4. Project specific forms with specific identification for all equipment and systems. Project
19 specific forms shall include design data for all equipment and systems to be tested and
20 descriptions of any other necessary supporting data required in the final report that will be
21 included (i.e. fan/pump curves, layout drawings, balancing valve charts, etc).
- 22 B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness
23 for TAB work. Include, at a minimum, the following:
 - 24 1. Airside:
 - 25 a. Verify that leakage and pressure tests on air distribution systems have been
26 satisfactorily completed.
 - 27 b. Duct systems are complete with terminals installed.
 - 28 c. Volume, smoke, and fire dampers are open and functional.
 - 29 d. Clean filters are installed.
 - 30 e. Fans are operating, free of vibration, and rotating in correct direction.
 - 31 f. Variable-frequency controllers' startup is complete and safeties are verified.
 - 32 g. Automatic temperature-control systems are operational.
 - 33 h. Ceilings are installed.
 - 34 i. Windows and doors are installed.
 - 35 j. Suitable access to balancing devices and equipment is provided.
 - 36 2. Hydronics:
 - 37 a. Verify leakage and pressure tests on water distribution systems have been
38 satisfactorily completed.
 - 39 b. Piping is complete with terminals installed.
 - 40 c. Water treatment is complete.

- 1 d. Systems are flushed, filled, and air purged.
- 2 e. Strainers are pulled and cleaned.
- 3 f. Control valves are functioning per the sequence of operation.
- 4 g. Shutoff and balance valves have been verified to be 100 percent open.
- 5 h. Pumps are started and proper rotation is verified.
- 6 i. Pump gage connections are installed directly at pump inlet and outlet flanges or in
- 7 discharge and suction pipe prior to valves or strainers.
- 8 j. Variable-frequency controllers' startup is complete and safeties are verified.
- 9 k. Suitable access to balancing devices and equipment is provided.

10 **3.4 GENERAL PROCEDURES FOR TESTING AND BALANCING**

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

- 15 B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the
- 16 minimum extent necessary for TAB procedures.
- 17 1. After testing and balancing, install test ports and duct access doors that comply with
- 18 requirements in Section 23 33 00 "Air Duct Accessories."
- 19 2. Install and join new insulation that matches removed materials. Restore insulation,
- 20 coverings, vapor barrier, and finish according to Section 23 07 13 "Duct Insulation,"
- 21 Section 23 07 16 "HVAC Equipment Insulation," and Section 23 07 19 "HVAC Piping
- 22 Insulation."

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

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

27 **3.5 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS**

- 28 A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and
- 29 recommended testing procedures. Cross-check the summation of required outlet volumes with
- 30 required fan volumes.

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

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

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

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

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

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

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

- 1 I. Check for airflow blockages.
- 2 J. Check condensate drains for proper connections and functioning.
- 3 K. Check for proper sealing of air-handling-unit components.
- 4 L. Verify that air duct system is sealed as specified in Section 23 31 13 "Metal Ducts."

5 **3.6 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS**

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

- 8 1. Measure total airflow.
 - 9 a. Set outside-air, return-air, and relief-air dampers for proper position that simulates
 - 10 minimum outdoor-air conditions.
 - 11 b. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary,
 - 12 perform multiple Pitot-tube traverses to obtain total airflow.
 - 13 c. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil
 - 14 traverse may be acceptable.
 - 15 d. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at
 - 16 terminals and calculate the total airflow.
- 17 2. Measure fan static pressures as follows:
 - 18 a. Measure static pressure directly at the fan outlet or through the flexible connection.
 - 19 b. Measure static pressure directly at the fan inlet or through the flexible connection.
 - 20 c. Measure static pressure across each component that makes up the air-handling
 - 21 system.
 - 22 d. Report artificial loading of filters at the time static pressures are measured.
- 23 3. Review Record Documents to determine variations in design static pressures versus
- 24 actual static pressures. Calculate actual system-effect factors. Recommend adjustments
- 25 to accommodate actual conditions.
- 26 4. Obtain approval from Engineer for adjustment of fan speed higher or lower than indicated
- 27 speed. Comply with requirements in HVAC Sections for air-handling units for adjustment
- 28 of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
- 29 5. Do not make fan-speed adjustments that result in motor overload. Consult equipment
- 30 manufacturers about fan-speed safety factors. Modulate dampers and measure fan-
- 31 motor amperage to ensure that no overload occurs. Measure amperage in full-cooling,
- 32 full-heating, economizer, and any other operating mode to determine the maximum
- 33 required brake horsepower.
- 34 6. Determine and make appropriate modifications for adjustment of fans, belts, and pulley
- 35 sizes to achieve indicated air-handling-unit performance.

- 36 B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated
- 37 airflows.

- 38 1. Measure airflow of submain and branch ducts.
- 39 2. Adjust submain and branch duct volume dampers for specified airflow.
- 40 3. Re-measure each submain and branch duct after all have been adjusted.

- 41 C. Adjust air inlets and outlets for each space to indicated airflows.

- 1 1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
- 2 2. Measure inlets and outlets airflow.
- 3 3. Adjust each inlet and outlet for specified airflow.
- 4 4. Re-measure each inlet and outlet after they have been adjusted.

- 5 D. Verify final system conditions.

- 6 1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within
- 7 design. Readjust to design if necessary.
- 8 2. Re-measure and confirm that total airflow is within design.
- 9 3. Re-measure all final fan operating data, rpms, volts, amps, and static profile.
- 10 4. Mark all final settings.
- 11 5. Test system in economizer mode. Verify proper operation and adjust if necessary.
- 12 6. Measure and record all operating data.
- 13 7. Record final fan-performance data.

14 3.7 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

- 15 A. Adjust the variable-air-volume systems as follows:

- 16 1. Verify that the system static pressure sensor is located two-thirds of the distance down
- 17 the duct from the fan discharge.
- 18 2. Verify that the system is under static pressure control.
- 19 3. Select the terminal unit that is most critical to the supply-fan airflow. Measure inlet static
- 20 pressure, and adjust system static pressure control set point so the entering static
- 21 pressure for the critical terminal unit is not less than the sum of the terminal-unit
- 22 manufacturer's recommended minimum inlet static pressure plus the static pressure
- 23 needed to overcome terminal-unit discharge system losses.

- 24 4. Calibrate and balance each terminal unit for maximum and minimum design airflow as
- 25 follows:

- 26 a. Adjust controls so that terminal is calling for maximum airflow. Some controllers
- 27 require starting with minimum airflow. Verify calibration procedure for specific
- 28 project.
- 29 b. Measure airflow and adjust calibration factor as required for design maximum
- 30 airflow. Record calibration factor.
- 31 c. When maximum airflow is correct, balance the air outlets downstream from
- 32 terminal units.
- 33 d. Adjust controls so that terminal is calling for minimum airflow.
- 34 e. Measure airflow and adjust calibration factor as required for design minimum
- 35 airflow. Record calibration factor. If no minimum calibration is available, note any
- 36 deviation from design airflow.
- 37 f. When in full cooling or full heating, ensure that there is no mixing of hot-deck and
- 38 cold-deck airstreams unless so designed.
- 39 g. On constant volume terminals, in critical areas where room pressure is to be
- 40 maintained, verify that the airflow remains constant over the full range of full
- 41 cooling to full heating. Note any deviation from design airflow or room pressure.

- 42 5. After terminals have been calibrated and balanced, test and adjust system for total
- 43 airflow. Adjust fans to deliver total design airflows within the maximum allowable fan
- 44 speed listed by fan manufacturer.

- 1 a. Set outside-air, return-air, and relief-air dampers for proper position that simulates
 2 minimum outdoor-air conditions.
- 3 b. Set terminals for maximum airflow. If system design includes diversity (where the
 4 total flow rate of all outlets is more than the indicated flow of the fans), adjust
 5 terminals for maximum and minimum airflow so that connected total matches fan
 6 selection and simulates actual load in the building.
- 7 1) Determine diversity factor.
- 8 2) Simulate system diversity by setting a required number of air terminals to
 9 minimum airflows, as approved by the design engineer.
- 10 3) Set air terminals that were at minimum airflow to maximum airflow. Set a
 11 sufficient number of air terminals that were previously at maximum airflow to
 12 minimum airflow to maintain diversity, and balance terminals that were just
 13 set to maximum.
- 14 c. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary,
 15 perform multiple Pitot-tube traverses to obtain total airflow.
- 16 d. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil
 17 traverse may be acceptable.
- 18 e. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at
 19 terminals and calculate the total airflow.
- 20 f. Obtain approval from Engineer before adjustment of fan speed higher or lower
 21 than indicated speed. Determine and make appropriate modifications for
 22 adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit
 23 performance.
- 24 g. Do not make fan-speed adjustments that result in motor overload. Consult
 25 equipment manufacturers about fan-speed safety factors. Modulate dampers and
 26 measure fan-motor amperage to ensure that no overload will occur. Measure
 27 amperage in full-cooling, full-heating, economizer, and any other operating mode
 28 to determine the maximum required brake horsepower.
- 29 6. Measure fan static pressures as follows:
- 30 a. Measure static pressure directly at the fan outlet or through the flexible connection.
- 31 b. Measure static pressure directly at the fan inlet or through the flexible connection.
- 32 c. Measure static pressure across each component that makes up the air-handling
 33 system.
- 34 d. Report any artificial loading of filters at the time static pressures are measured.
- 35 7. Set final return and outside airflow to the fan while operating at maximum return airflow
 36 and minimum outdoor airflow.
- 37 a. Balance the return-air ducts and inlets the same as described for constant-volume
 38 air systems.
- 39 b. Verify that terminal units are meeting design airflow under system maximum flow.
- 40 8. Re-measure the inlet static pressure at the most critical terminal unit and adjust the
 41 system static pressure set point to the most energy-efficient set point to maintain the
 42 optimum system static pressure. Record set point and give to controls contractor.
 43 Coordinate maximum and minimum static pressure setpoints with Controls Contractor for
 44 static pressure setpoint reset. Record damper positions for associated terminal units at
 45 maximum and minimum static pressure setpoints.
- 46 9. Simulate maximum filter loading. The intent is for the variable frequency drive to operate
 47 between 55-60 Hz at maximum filter loading. Remeasure the static pressure at the most
 48 critical terminal unit and adjust the static pressure controller to ensure that adequate

- 1 static pressure is maintained at the most critical unit. Report the minimum static pressure
 2 value and speed of variable frequency drives.
 3 10. Verify final system conditions as follows:
- 4 a. Re-measure and confirm that minimum outdoor, return, and relief airflows are
 5 within design. Readjust to match design if necessary.
 - 6 b. Re-measure and confirm that total airflow is within design.
 - 7 c. Re-measure final fan operating data, rpms, volts, amps, and static profile.
 - 8 d. Mark final settings.
 - 9 e. Test system in economizer mode. Verify proper operation and adjust if necessary.
 10 Measure and record all operating data.
 - 11 f. Verify tracking between supply and return fans.

12 **3.8 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS**

- 13 A. Prepare test reports for pumps, coils, and heat exchangers. Obtain approved submittals and
 14 manufacturer-recommended testing procedures. Crosscheck the summation of required coil
 15 and heat exchanger flow rates with pump design flow rate.
- 16 B. Prepare schematic diagrams of systems' "as-built" piping layouts.
- 17 C. In addition to requirements in "Preparation" Article, prepare hydronic systems for testing and
 18 balancing as follows:
 - 19 1. Check liquid level in expansion tank.
 - 20 2. Check highest vent for adequate pressure.
 - 21 3. Check flow-control valves for proper position.
 - 22 4. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
 - 23 5. Verify that motor starters are equipped with properly sized thermal protection.
 - 24 6. Check that air has been purged from the system.

25 **3.9 PROCEDURES FOR CONSTANT-FLOW HYDRONIC SYSTEMS**

- 26 A. Adjust pumps to deliver total design gpm.
 - 27 1. Measure total water flow.
 - 28 a. Position valves for full flow through coils.
 - 29 b. Measure flow by main flow meter, if installed.
 - 30 c. If main flow meter is not installed, determine flow by pump TDH or exchanger
 31 pressure drop.
 - 32 2. Measure pump TDH as follows:
 - 33 a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe
 34 prior to any valves.
 - 35 b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to
 36 any valves or strainers.
 - 37 c. Convert pressure to head and correct for differences in gage heights.
 - 38 d. Verify pump impeller size by measuring the TDH with the discharge valve closed.
 39 Note the point on manufacturer's pump curve at zero flow, and verify that the pump
 40 has the intended impeller size.

- 1) If impeller sizes must be adjusted to achieve pump performance, obtain approval from Engineer and comply with requirements of Division 23 Section "Hydronic Pumps".
- 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.
 4. Mark pump manufacturer's head-capacity curve.
- G. Verify that memory stops have been set.

3.10 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.

- 1 2. Determine whether there is diversity in the system.

- 2 C. For systems with no diversity (when the total flow rate of all valves is equal to the indicated flow
- 3 of the pumps):

- 4 1. Adjust pumps to deliver total design gpm.

- 5 a. Measure total water flow.

- 6 1) Position valves for full flow through coils.
- 7 2) Measure flow by main flow meter, if installed.
- 8 3) If main flow meter is not installed, determine flow by pump TDH or
- 9 exchanger pressure drop.

- 10 b. Measure pump TDH as follows:

- 11 1) Measure discharge pressure directly at the pump outlet flange or in
- 12 discharge pipe prior to any valves.
- 13 2) Measure inlet pressure directly at the pump inlet flange or in suction pipe
- 14 prior to any valves or strainers.
- 15 3) Convert pressure to head and correct for differences in gage heights.
- 16 4) Verify pump impeller size by measuring the TDH with the discharge valve
- 17 closed. Note the point on manufacturer's pump curve at zero flow and verify
- 18 that the pump has the intended impeller size.

- 19 a) If impeller sizes must be adjusted to achieve pump performance,
- 20 obtain approval from Engineer and comply with requirements of
- 21 Division 23 Section "Hydronic Pumps".

- 22 5) With valves open, read pump TDH. Adjust pump discharge valve until
- 23 design water flow is achieved.

- 24 c. Monitor motor performance during procedures and do not operate motor in an
- 25 overloaded condition.

- 26 2. Adjust flow-measuring devices installed in mains and branches to design water flows.

- 27 a. Measure flow in main and branch pipes.
- 28 b. Adjust main and branch balance valves for design flow.
- 29 c. Re-measure each main and branch after all have been adjusted.

- 30 3. Adjust flow-measuring devices installed at terminals for each space to design water
- 31 flows.

- 32 a. Measure flow at terminals.
- 33 b. Adjust each terminal to design flow.
- 34 c. Re-measure each terminal after it is adjusted.
- 35 d. Position control valves to bypass the coil and adjust the bypass valve to maintain
- 36 design flow.
- 37 e. Perform temperature tests after flows have been balanced.

- 38 4. For systems with pressure-independent valves at terminals:

- 39 a. Measure differential pressure and verify that it is within manufacturer's specified
- 40 range.

- 1 b. Perform temperature tests after flows have been verified.
- 2 5. For systems without pressure-independent valves or flow-measuring devices at
- 3 terminals:
- 4 a. Measure and balance coils by either coil pressure drop or temperature method.
- 5 b. If balanced by coil pressure drop, perform temperature tests after flows have been
- 6 verified.
- 7 6. Prior to verifying final system conditions, determine the system differential-pressure set
- 8 point. Re-measure the differential pressure at the most critical valve and adjust the
- 9 system differential pressure set point to the most energy-efficient set point to maintain the
- 10 optimum system differential pressure. Record set point and give to Controls Contractor.
- 11 Coordinate maximum and minimum differential pressure setpoints with Controls
- 12 Contractor for differential pressure setpoint reset. Record valve positions for associated
- 13 units at maximum and minimum differential pressure setpoints.
- 14 7. If the pump discharge valve was used to set total system flow with variable-frequency
- 15 controller at 60 Hz, at completion open discharge valve 100 percent and allow variable-
- 16 frequency controller to control system differential-pressure set point. Record pump data
- 17 under both conditions.
- 18 8. Mark final settings and verify that all memory stops have been set.
- 19 9. Verify final system conditions as follows:
- 20 a. Re-measure and confirm that total water flow is within design.
- 21 b. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
- 22 c. Mark final settings.
- 23 d. Mark pump manufacturer's head-capacity curve.
- 24 10. Verify that memory stops have been set.
- 25 D. For systems with diversity (when the total flow rate of all valves is more than the indicated flow
- 26 of the pumps):
- 27 1. Determine diversity factor.
- 28 2. Simulate system diversity by closing required number of control valves, as approved by
- 29 the design engineer.
- 30 3. Adjust pumps to deliver total design gpm.
- 31 a. Measure total water flow.
- 32 1) Position valves for full flow through coils.
- 33 2) Measure flow by main flow meter, if installed.
- 34 3) If main flow meter is not installed, determine flow by pump TDH or
- 35 exchanger pressure drop.
- 36 b. Measure pump TDH as follows:
- 37 1) Measure discharge pressure directly at the pump outlet flange or in
- 38 discharge pipe prior to any valves.
- 39 2) Measure inlet pressure directly at the pump inlet flange or in suction pipe
- 40 prior to any valves or strainers.
- 41 3) Convert pressure to head and correct for differences in gage heights.
- 42 4) Verify pump impeller size by measuring the TDH with the discharge valve
- 43 closed. Note the point on manufacturer's pump curve at zero flow and verify
- 44 that the pump has the intended impeller size.

- 1 a) If impeller sizes must be adjusted to achieve pump performance,
2 obtain approval from Engineer and comply with requirements of
3 Division 23 Section "Hydronic Pumps".
- 4 5) With valves open, read pump TDH. Adjust pump discharge valve until
5 design water flow is achieved.
- 6 c. Monitor motor performance during procedures and do not operate motor in an
7 overloaded condition.
- 8 4. Adjust flow-measuring devices installed in mains and branches to design water flows.
- 9 a. Measure flow in main and branch pipes.
10 b. Adjust main and branch balance valves for design flow.
11 c. Re-measure each main and branch after all have been adjusted.
- 12 5. Adjust flow-measuring devices installed at terminals for each space to design water
13 flows.
- 14 a. Measure flow at terminals.
15 b. Adjust each terminal to design flow.
16 c. Re-measure each terminal after it is adjusted.
17 d. Position control valves to bypass the coil, and adjust the bypass valve to maintain
18 design flow.
19 e. Perform temperature tests after flows have been balanced.
- 20 6. For systems with pressure-independent valves at terminals:
- 21 a. Measure differential pressure, and verify that it is within manufacturer's specified
22 range.
23 b. Perform temperature tests after flows have been verified.
- 24 7. For systems without pressure-independent valves or flow-measuring devices at
25 terminals:
- 26 a. Measure and balance coils by either coil pressure drop or temperature method.
27 b. If balanced by coil pressure drop, perform temperature tests after flows have been
28 verified.
- 29 8. Open control valves that were shut. Close a sufficient number of control valves that were
30 previously open to maintain diversity, and balance terminals that were just opened.
- 31 9. Prior to verifying final system conditions, determine system differential-pressure set point.
32 Re-measure the differential pressure at the most critical valve and adjust the system
33 differential pressure set point to the most energy-efficient set point to maintain the
34 optimum system differential pressure. Record set point and give to Controls Contractor.
35 Coordinate maximum and minimum differential pressure setpoints with Controls
36 Contractor for differential pressure setpoint reset. Record valve positions for associated
37 units at maximum and minimum differential pressure setpoints.
- 38 10. If the pump discharge valve was used to set total system flow with variable-frequency
39 controller at 60 Hz, at completion open discharge valve 100 percent and allow variable-
40 frequency controller to control system differential-pressure set point. Record pump data
41 under both conditions.
- 42 11. Mark final settings and verify that memory stops have been set.
- 43 12. Verify final system conditions as follows:

- 1 a. Re-measure and confirm that total water flow is within design.
- 2 b. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
- 3 c. Mark final settings.
- 4 d. Mark pump manufacturer's head-capacity curve.

5 13. Verify that memory stops have been set.

6 **3.11 PROCEDURES FOR MOTORS**

7 A. Motors 1/2 HP and Larger: Test at final balanced conditions and record the following data:

- 8 1. Manufacturer's name, model number, and serial number.
- 9 2. Motor horsepower rating.
- 10 3. Motor rpm.
- 11 4. Phase and hertz.
- 12 5. Nameplate and measured voltage, each phase.
- 13 6. Nameplate and measured amperage, each phase.
- 14 7. Starter size and thermal-protection-element rating.
- 15 8. Service factor and frame size.

16 B. Motors Driven by Variable-Frequency Controllers: Test manual bypass of controller to prove
17 proper operation.

18 **3.12 PROCEDURES FOR CONDENSING UNITS**

- 19 A. Verify proper rotation of fans.
- 20 B. Measure entering- and leaving-air temperatures.
- 21 C. Record fan and motor operating data.

22 **3.13 PROCEDURES FOR BOILERS**

- 23 A. Hydronic Boilers:
 - 24 1. Measure and record entering- and leaving-water temperatures.
 - 25 2. Measure and record water flow.
 - 26 3. Record relief valve pressure setting.

27 **3.14 PROCEDURES FOR HEAT-TRANSFER COILS**

- 28 A. Measure, adjust, and record the following data for each water coil:
 - 29 1. Entering- and leaving-water temperature.
 - 30 2. Water flow rate.
 - 31 3. Water pressure drop for major (more than 20 gpm) equipment coils, excluding unitary
32 equipment such as reheat coils, unit heaters, and fan-coil units.
 - 33 4. Dry-bulb temperature of entering and leaving air.
 - 34 5. Wet-bulb temperature of entering and leaving air for cooling coils.
 - 35 6. Airflow.
 - 36 7. Air pressure drop.

1 8. Coils with pressure independent control valves: Measure coil airflow rate, entering and
 2 leaving air temperatures and calculate energy transfer. Measure coil entering and
 3 leaving water temperatures and use energy balance calculation to determine actual flow
 4 rate and record.

5 B. Measure, adjust, and record the following data for each electric heating coil:

- 6 1. Nameplate data.
- 7 2. Airflow.
- 8 3. Entering- and leaving-air temperature at full load.
- 9 4. Voltage and amperage input of each phase at full load.
- 10 5. Calculated kilowatt at full load.
- 11 6. Fuse or circuit-breaker rating for overload protection.

12 **3.15 DUCT LEAKAGE TESTS**

- 13 A. Witness the duct pressure testing performed by Installer.
- 14 B. Verify that proper test methods are used and that leakage rates are within specified tolerances.
- 15 C. Report deficiencies observed.

16 **3.16 CONTROLS VERIFICATION**

- 17 A. In conjunction with system balancing, perform the following:
 - 18 1. Verify temperature control system is operating within the design limitations.
 - 19 2. Confirm that the sequences of operation are in compliance with Contract Documents.
 - 20 3. Verify that controllers are calibrated and function as intended.
 - 21 4. Verify that controller set points are as indicated.
 - 22 5. Verify the operation of lockout or interlock systems.
 - 23 6. Verify the operation of valve and damper actuators.
 - 24 7. Verify that controlled devices are properly installed and connected to correct controller.
 - 25 8. Verify that controlled devices travel freely and are in position indicated by controller:
 26 open, closed, or modulating.
 - 27 9. Verify location and installation of sensors to ensure that they sense only intended
 28 temperature, humidity, or pressure.
- 29 B. Reporting: Include a summary of verifications performed, remaining deficiencies, and variations
 30 from indicated conditions.

31 **3.17 TOLERANCES**

- 32 A. Set HVAC system's airflow rates and water flow rates within the following tolerances:
 - 33 1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.
 - 34 2. Air Outlets and Inlets: Plus or minus 10 percent.
 - 35 3. Heating-Water Flow Rate: Plus or minus 10 percent.
 - 36 4. Cooling-Water Flow Rate: Plus or minus 10 percent.
 - 37 5. Smoke Control Systems: Plus or minus 5 percent.

- 1 B. Maintaining pressure relationships as designed shall have priority over the tolerances specified
2 above.

3 **3.18 PROGRESS REPORTING**

- 4 A. Initial Construction-Phase Report: Based on examination of the Contract Documents as
5 specified in "Examination" Article, prepare a report on the adequacy of design for systems
6 balancing devices. Recommend changes and additions to systems balancing devices to
7 facilitate proper performance measuring and balancing. Recommend changes and additions to
8 HVAC systems and general construction to allow access for performance measuring and
9 balancing devices.

- 10 B. Status Reports: Prepare weekly progress reports to describe completed procedures,
11 procedures in progress, and scheduled procedures. Include a list of deficiencies and problems
12 found in systems being tested and balanced. Prepare a separate report for each system and
13 each building floor for systems serving multiple floors.

14 **3.19 FINAL REPORT**

- 15 A. General: Prepare a certified written report; tabulate and divide the report into separate sections
16 for tested systems and balanced systems.

- 17 1. Include a certification sheet at the front of the report's binder, signed and sealed by the
18 certified testing and balancing engineer.
19 2. Include a list of instruments used for procedures, along with proof of calibration.
20 3. Certify validity and accuracy of field data.
21 4. Include warranty certificate meeting the requirements of one of the following programs:
22 a. AABC – National Performance Guaranty
23 b. NEBB – Conformance Certification

- 24 B. Final Report Contents: In addition to certified field-report data, include the following:

- 25 1. Pump curves, marked with operating conditions.
26 2. Fan curves, marked with operating conditions.
27 3. Manufacturers' test data.
28 4. Field test reports prepared by system and equipment installers.
29 5. Other information relative to equipment performance; do not include Shop Drawings and
30 Product Data.

- 31 C. General Report Data: In addition to form titles and entries, include the following data:

- 32 1. Title page.
33 2. Name and address of the TAB specialist.
34 3. Project name.
35 4. Project location.
36 5. Architect's name and address.
37 6. Engineer's name and address.
38 7. Contractor's name and address.
39 8. Report date.
40 9. Signature of TAB supervisor who certifies the report.
41 10. Table of Contents with the total number of pages defined for each section of the report.
42 Number each page in the report.
43 11. Summary of contents including the following:

- 1 a. Indicated versus final performance.
- 2 b. Notable characteristics of systems.
- 3 c. Description of system operation sequence if it varies from the Contract
- 4 Documents.

- 5 12. Nomenclature sheets for each item of equipment.
- 6 13. Data for terminal units, including manufacturer's name, type, size, and fittings.
- 7 14. Notes to explain why certain final data in the body of reports vary from indicated values.
- 8 15. Test conditions for fans and pump performance forms including the following:
 - 9 a. Settings for outdoor-, return-, and exhaust-air dampers.
 - 10 b. Conditions of filters.
 - 11 c. Cooling coil, wet- and dry-bulb conditions.
 - 12 d. Face and bypass damper settings at coils.
 - 13 e. Fan drive settings including settings and percentage of maximum pitch diameter.
 - 14 f. Inlet vane settings for variable-air-volume systems.
 - 15 g. Settings for supply-air, static-pressure controller.
 - 16 h. Other system operating conditions that affect performance.

- 17 D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present
- 18 each system with single-line diagram and include the following:
 - 19 1. Quantities of outdoor, supply, return, and exhaust airflows.
 - 20 2. Water and steam flow rates.
 - 21 3. Duct, outlet, and inlet sizes.
 - 22 4. Pipe and valve sizes and locations.
 - 23 5. Terminal units.
 - 24 6. Balancing stations.
 - 25 7. Position of balancing devices.

- 26 E. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:
 - 27 1. Unit Data:
 - 28 a. Unit identification.
 - 29 b. Location.
 - 30 c. Make and type.
 - 31 d. Model number and unit size.
 - 32 e. Manufacturer's serial number.
 - 33 f. Unit arrangement and class.
 - 34 g. Discharge arrangement.
 - 35 h. Sheave make, size in inches (mm), and bore.
 - 36 i. Center-to-center dimensions of sheave and amount of adjustments in inches (mm).
 - 37 j. Number, make, and size of belts.
 - 38 k. Number, type, and size of filters.
 - 39 2. Motor Data:
 - 40 a. Motor make, and frame type and size.
 - 41 b. Horsepower and rpm.
 - 42 c. Volts, phase, and hertz.
 - 43 d. Full-load amperage and service factor.
 - 44 e. Sheave make, size in inches (mm), and bore.
 - 45 f. Center-to-center dimensions of sheave and amount of adjustments in inches (mm).

- 1 3. Test Data (Indicated and Actual Values):
- 2 a. Total airflow rate in cfm (L/s).
- 3 b. Total system static pressure in inches wg (Pa).
- 4 c. Fan rpm.
- 5 d. Discharge static pressure in inches wg (Pa).
- 6 e. Filter static-pressure differential in inches wg (Pa).
- 7 f. Preheat-coil static-pressure differential in inches wg (Pa).
- 8 g. Cooling-coil static-pressure differential in inches wg (Pa).
- 9 h. Heating-coil static-pressure differential in inches wg (Pa).
- 10 i. Outdoor airflow in cfm (L/s).
- 11 j. Return airflow in cfm (L/s).
- 12 k. Outdoor-air damper position.
- 13 l. Return-air damper position.
- 14 m. Vortex damper position.
- 15 F. Apparatus-Coil Test Reports:
- 16 1. Coil Data:
- 17 a. System identification.
- 18 b. Location.
- 19 c. Coil type.
- 20 d. Number of rows.
- 21 e. Fin spacing in fins per inch (mm) o.c.
- 22 f. Make and model number.
- 23 g. Face area in sq. ft. (sq. m).
- 24 h. Tube size in NPS (DN).
- 25 i. Tube and fin materials.
- 26 j. Circuiting arrangement.
- 27 2. Test Data (Indicated and Actual Values):
- 28 a. Airflow rate in cfm (L/s).
- 29 b. Average face velocity in fpm (m/s).
- 30 c. Air pressure drop in inches wg (Pa).
- 31 d. Outdoor-air, wet- and dry-bulb temperatures in deg F (deg C).
- 32 e. Return-air, wet- and dry-bulb temperatures in deg F (deg C).
- 33 f. Entering-air, wet- and dry-bulb temperatures in deg F (deg C).
- 34 g. Leaving-air, wet- and dry-bulb temperatures in deg F (deg C).
- 35 h. Water flow rate in gpm (L/s).
- 36 i. Water pressure differential in feet of head or psig (kPa).
- 37 j. Entering-water temperature in deg F (deg C).
- 38 k. Leaving-water temperature in deg F (deg C).
- 39 l. Refrigerant expansion valve and refrigerant types.
- 40 m. Refrigerant suction pressure in psig (kPa).
- 41 n. Refrigerant suction temperature in deg F (deg C).
- 42 o. Inlet steam pressure in psig (kPa).
- 43 G. Gas- Fired Heat Apparatus Test Reports: In addition to manufacturer's factory startup
- 44 equipment reports, include the following:
- 45 1. Unit Data:
- 46 a. System identification.

- 1 b. Location.
- 2 c. Make and type.
- 3 d. Model number and unit size.
- 4 e. Manufacturer's serial number.
- 5 f. Fuel type in input data.
- 6 g. Output capacity in Btu/h (kW).
- 7 h. Ignition type.
- 8 i. Burner-control types.
- 9 j. Motor horsepower and rpm.
- 10 k. Motor volts, phase, and hertz.
- 11 l. Motor full-load amperage and service factor.
- 12 m. Sheave make, size in inches (mm), and bore.
- 13 n. Center-to-center dimensions of sheave and amount of adjustments in inches (mm).

14 2. Test Data (Indicated and Actual Values):

- 15 a. Total airflow rate in cfm (L/s).
- 16 b. Entering-air temperature in deg F (deg C).
- 17 c. Leaving-air temperature in deg F (deg C).
- 18 d. Air temperature differential in deg F (deg C).
- 19 e. Entering-air static pressure in inches wg (Pa).
- 20 f. Leaving-air static pressure in inches wg (Pa).
- 21 g. Air static-pressure differential in inches wg (Pa).
- 22 h. Low-fire fuel input in Btu/h (kW).
- 23 i. High-fire fuel input in Btu/h (kW).
- 24 j. Manifold pressure in psig (kPa).
- 25 k. High-temperature-limit setting in deg F (deg C).
- 26 l. Operating set point in Btu/h (kW).
- 27 m. Motor voltage at each connection.
- 28 n. Motor amperage for each phase.
- 29 o. Heating value of fuel in Btu/h (kW).

30 H. Fan Test Reports: For supply, return, and exhaust fans, include the following:

31 1. Fan Data:

- 32 a. System identification.
- 33 b. Location.
- 34 c. Make and type.
- 35 d. Model number and size.
- 36 e. Manufacturer's serial number.
- 37 f. Arrangement and class.
- 38 g. Sheave make, size in inches (mm), and bore.
- 39 h. Center-to-center dimensions of sheave and amount of adjustments in inches (mm).

40 2. Motor Data:

- 41 a. Motor make, and frame type and size.
- 42 b. Horsepower and rpm.
- 43 c. Volts, phase, and hertz.
- 44 d. Full-load amperage and service factor.
- 45 e. Sheave make, size in inches (mm), and bore.
- 46 f. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
- 47 g. Number, make, and size of belts.
- 48 h. Belt tension in lbs.

- 1 3. Test Data (Indicated and Actual Values):
- 2 a. Total airflow rate in cfm (L/s).
- 3 b. Total system static pressure in inches wg (Pa).
- 4 c. Fan rpm.
- 5 d. Discharge static pressure in inches wg (Pa).
- 6 e. Suction static pressure in inches wg (Pa).
- 7 I. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid
- 8 representing the duct cross-section and record the following:
- 9 1. Report Data:
- 10 a. System and air-handling-unit number.
- 11 b. Location and zone.
- 12 c. Traverse air temperature in deg F (deg C).
- 13 d. Duct static pressure in inches wg (Pa).
- 14 e. Duct size in inches (mm).
- 15 f. Duct area in sq. ft. (sq. m).
- 16 g. Indicated airflow rate in cfm (L/s).
- 17 h. Indicated velocity in fpm (m/s).
- 18 i. Actual airflow rate in cfm (L/s).
- 19 j. Actual average velocity in fpm (m/s).
- 20 k. Barometric pressure in psig (Pa).
- 21 J. Air-Terminal-Device Reports:
- 22 1. Unit Data:
- 23 a. System and air-handling unit identification.
- 24 b. Location and zone.
- 25 c. Apparatus used for test.
- 26 d. Area served.
- 27 e. Make.
- 28 f. Number from system diagram.
- 29 g. Type and model number.
- 30 h. Size.
- 31 i. Effective area in sq. ft. (sq. m).
- 32 2. Test Data (Indicated and Actual Values):
- 33 a. Airflow rate in cfm (L/s).
- 34 b. Air velocity in fpm (m/s).
- 35 c. Preliminary airflow rate as needed in cfm (L/s).
- 36 d. Preliminary velocity as needed in fpm (m/s).
- 37 e. Final airflow rate in cfm (L/s).
- 38 f. Final velocity in fpm (m/s).
- 39 g. Space temperature in deg F (deg C).
- 40 K. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:
- 41 1. Unit Data:
- 42 a. System and air-handling-unit identification.
- 43 b. Location and zone.

- 1 c. Room or riser served.
- 2 d. Coil make and size.
- 3 e. Flowmeter type.

- 4 2. Test Data (Indicated and Actual Values):

- 5 a. Airflow rate in cfm (L/s).
- 6 b. Entering-water temperature in deg F (deg C).
- 7 c. Leaving-water temperature in deg F (deg C).
- 8 d. Water pressure drop in feet of head or psig (kPa).
- 9 e. Entering-air temperature in deg F (deg C).
- 10 f. Leaving-air temperature in deg F (deg C).

- 11 L. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves and
- 12 include the following:

- 13 1. Unit Data:

- 14 a. Unit identification.
- 15 b. Location.
- 16 c. Service.
- 17 d. Make and size.
- 18 e. Model number and serial number.
- 19 f. Water flow rate in gpm (L/s).
- 20 g. Water pressure differential in feet of head or psig (kPa).
- 21 h. Required net positive suction head in feet of head or psig (kPa).
- 22 i. Pump rpm.
- 23 j. Impeller diameter in inches (mm).
- 24 k. Motor make and frame size.
- 25 l. Motor horsepower and rpm.
- 26 m. Voltage at each connection.
- 27 n. Amperage for each phase.
- 28 o. Full-load amperage and service factor.
- 29 p. Seal type.

- 30 2. Test Data (Indicated and Actual Values):

- 31 a. Static head in feet of head or psig (kPa).
- 32 b. Pump shutoff pressure in feet of head or psig (kPa).
- 33 c. Actual impeller size in inches (mm).
- 34 d. Full-open flow rate in gpm (L/s).
- 35 e. Full-open pressure in feet of head or psig (kPa).
- 36 f. Final discharge pressure in feet of head or psig (kPa).
- 37 g. Final suction pressure in feet of head or psig (kPa).
- 38 h. Final total pressure in feet of head or psig (kPa).
- 39 i. Final water flow rate in gpm (L/s).
- 40 j. Voltage at each connection.
- 41 k. Amperage for each phase.

- 42 M. Instrument Calibration Reports:

- 43 1. Report Data:

- 44 a. Instrument type and make.
- 45 b. Serial number.

- 1 c. Application.
- 2 d. Dates of use.
- 3 e. Dates of calibration.

4 **3.20 VERIFICATION OF TAB REPORT**

- 5 A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of
6 commissioning authority
- 7 B. At Engineer's option, Engineer or Commissioning authority shall randomly select
8 measurements, documented in the final report, to be rechecked. Rechecking shall be limited to
9 either 10 percent of the total measurements recorded or the extent of measurements that can
10 be accomplished in a normal 8-hour business day.
- 11 C. If rechecks yield measurements that differ from the measurements documented in the final
12 report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
- 13 D. If the number of "FAILED" measurements is greater than 10 percent of the total measurements
14 checked during the final inspection, the testing and balancing shall be considered incomplete
15 and shall be rejected.
- 16 E. If TAB work fails, proceed as follows:
 - 17 1. TAB specialists shall recheck all measurements and make adjustments. Revise the final
18 report and balancing device settings to include all changes; resubmit the final report and
19 request a second final inspection.
 - 20 2. If the second final inspection also fails, Owner may contract the services of another TAB
21 specialist to complete TAB work according to the Contract Documents and deduct the
22 cost of the services from the original TAB specialist's final payment.
 - 23 3. If the second verification also fails, design professional may contact AABC Headquarters
24 regarding the AABC National Performance Guaranty or NEBB Headquarters regarding
25 the NEBB Conformance Certification.
- 26 F. Prepare test and inspection reports.

27 **3.21 ADDITIONAL TESTS**

- 28 A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are
29 being maintained throughout and to correct unusual conditions.
- 30 B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and
31 winter conditions, perform additional TAB during near-peak summer and winter conditions.

32 **END OF SECTION 23 05 93**

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1 **SECTION 23 07 13.11 - INSULATION FOR INDOOR GENERAL HVAC DUCTS**

2 **PART 1 - GENERAL**

3 **1.1 RELATED DOCUMENTS**

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

6 **1.2 SUMMARY**

- 7 A. Section includes insulating the following duct services:

- 8 1. Indoor, concealed supply, return, and outdoor air.
9 2. Indoor, exposed supply, return, and outdoor air.
10 3. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
11 4. Indoor, exposed exhaust between isolation damper and penetration of building exterior.

- 12 B. Related Sections:

- 13 1. Section 23 31 13 "Metal Ducts" for duct liners.

14 **1.3 ACTION SUBMITTALS**

- 15 A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor
16 permeance thickness, and jackets (both factory- and field-applied if any).

- 17 B. Shop Drawings:

- 18 1. Detail application for each type of insulation and hanger.
19 2. Detail insulation application for each type of insulation.

20 **1.4 QUALITY ASSURANCE**

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

- 24 B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing
25 identical products according to ASTM E84, by a testing agency acceptable to authorities having
26 jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and
27 cement material containers, with appropriate markings of applicable testing agency.

- 28 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed
29 index of 50 or less.

1 **1.5 DELIVERY, STORAGE, AND HANDLING**

2 A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate
3 ASTM standard designation, type and grade, and maximum use temperature.

4 **1.6 COORDINATION**

5 A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in
6 Section 23 05 29 "Hangers and Supports for HVAC Piping and Equipment."

7 B. Coordinate clearance requirements with duct Installer for duct insulation application. Before
8 preparing ductwork Shop Drawings, establish and maintain clearance requirements for
9 installation of insulation and field-applied jackets and finishes and for space required for
10 maintenance.

11 **1.7 SCHEDULING**

12 A. Schedule insulation application after pressure testing systems and, where required, after
13 installing and testing heat tracing. Insulation application may begin on segments that have
14 satisfactory test results.

15 B. Complete installation and concealment of plastic materials as rapidly as possible in each area of
16 construction.

17 **PART 2 - PRODUCTS**

18 **2.1 INSULATION MATERIALS**

19 A. Comply with requirements in "Duct Insulation Schedule, General," and "Indoor Duct and Plenum
20 Insulation Schedule" articles for where insulating materials shall be applied.

21 B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

22 C. Products that come in contact with stainless steel shall have a leachable chloride content of less
23 than 50 ppm when tested according to ASTM C871.

24 D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable
25 according to ASTM C795.

26 E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing
27 process.

28 F. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin.
29 Comply with ASTM C553, Type II and ASTM C1290, Type III with factory-applied FSK jacket.
30 Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

31 1. Products: Subject to compliance with requirements, provide one of the following:

32 a. CertainTeed Corp.: SoftTouch Duct Wrap.

33 b. Johns Manville; Microlite.

34 c. Knauf Insulation; Friendly Feel Duct Wrap.

- 1 d. Owens Corning; SOFTR All-Service Duct Wrap.
- 2 G. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin.
 3 Comply with ASTM C612, Type IA or Type IB. For duct and plenum applications, provide
 4 insulation with factory-applied ASJ. Factory-applied jacket requirements are specified in
 5 "Factory-Applied Jackets" Article.
- 6 1. Products: Subject to compliance with requirements, provide one of the following:
- 7 a. CertainTeed Corp.; Commercial Board.
 8 b. Johns Manville; 800 Series Spin-Glas.
 9 c. Knauf Insulation; Insulation Board.
 10 d. Owens Corning; Fiberglas 700 Series.
- 11 H. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting
 12 resin. Semirigid board material with factory-applied FSK jacket complying with ASTM C1393,
 13 Type II or Type IIIA Category 2, or with properties similar to ASTM C612, Type IB. Nominal
 14 density is 2.5 lb/cu. ft. (40 kg/cu. m) or more. Thermal conductivity (k-value) at 100 deg F (55
 15 deg C) is 0.29 Btu x in./h x sq. ft. x deg F (0.042 W/m x K) or less. Factory-applied jacket
 16 requirements are specified in "Factory-Applied Jackets" Article.
- 17 1. Products: Subject to compliance with requirements, provide one of the following:
- 18 a. CertainTeed Corp.; CrimpWrap.
 19 b. Johns Manville; MicroFlex.
 20 c. Knauf Insulation; Pipe and Tank Insulation.
 21 d. Owens Corning; Fiberglas Pipe and Tank Insulation.

22 **2.2 ADHESIVES**

- 23 A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding
 24 insulation to itself and to surfaces to be insulated unless otherwise indicated.
- 25 B. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
- 26 1. Products: Subject to compliance with requirements, provide one of the following:
- 27 a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller
 28 Company; CP-127.
 29 b. Eagle Bridges - Marathon Industries; 225.
 30 c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller
 31 Company; 85-60/85-70.
 32 d. Mon-Eco Industries, Inc.; 22-25.
- 33 2. Fiberglass adhesive shall have a VOC content of 80 g/L or less when calculated
 34 according to 40 CFR 59, Subpart D (EPA Method 24).
 35 3. Adhesive shall comply with the testing and product requirements of the California
 36 Department of Public Health's "Standard Method for the Testing and Evaluation of
 37 Volatile Organic Chemical Emissions from Indoor Sources Using Environmental
 38 Chambers."
- 39 C. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for
 40 bonding insulation jacket lap seams and joints.

- 1 1. Products: Subject to compliance with requirements, provide one of the following:
- 2 a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller
- 3 Company; CP-82.
- 4 b. Eagle Bridges - Marathon Industries; 225.
- 5 c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller
- 6 Company; 85-50.Mon-Eco Industries, Inc.; 22-25.

- 7 2. Adhesive shall have a VOC content of 80 g/L or less when calculated according to
- 8 40 CFR 59, Subpart D (EPA Method 24).
- 9 3. Adhesive shall comply with the testing and product requirements of the California
- 10 Department of Public Health's "Standard Method for the Testing and Evaluation of
- 11 Volatile Organic Chemical Emissions from Indoor Sources Using Environmental
- 12 Chambers."

13 **2.3 MASTICS AND COATINGS**

- 14 A. Materials shall be compatible with insulation materials, jackets, and substrates.

- 15 1. VOC Content: 50 g/L or less.
- 16 2. Low-Emitting Materials: Mastic coatings shall comply with the testing and product
- 17 requirements of the California Department of Public Health's "Standard Method for the
- 18 Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources
- 19 Using Environmental Chambers."

- 20 B. Vapor-Retarder Mastic: Water based; suitable for indoor use on below ambient services.

- 21 1. Products: Subject to compliance with requirements, provide one of the following:
- 22 a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller
- 23 Company; 30-80/30-90.
- 24 b. Vimasco Corporation; 749.

- 25 2. Water-Vapor Permeance: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation
- 26 type and service conditions.
- 27 3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
- 28 4. Comply with MIL-PRF-19565C, Type II, for permeance requirements.
- 29 5. Color: White.

- 30 C. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.

- 31 1. Manufacturers: Subject to compliance with requirements, provide products by one of the
- 32 following:
- 33 a. Childers Brand; H. B. Fuller Construction Products; CP-10.
- 34 b. Eagle Bridges - Marathon Industries; 550.
- 35 c. Foster Brand; H. B. Fuller Construction Products; 46-50.
- 36 d. Mon-Eco Industries, Inc; 55-50.

- 37 2. Vimasco Corporation; WC-1/WC-5.Water-Vapor Permeance: ASTM E96, greater than
- 38 1.0 perm (0.66 metric perms) at manufacturer's recommended dry film thickness.
- 39 3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
- 40 4. Color: White.

1 **2.4 SEALANTS**

2 A. FSK Flashing Sealants:

3 1. Products: Subject to compliance with requirements, provide one of the following:

- 4 a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller
5 Company; CP-76.Eagle Bridges - Marathon Industries; 405.
- 6 b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller
7 Company; 95-44.
- 8 c. Mon-Eco Industries, Inc.; 44-05.

- 9 2. Materials shall be compatible with insulation materials, jackets, and substrates.
- 10 3. Fire- and water-resistant, flexible, elastomeric sealant.
- 11 4. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
- 12 5. Color: Aluminum.
- 13 6. Sealant shall have a VOC content of 420 g/L or less.
- 14 7. Sealant shall comply with the testing and product requirements of the California
15 Department of Public Health's "Standard Method for the Testing and Evaluation of
16 Volatile Organic Chemical Emissions from Indoor Sources Using Environmental
17 Chambers."

18 **2.5 FACTORY-APPLIED JACKETS**

19 A. Insulation system schedules indicate factory-applied jackets on various applications. When
20 factory-applied jackets are indicated, comply with the following:

- 21 1. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing;
22 complying with ASTM C1136, Type II.

23 **2.6 FIELD-APPLIED FABRIC-REINFORCING MESH**

24 A. Woven Glass-Fiber Fabric: Approximately 6 oz./sq. yd. (203 g/sq. m) with a thread count of 5
25 strands by 5 strands/sq. in. (2 strands by 2 strands/sq. mm) for covering ducts.

26 1. Manufacturers: Subject to compliance with requirements, provide products by the
27 following:

- 28 a. Childers Brand; H. B. Fuller Construction Products; Chil-Glas Number 5.

29 **2.7 FIELD-APPLIED JACKETS**

30 A. Field-applied jackets shall comply with ASTM C921, Type I, unless otherwise indicated.

31 B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

32 **2.8 SECUREMENTS**

33 A. Bands:

- 34 1. Aluminum: ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14,
35 0.020 inch (0.51 mm) thick, 1/2 inch (13 mm) wide with wing seal.

- 1 2. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept
2 metal bands. Spring size determined by manufacturer for application.
- 3 B. Insulation Pins and Hangers:
- 4 1. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to
5 projecting spindle that is capable of holding insulation, of thickness indicated, securely in
6 position indicated when self-locking washer is in place. Comply with the following
7 requirements:
- 8 a. Manufacturers: Subject to compliance with requirements, provide products by one
9 of the following:
- 10 1) AGM Industries, Inc.
11 2) Gemco.
12 3) Midwest Fasteners, Inc.
- 13 b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick
14 by 2 inches (50 mm) square.
- 15 c. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch- (2.6-
16 mm-) diameter shank, length to suit depth of insulation indicated.
- 17 d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated
18 capability to bond insulation hanger securely to substrates indicated without
19 damaging insulation, hangers, and substrates.
- 20 2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-)
21 thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation
22 securely in place but not less than 1-1/2 inches (38 mm) in diameter.
- 23 a. Products: Subject to compliance with requirements, provide one of the following:
- 24 1) AGM Industries, Inc.; RC-150.
25 2) GEMCO; R-150.
26 3) Midwest Fasteners, Inc.; WA-150.
27 4) Nelson Stud Welding; Speed Clips.
- 28 b. Protect ends with capped self-locking washers incorporating a spring steel insert to
29 ensure permanent retention of cap in exposed locations.
- 30 C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel
31 or Monel.

32 **PART 3 - EXECUTION**

33 **3.1 EXAMINATION**

- 34 A. Examine substrates and conditions for compliance with requirements for installation tolerances
35 and other conditions affecting performance of insulation application.
- 36 1. Verify that systems to be insulated have been tested and are free of defects.
37 2. Verify that surfaces to be insulated are clean and dry.
- 38 B. Proceed with installation only after unsatisfactory conditions have been corrected.

1 **3.2 PREPARATION**

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

4 **3.3 GENERAL INSTALLATION REQUIREMENTS**

5 A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces;
6 free of voids throughout the length of ducts and fittings.

7 B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for
8 each item of duct system as specified in insulation system schedules.

9 C. Install accessories compatible with insulation materials and suitable for the service. Install
10 accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or
11 dry state.

12 D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

13 E. Install multiple layers of insulation with longitudinal and end seams staggered.

14 F. Keep insulation materials dry during application and finishing.

15 G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with
16 adhesive recommended by insulation material manufacturer.

17 H. Install insulation with least number of joints practical.

18 I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers,
19 supports, anchors, and other projections with vapor-barrier mastic.

- 20 1. Install insulation continuously through hangers and around anchor attachments.
21 2. For insulation application where vapor barriers are indicated, extend insulation on anchor
22 legs from point of attachment to supported item to point of attachment to structure. Taper
23 and seal ends at attachment to structure with vapor-barrier mastic.

24 J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet
25 and dry film thicknesses.

26 K. Install insulation with factory-applied jackets as follows:

- 27 1. Draw jacket tight and smooth.
28 2. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as
29 insulation jacket. Secure strips with adhesive and outward clinching staples along both
30 edges of strip, spaced 4 inches (100 mm) o.c.
31 3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Clean and dry surface
32 to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4
33 inches (100 mm) o.c.

34 a. For below ambient services, apply vapor-barrier mastic over staples.

35 4. Cover joints and seams with tape, according to insulation material manufacturer's written
36 instructions, to maintain vapor seal.

- 1 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and
- 2 at ends adjacent to duct flanges and fittings.

- 3 L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal
- 4 thickness.

- 5 M. Repair damaged insulation facings by applying same facing material over damaged areas.
- 6 Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal
- 7 patches similar to butt joints.

8 **3.4 PENETRATIONS**

- 9 A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof
- 10 penetrations.

- 11 1. Seal penetrations with flashing sealant.
- 12 2. For applications requiring only indoor insulation, terminate insulation above roof surface
- 13 and seal with joint sealant. For applications requiring indoor and outdoor insulation, install
- 14 insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with
- 15 joint sealant.
- 16 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches (50 mm) below
- 17 top of roof flashing.
- 18 4. Seal jacket to roof flashing with flashing sealant.

- 19 B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously
- 20 through wall penetrations.

- 21 1. Seal penetrations with flashing sealant.
- 22 2. For applications requiring only indoor insulation, terminate insulation inside wall surface
- 23 and seal with joint sealant. For applications requiring indoor and outdoor insulation, install
- 24 insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with
- 25 joint sealant.
- 26 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least
- 27 2 inches (50 mm).
- 28 4. Seal jacket to wall flashing with flashing sealant.

- 29 C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated):
- 30 Install insulation continuously through walls and partitions.

- 31 D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire
- 32 damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves
- 33 to match adjacent insulation and overlap duct insulation at least 2 inches (50 mm).

- 34 1. Comply with requirements in Section 07 84 13 "Penetration Firestopping."

- 35 E. Insulation Installation at Floor Penetrations:

- 36 1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper
- 37 sleeves and externally insulate damper sleeve beyond floor to match adjacent duct
- 38 insulation. Overlap damper sleeve and duct insulation at least 2 inches (50 mm).
- 39 2. Seal penetrations through fire-rated assemblies. Comply with requirements in
- 40 Section 07 84 13 "Penetration Firestopping."

1 **3.5 INSTALLATION OF MINERAL-FIBER INSULATION**

- 2 A. Blanket Insulation Installation on Ducts and Plenums: Secure with insulation pins.
- 3 1.
- 4 2. Install metal, adhesively attached, perforated-base insulation hangers on sides and
- 5 bottom of horizontal ducts and sides of vertical ducts as follows:
- 6 a. On duct sides with dimensions 18 inches (450 mm) and smaller, place pins along
- 7 longitudinal centerline of duct. Space 3 inches (75 mm) maximum from insulation
- 8 end joints, and 16 inches (400 mm) o.c.
- 9 b. On duct sides with dimensions larger than 18 inches (450 mm), place pins 16
- 10 inches (400 mm) o.c. each way, and 3 inches (75 mm) maximum from insulation
- 11 joints. Install additional pins to hold insulation tightly against surface at cross
- 12 bracing.
- 13 c. Pins may be omitted from top surface of horizontal, rectangular ducts and
- 14 plenums.
- 15 d. Do not overcompress insulation during installation.
- 16 e. Impale insulation over pins and attach speed washers.
- 17 f. Cut excess portion of pins extending beyond speed washers or bend parallel with
- 18 insulation surface. Cover exposed pins and washers with tape matching insulation
- 19 facing.
- 20 3. For ducts and plenums with surface temperatures below ambient, install a continuous
- 21 unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with
- 22 insulation by removing 2 inches (50 mm) from one edge and one end of insulation
- 23 segment. Secure laps to adjacent insulation section with 1/2-inch (13-mm) outward-
- 24 clinching staples, 1 inch (25 mm) o.c. Install vapor barrier consisting of factory- or field-
- 25 applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and
- 26 protrusions.
- 27 a. Repair punctures, tears, and penetrations with mastic to maintain vapor-barrier
- 28 seal.
- 29 b. Install vapor stops for ductwork and plenums operating below 50 deg F (10 deg C)
- 30 at 18-foot (5.5-m) intervals. Vapor stops shall consist of vapor-barrier mastic
- 31 applied in a Z-shaped pattern over insulation face, along butt end of insulation, and
- 32 over the surface. Cover insulation face and surface to be insulated a width equal to
- 33 two times the insulation thickness, but not less than 3 inches (75 mm).
- 34 4. Overlap unfaced blankets a minimum of 2 inches (50 mm) on longitudinal seams and end
- 35 joints. At end joints, secure with steel bands spaced a maximum of 18 inches (450 mm)
- 36 o.c.
- 37 5. Install insulation on rectangular duct elbows and transitions with a full insulation section
- 38 for each surface. Install insulation on round and flat-oval duct elbows with individually
- 39 mitered gores cut to fit the elbow.
- 40 6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with
- 41 6-inch- (150-mm-) wide strips of same material used to insulate duct. Secure on
- 42 alternating sides of stiffener, hanger, and flange with pins spaced 6 inches (150 mm) o.c.
- 43 B. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
- 44 1. Apply adhesives according to manufacturer's recommended coverage rates per unit
- 45 area, for 50 percent coverage of duct and plenum surfaces.
- 46 2. Install metal, adhesively attached, perforated-base insulation hangers on sides and
- 47 bottom of horizontal ducts and sides of vertical ducts as follows:

1 **SECTION 23 07 13.13 - INSULATION FOR COMMERCIAL KITCHEN EXHAUST DUCTS**

2 **PART 1 - GENERAL**

3 **1.1 RELATED DOCUMENTS**

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

6 **1.2 SUMMARY**

- 7 A. Section includes insulating the following duct services:
8 1. Indoor, concealed, Type I, commercial, kitchen hood exhaust.
9 2. Indoor, exposed, Type I, commercial, kitchen hood exhaust.
10 3. Indoor, concealed oven and warewash exhaust.
11 4. Indoor, exposed oven and warewash exhaust.

12 **1.3 ACTION SUBMITTALS**

- 13 A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor
14 permeance thickness, and jackets (both factory- and field-applied if any).
15 B. Shop Drawings:
16 1. Detail application for each type of insulation and hanger.
17 2. Detail insulation application for each type of insulation.

18 **1.4 QUALITY ASSURANCE**

- 19 A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship
20 program or another craft training program certified by the Department of Labor, Bureau of
21 Apprenticeship and Training.
22 B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing
23 identical products according to ASTM E84, by a testing agency acceptable to authorities having
24 jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and
25 cement material containers, with appropriate markings of applicable testing agency.
26 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed
27 index of 50 or less.

28 **1.5 DELIVERY, STORAGE, AND HANDLING**

- 29 A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate
30 ASTM standard designation, type and grade, and maximum use temperature.

1 **1.6 COORDINATION**

- 2 A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in
3 Section 23 05 29 "Hangers and Supports for HVAC Piping and Equipment."
- 4 B. Coordinate clearance requirements with duct Installer for duct insulation application. Before
5 preparing ductwork Shop Drawings, establish and maintain clearance requirements for
6 installation of insulation and field-applied jackets and finishes and for space required for
7 maintenance.

8 **1.7 SCHEDULING**

- 9 A. Schedule insulation application after pressure testing systems and, where required, after
10 installing and testing heat tracing. Insulation application may begin on segments that have
11 satisfactory test results.
- 12 B. Complete installation and concealment of plastic materials as rapidly as possible in each area of
13 construction.

14 **PART 2 - PRODUCTS**

15 **2.1 INSULATION MATERIALS**

- 16 A. Comply with requirements in "Duct Insulation Schedule, General," and "Indoor Duct and Plenum
17 Insulation Schedule" articles for where insulating materials shall be applied.
- 18 B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- 19 C. Products that come in contact with stainless steel shall have a leachable chloride content of less
20 than 50 ppm when tested according to ASTM C871.
- 21 D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable
22 according to ASTM C795.

23 **2.2 FIRE-RATED INSULATION SYSTEMS**

- 24 A. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is tested
25 and certified to provide a 2-hour fire rating by an NRTL acceptable to authorities having
26 jurisdiction.
- 27 1. Manufacturers: Subject to compliance with requirements, provide products by one of the
28 following:
- 29 a. 3M; Fire Barrier Wrap Products.
30 b. CertainTeed Corporation; FlameChek.
31 c. Johns Manville; a Berkshire Hathaway company; Firetemp Wrap.
32 d. Thermal Ceramics; FireMaster Duct Wrap.
33 e. Unifrax Corporation, FyreWrap.

1 **2.3 ADHESIVES**

- 2 A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding
3 insulation to itself and to surfaces to be insulated unless otherwise indicated.
- 4 B. FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation
5 jacket lap seams and joints.
- 6 1. Products: Subject to compliance with requirements, provide one of the following:
- 7 a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller
8 Company; CP-82.
- 9 b. Eagle Bridges - Marathon Industries; 225.
- 10 c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller
11 Company; 85-50.Mon-Eco Industries, Inc.; 22-25.
- 12 2. Adhesive shall have a VOC content of 80 g/L or less when calculated according to
13 40 CFR 59, Subpart D (EPA Method 24).
- 14 3. Adhesive shall comply with the testing and product requirements of the California
15 Department of Public Health's "Standard Method for the Testing and Evaluation of
16 Volatile Organic Chemical Emissions from Indoor Sources Using Environmental
17 Chambers."

18 **2.4 MASTICS AND COATINGS**

- 19 A. Materials shall be compatible with insulation materials, jackets, and substrates.
- 20 1. VOC Content: 50 g/L or less.
- 21 2. Low-Emitting Materials: Mastic coatings shall comply with the testing and product
22 requirements of the California Department of Public Health's "Standard Method for the
23 Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources
24 Using Environmental Chambers."
- 25 B. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.
- 26 1. Manufacturers: Subject to compliance with requirements, provide products by one of the
27 following:
- 28 a. Childers Brand; H. B. Fuller Construction Products; CP-10.
- 29 b. Eagle Bridges - Marathon Industries; 550.
- 30 c. Foster Brand; H. B. Fuller Construction Products; 46-50.
- 31 d. Mon-Eco Industries, Inc; 55-50.
- 32 e. Vimasco Corporation; WC-1/WC-5.
- 33 2. Water-Vapor Permeance: ASTM E96, greater than 1.0 perm (0.66 metric perms) at
34 manufacturer's recommended dry film thickness.
- 35 3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
- 36 4. Color: White.

37 **2.5 SEALANTS**

- 38 A. FSK Flashing Sealants:

- 1 1. Products: Subject to compliance with requirements, provide one of the following:
- 2 a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller
- 3 Company; CP-76.Eagle Bridges - Marathon Industries; 405.
- 4 b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller
- 5 Company; 95-44.
- 6 c. Mon-Eco Industries, Inc.; 44-05.
- 7 2. Materials shall be compatible with insulation materials, jackets, and substrates.
- 8 3. Fire- and water-resistant, flexible, elastomeric sealant.
- 9 4. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
- 10 5. Color: Aluminum.
- 11 6. Sealant shall have a VOC content of 420 g/L or less.
- 12 7. Sealant shall comply with the testing and product requirements of the California
- 13 Department of Public Health's "Standard Method for the Testing and Evaluation of
- 14 Volatile Organic Chemical Emissions from Indoor Sources Using Environmental
- 15 Chambers."

16 **2.6 FACTORY-APPLIED JACKETS**

- 17 A. Insulation system schedules indicate factory-applied jackets on various applications. When
- 18 factory-applied jackets are indicated, comply with the following:
- 19 1. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing;
- 20 complying with ASTM C1136, Type II.

21 **2.7 FIELD-APPLIED JACKETS**

- 22 A. Field-applied jackets shall comply with ASTM C921, Type I, unless otherwise indicated.
- 23 B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

24 **2.8 TAPES**

- 25 A. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive;
- 26 complying with ASTM C1136.
- 27 1. Products: Subject to compliance with requirements, provide one of the following :
- 28 a. ABI, Ideal Tape Division; 491 AWF FSK.
- 29 b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
- 30 c. Compac Corporation; 110 and 111.
- 31 d. Venture Tape; 1525 CW NT, 1528 CW, and 1528 CW/SQ.
- 32 2. Width: 3 inches (75 mm).
- 33 3. Thickness: 6.5 mils (0.16 mm).
- 34 4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
- 35 5. Elongation: 2 percent.
- 36 6. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
- 37 7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

1 **2.9 SECUREMENTS**

2 A. Bands:

- 3 1. Stainless Steel: ASTM A167 or ASTM A240/A240M, Type 304 or Type 316; 0.015 inch
4 (0.38 mm) thick, 3/4 inch (19 mm) wide with wing seal.
5 2. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept
6 metal bands. Spring size determined by manufacturer for application.

7 B. Insulation Pins and Hangers:

- 8 1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully
9 annealed for capacitor-discharge welding, 0.106-inch- (2.6-mm-) diameter shank, length
10 to suit depth of insulation indicated with integral 1-1/2-inch (38-mm) galvanized carbon-
11 steel washer.

- 12 2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-)
13 thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation
14 securely in place but not less than 1-1/2 inches (38 mm) in diameter.

- 15 a. Products: Subject to compliance with requirements, provide one of the following:

- 16 1) AGM Industries, Inc.; RC-150.
17 2) GEMCO; R-150.
18 3) Midwest Fasteners, Inc.; WA-150.
19 4) Nelson Stud Welding; Speed Clips.

- 20 b. Protect ends with capped self-locking washers incorporating a spring steel insert to
21 ensure permanent retention of cap in exposed locations.

- 22 C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel
23 or Monel.

24 **PART 3 - EXECUTION**

25 **3.1 EXAMINATION**

- 26 A. Examine substrates and conditions for compliance with requirements for installation tolerances
27 and other conditions affecting performance of insulation application.

- 28 1. Verify that systems to be insulated have been tested and are free of defects.
29 2. Verify that surfaces to be insulated are clean and dry.

- 30 B. Proceed with installation only after unsatisfactory conditions have been corrected.

31 **3.2 PREPARATION**

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

1 **3.3 GENERAL INSTALLATION REQUIREMENTS**

- 2 A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces;
3 free of voids throughout the length of ducts and fittings.
- 4 B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for
5 each item of duct system as specified in insulation system schedules.
- 6 C. Install accessories compatible with insulation materials and suitable for the service. Install
7 accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or
8 dry state.
- 9 D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- 10 E. Install multiple layers of insulation with longitudinal and end seams staggered.
- 11 F. Keep insulation materials dry during application and finishing.
- 12 G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with
13 adhesive recommended by insulation material manufacturer.
- 14 H. Install insulation with least number of joints practical.
- 15 I. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet
16 and dry film thicknesses.
- 17 J. Install insulation with factory-applied jackets as follows:
 - 18 1. Draw jacket tight and smooth.
 - 19 2. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as
20 insulation jacket. Secure strips with adhesive and outward clinching staples along both
21 edges of strip, spaced 4 inches (100 mm) o.c.
 - 22 3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Clean and dry surface
23 to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4
24 inches (100 mm) o.c.
 - 25 4. Cover joints and seams with tape, according to insulation material manufacturer's written
26 instructions, to maintain vapor seal.
- 27 K. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal
28 thickness.
- 29 L. Repair damaged insulation facings by applying same facing material over damaged areas.
30 Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal
31 patches similar to butt joints.

32 **3.4 PENETRATIONS**

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

- 1 insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with
- 2 joint sealant.
- 3 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches (50 mm) below
- 4 top of roof flashing.
- 5 4. Seal jacket to roof flashing with flashing sealant.

- 6 B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously
- 7 through wall penetrations.

- 8 1. Seal penetrations with flashing sealant.
- 9 2. For applications requiring only indoor insulation, terminate insulation inside wall surface
- 10 and seal with joint sealant. For applications requiring indoor and outdoor insulation, install
- 11 insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with
- 12 joint sealant.
- 13 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least
- 14 2 inches (50 mm).
- 15 4. Seal jacket to wall flashing with flashing sealant.

- 16 C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated):
- 17 Install insulation continuously through walls and partitions.

- 18 D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire
- 19 damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves
- 20 to match adjacent insulation and overlap duct insulation at least 2 inches (50 mm).

- 21 1. Comply with requirements in Section 07 84 13 "Penetration Firestopping."

- 22 E. Insulation Installation at Floor Penetrations:

- 23 1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper
- 24 sleeves and externally insulate damper sleeve beyond floor to match adjacent duct
- 25 insulation. Overlap damper sleeve and duct insulation at least 2 inches (50 mm).
- 26 2. Seal penetrations through fire-rated assemblies. Comply with requirements in
- 27 Section 07 84 13 "Penetration Firestopping."

28 3.5 FIELD-APPLIED JACKET INSTALLATION

- 29 A. Where FSK jackets are indicated, install as follows:

- 30 1. Install lap or joint strips with same material as jacket.
- 31 2. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation
- 32 with vapor-barrier mastic.

33 B.

34 3.6 FIRE-RATED INSULATION SYSTEM INSTALLATION

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

- 37 B. Insulate duct access panels and doors to achieve same fire rating as duct.

- 1 C. Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are
2 specified in Section 07 84 13 "Penetration Firestopping."
- 3 D. Secure fire-rated insulation with stainless-steel bands 12 inches (300 mm) o.c. and at end
4 joints.
- 5 E. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-
6 discharge-weld pins sides of vertical ducts as follows:
 - 7 1. On duct sides with dimensions 18 inches (450 mm) and smaller, place pins along
8 longitudinal centerline of duct. Space 3 inches (75 mm) maximum from insulation end
9 joints, and 16 inches (400 mm) o.c.
 - 10 2. On duct sides with dimensions larger than 18 inches (450 mm), space pins 16 inches
11 (400 mm) o.c. each way, and 3 inches (75 mm) maximum from insulation joints. Install
12 additional pins to hold insulation tightly against surface at cross bracing.
 - 13 3. Do not overcompress insulation during installation.
 - 14 4. Cut excess portion of pins extending beyond speed washers or bend parallel with
15 insulation surface. Cover exposed pins and washers with tape matching insulation facing.

16 **3.7 DUCT INSULATION SCHEDULE, GENERAL**

- 17 A. Plenums and Ducts Requiring Insulation:
 - 18 1. Indoor, concealed, Type I, commercial, kitchen hood exhaust.
 - 19 2. Indoor, exposed, Type I, commercial, kitchen hood exhaust.
 - 20 3. Indoor, concealed oven and warewash exhaust.
 - 21 4. Indoor, exposed oven and warewash exhaust.
- 22 B. Items Not Insulated:
 - 23 1. Metal ducts with duct liner of sufficient thickness to comply with energy code and
24 ASHRAE/IESNA 90.1.
 - 25 2. Factory-insulated plenums and casings.
 - 26 3. Flexible connectors.
 - 27 4. Vibration-control devices.
 - 28 5. Factory-insulated access panels and doors.

29 **3.8 INDOOR DUCT AND PLENUM INSULATION SCHEDULE**

- 30 A. Concealed, Type I, Commercial, Kitchen Hood Exhaust Duct and Plenum Insulation: Fire-rated
31 blanket; thickness as required to achieve 2-hour fire rating.
- 32 B. Concealed, Oven and Warewash Exhaust Duct and Plenum Insulation: Fire-rated blanket;
33 thickness as required to achieve 2-hour fire rating.
- 34 C. Exposed, Type I, Commercial, Kitchen Hood Exhaust Duct and Plenum Insulation: Fire-rated
35 blanket; thickness as required to achieve 2-hour fire rating.
- 36 D. Exposed, Oven and Warewash Exhaust Duct and Plenum Insulation: Fire-rated blanket;
37 thickness as required to achieve 2-hour fire rating.

38 **END OF SECTION 23 07 13.13**

1 **SECTION 23 07 19.11 - INSULATION FOR CONDENSATE DRAIN PIPING**

2 **PART 1 - GENERAL**

3 **1.1 RELATED DOCUMENTS**

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

6 **1.2 SUMMARY**

- 7 A. Section includes insulating the following HVAC piping systems:

- 8 1. Condensate drain piping, indoors.

9 **1.3 ACTION SUBMITTALS**

- 10 A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor
11 permeance thickness, and jackets (both factory and field applied if any).

- 12 B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

- 13 1. Detail application of protective shields, saddles, and inserts at hangers for each type of
14 insulation and hanger.
15 2. Detail insulation application at pipe expansion joints for each type of insulation.
16 3. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each
17 type of insulation.
18 4. Detail removable insulation at piping specialties.
19 5. Detail application of field-applied jackets.
20 6. Detail application at linkages of control devices.

21 **1.4 QUALITY ASSURANCE**

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

- 25 B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing
26 identical products according to ASTM E84, by a testing and inspecting agency acceptable to
27 authorities having jurisdiction. Factory label insulation and jacket materials and adhesive,
28 mastic, tapes, and cement material containers, with appropriate markings of applicable testing
29 agency.

- 30 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed
31 index of 50 or less.
32 2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed
33 index of 150 or less.

1 **1.5 DELIVERY, STORAGE, AND HANDLING**

2 A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate
3 ASTM standard designation, type and grade, and maximum use temperature.

4 **1.6 COORDINATION**

5 A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in
6 Section 23 05 29 "Hangers and Supports for HVAC Piping and Equipment."

7 B. Coordinate clearance requirements with piping Installer for piping insulation application. Before
8 preparing piping Shop Drawings, establish and maintain clearance requirements for installation
9 of insulation and field-applied jackets and finishes and for space required for maintenance.

10 **1.7 SCHEDULING**

11 A. Schedule insulation application after pressure testing systems and, where required, after
12 installing and testing heat tracing. Insulation application may begin on segments that have
13 satisfactory test results.

14 B. Complete installation and concealment of plastic materials as rapidly as possible in each area of
15 construction.

16 **PART 2 - PRODUCTS**

17 **2.1 INSULATION MATERIALS**

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

21 B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

22 C. Products that come in contact with stainless steel shall have a leachable chloride content of less
23 than 50 ppm when tested according to ASTM C871.

24 D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable
25 according to ASTM C795.

26 E. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply
27 with ASTM C534, Type I for tubular materials.

28 1. Products: Subject to compliance with requirements, provide one of the following:

29 a. Aeroflex USA, Inc.; Aerocel.

30 b. Armacell LLC; AP Armaflex.

31 c. K-Flex USA; Insul-Lock, Insul-Tube, and K-FLEX LS.

1 **2.2 ADHESIVES**

- 2 A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding
3 insulation to itself and to surfaces to be insulated unless otherwise indicated.
- 4 B. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.
- 5 1. Products: Subject to compliance with requirements, available products that may be
6 incorporated into the Work include, but are not limited to, the following:
- 7 a. Aeroflex USA, Inc.; Aeroseal.
8 b. ArmaceLL LLC; Armaflex 520 Adhesive.
9 c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller
10 Company; 85-75.
11 d. K-Flex USA; R-373 Contact Adhesive.

12 **2.3 MASTICS AND COATINGS**

- 13 A. Materials shall be compatible with insulation materials, jackets, and substrates.
- 14 1. VOC Content: 50 g/L or less.
15 2. Low-Emitting Materials: Mastic coatings shall comply with the testing and product
16 requirements of the California Department of Public Health's "Standard Method for the
17 Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources
18 Using Environmental Chambers."
- 19 B. Vapor-Retarder Mastic: Water based; suitable for indoor use on below-ambient services.
- 20 1. Products: Subject to compliance with requirements, available products that may be
21 incorporated into the Work include, but are not limited to, the following:
- 22 a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller
23 Company; 30-80 / 30-90.
24 b. Vimasco Corporation; 749.
- 25 2. Water-Vapor Permeance: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation
26 type and service conditions.
27 3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
28 4. Comply with MIL-PRF-19565C, Type II, for permeance requirements.
29 5. Color: White.

30 **2.4 FIELD-APPLIED FABRIC-REINFORCING MESH**

- 31 A. Woven Glass-Fiber Fabric: Approximately 2 oz./sq. yd. (68 g/sq. m) with a thread count of 10
32 strands by 10 strands/sq. in. (4 strands by 4 strands/sq. mm) for covering pipe and pipe fittings.
- 33 1. Products: Subject to compliance with requirements, available products that may be
34 incorporated into the Work include, but are not limited to, the following:
- 35 a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller
36 Company; Chil-Glas Number 10.

1 **2.5 FIELD-APPLIED JACKETS**

2 A. Field-applied jackets shall comply with ASTM C921, Type I, unless otherwise indicated.

3 B. Metal Jacket:

4 1. Products: Subject to compliance with requirements, available products that may be
5 incorporated into the Work include, but are not limited to, the following:

6 a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller
7 Company; Metal Jacketing Systems.

8 b. ITW Insulation Systems; Aluminum and Stainless Steel Jacketing.

9 c. RPR Products, Inc.; Insul-Mate.

10 2. Aluminum Jacket: Comply with ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or
11 5005, Temper H-14.

12 a. Sheet and roll stock ready for shop or field sizing.

13 b. Finish and thickness are indicated in field-applied jacket schedules.

14 c. Moisture Barrier for Indoor Applications: 2.5-mil- (0.063-mm-) thick polysurlyn.

15 d. Moisture Barrier for Outdoor Applications: .

16 e. Factory-Fabricated Fitting Covers:

17 1) Same material, finish, and thickness as jacket.

18 2) Field fabricate fitting covers only if factory-fabricated fitting covers are not
19 available.

20 **2.6 SECUREMENTS**

21 A. Bands:

22 1. Products: Subject to compliance with requirements, available products that may be
23 incorporated into the Work include, but are not limited to, the following:

24 a. ITW Insulation Systems; Gerrard Strapping and Seals.

25 b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.

26 2. Stainless Steel: ASTM A167 or ASTM A240/A240M, Type 304; 0.015 inch (0.38 mm)
27 thick, 1/2 inch (13 mm) wide with wing seal.

28 B. Wire: 0.062-inch (1.6-mm) soft-annealed, stainless steel.

29 **PART 3 - EXECUTION**

30 **3.1 EXAMINATION**

31 A. Examine substrates and conditions for compliance with requirements for installation tolerances
32 and other conditions affecting performance of insulation application.

33 1. Verify that systems to be insulated have been tested and are free of defects.

34 2. Verify that surfaces to be insulated are clean and dry.

35 3. Proceed with installation only after unsatisfactory conditions have been corrected.

1 **3.2 PREPARATION**

- 2 A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will
3 adversely affect insulation application.
- 4 B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements
5 for heat tracing that apply to insulation.
- 6 C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with
7 stainless-steel surfaces, use demineralized water.

8 **3.3 GENERAL INSTALLATION REQUIREMENTS**

- 9 A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces;
10 free of voids throughout the length of piping including fittings, valves, and specialties.
- 11 B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required
12 for each item of pipe system as specified in insulation system schedules.
- 13 C. Install accessories compatible with insulation materials and suitable for the service. Install
14 accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or
15 dry state.
- 16 D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- 17 E. Install multiple layers of insulation with longitudinal and end seams staggered.
- 18 F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- 19 G. Keep insulation materials dry during application and finishing.
- 20 H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with
21 adhesive recommended by insulation material manufacturer.
- 22 I. Install insulation with least number of joints practical.
- 23 J. Below Ambient Systems.
 - 24 1. Provide continuous vapor barrier; seal joints, longitudinal seams, and penetrations in
25 insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic
26 and joint sealant.
 - 27 2. Where mastic is indicated provide vapor-barrier mastic as required for indoor or outdoor
28 application.
 - 29 3. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties
- 30 K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet
31 and dry film thicknesses.
- 32 L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal
33 thickness.
- 34 M. Repair damaged insulation facings by applying same facing material over damaged areas.
35 Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal
36 patches similar to butt joints.

1 **3.4 PENETRATIONS**

2 A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof
3 penetrations.

- 4 1. Seal penetrations with flashing sealant.
5 2. For applications requiring only indoor insulation, terminate insulation above roof surface
6 and seal with joint sealant. For applications requiring indoor and outdoor insulation, install
7 insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with
8 joint sealant.
9 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches (50 mm) below
10 top of roof flashing.
11 4. Seal jacket to roof flashing with flashing sealant.

12 B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously
13 through wall penetrations.

- 14 1. Seal penetrations with flashing sealant.
15 2. For applications requiring only indoor insulation, terminate insulation inside wall surface
16 and seal with joint sealant. For applications requiring indoor and outdoor insulation, install
17 insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with
18 joint sealant.
19 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least
20 2 inches (50 mm).
21 4. Seal jacket to wall flashing with flashing sealant.

22 C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated):
23 Install insulation continuously through walls and partitions.

24 D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation
25 continuously through penetrations of fire-rated walls and partitions.

- 26 1. Comply with requirements in Section 07 84 13 "Penetration Firestopping" for firestopping
27 and fire-resistive joint sealers.

28 E. Insulation Installation at Floor Penetrations:

- 29 1. Pipe: Install insulation continuously through floor penetrations.
30 2. Seal penetrations through fire-rated assemblies. Comply with requirements in
31 Section 07 84 13 "Penetration Firestopping."

32 **3.5 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION**

33 A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate
34 openings in insulation that allow passage of air to surface being insulated.

35 B. Insulation Installation on Pipe Fittings and Elbows:

- 36 1. Install mitered sections of pipe insulation.
37 2. Secure insulation materials and seal seams with manufacturer's recommended adhesive
38 to eliminate openings in insulation that allow passage of air to surface being insulated.

39 C. Insulation Installation on Valves and Pipe Specialties:

- 1 1. Install preformed valve covers manufactured of same material as pipe insulation when
- 2 available.
- 3 2. When preformed valve covers are not available, install cut sections of pipe and sheet
- 4 insulation to valve body. Arrange insulation to permit access to packing and to allow
- 5 valve operation without disturbing insulation.
- 6 3. Install insulation to flanges as specified for flange insulation application.
- 7 4. Secure insulation to valves and specialties and seal seams with manufacturer's
- 8 recommended adhesive to eliminate openings in insulation that allow passage of air to
- 9 surface being insulated.

10 3.6 FIELD-APPLIED JACKET INSTALLATION

- 11 A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with
- 12 factory-applied jackets.
 - 13 1. Draw jacket smooth and tight to surface with 2-inch (50-mm) overlap at seams and joints.
 - 14 2. Embed glass cloth between two 0.062-inch- (1.6-mm-) thick coats of mastic.
 - 15 3. Completely encapsulate insulation with coating, leaving no exposed insulation.
 - 16 4. Finish to achieve smooth, uniform finish.
- 17 B. Where metal jackets are indicated, install with 2-inch (50-mm) overlap at longitudinal seams and
- 18 end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with
- 19 weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-
- 20 steel bands 12 inches (300 mm) o.c. and at end joints.
- 21 C. Do not install metal jacket over field-applied glass-cloth jacket unless indicated in schedule.

22 3.7 FINISHES

- 23 A. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of
- 24 insulation manufacturer's recommended protective coating. Color per schedule below.
- 25 B. Color: Final color as selected by Engineer. Vary first and second coats to allow visual inspection
- 26 of the completed Work.
 - 27 1. White.
- 28 C. Do not field paint aluminum jackets.

29 3.8 PIPING INSULATION SCHEDULE, GENERAL

- 30 A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for
- 31 each piping system and pipe size range. If more than one material is listed for a piping system,
- 32 selection from materials listed is Contractor's option.

33 3.9 INDOOR PIPING INSULATION SCHEDULE

- 34 A. Condensate and Equipment Drain Water below 60 Deg F (16 Deg C):
- 35 1. All Pipe Sizes: Insulation shall be the following:

1 a. Flexible Elastomeric: 3/4 inch (19 mm) thick.

2 **3.10 INDOOR, FIELD-APPLIED JACKET SCHEDULE**

3 A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-
4 applied jacket over the factory-applied jacket.

5 B. Piping, Concealed:

6 1. None.

7 C. Piping, Exposed:

8 1. Aluminum, Corrugated: 0.016 inch (0.41 mm) thick.

9 D. Fittings, valves, strainers, flanges, unions, and other specialties, Concealed:

10 1. None.

11 E. Fittings, valves, strainers, flanges, unions, and other specialties, Exposed:

12 1. Glass cloth jacket.

13 **END OF SECTION 23 07 19.11**

1 **SECTION 23 07 19.12 - INSULATION FOR CHILLED WATER PIPING**

2 **PART 1 - GENERAL**

3 **1.1 RELATED DOCUMENTS**

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

6 **1.2 SUMMARY**

- 7 A. Section includes insulating the following HVAC piping systems:
8 1. Chilled-water piping, indoors and outdoors.
9 2. Process cooling-water piping, indoors.

10 **1.3 ACTION SUBMITTALS**

- 11 A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor
12 permeance thickness, and jackets (both factory and field applied if any).
- 13 B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
- 14 1. Detail application of protective shields, saddles, and inserts at hangers for each type of
15 insulation and hanger.
16 2. Detail attachment and covering of heat tracing inside insulation.
17 3. Detail insulation application at pipe expansion joints for each type of insulation.
18 4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each
19 type of insulation.
20 5. s.
21 6. Detail application of field-applied jackets.
22 7. Detail application at linkages of control devices.

23 **1.4 QUALITY ASSURANCE**

- 24 A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship
25 program or another craft training program certified by the Department of Labor, Bureau of
26 Apprenticeship and Training.
- 27 B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing
28 identical products according to ASTM E84, by a testing and inspecting agency acceptable to
29 authorities having jurisdiction. Factory label insulation and jacket materials and adhesive,
30 mastic, tapes, and cement material containers, with appropriate markings of applicable testing
31 agency.
- 32 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed
33 index of 50 or less.
34 2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed
35 index of 150 or less.

1 **1.5 DELIVERY, STORAGE, AND HANDLING**

2 A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate
3 ASTM standard designation, type and grade, and maximum use temperature.

4 **1.6 COORDINATION**

5 A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in
6 Section 23 05 29 "Hangers and Supports for HVAC Piping and Equipment."

7 B. Coordinate clearance requirements with piping Installer for piping insulation application. Before
8 preparing piping Shop Drawings, establish and maintain clearance requirements for installation
9 of insulation and field-applied jackets and finishes and for space required for maintenance.

10 C. Coordinate installation and testing of heat tracing.

11 **1.7 SCHEDULING**

12 A. Schedule insulation application after pressure testing systems and, where required, after
13 installing and testing heat tracing. Insulation application may begin on segments that have
14 satisfactory test results.

15 B. Complete installation and concealment of plastic materials as rapidly as possible in each area of
16 construction.

17 **PART 2 - PRODUCTS**

18 **2.1 INSULATION MATERIALS**

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

22 B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

23 C. Products that come in contact with stainless steel shall have a leachable chloride content of less
24 than 50 ppm when tested according to ASTM C871.

25 D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable
26 according to ASTM C795.

27 E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing
28 process.

29 F. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid,
30 hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied
31 Jackets" Article.

32 1. Products: Subject to compliance with requirements, available products that may be
33 incorporated into the Work include, but are not limited to, the following:

- 1 a. Pittsburgh Corning Corporation; Foamglas.
- 2 2. Block Insulation: ASTM C552, Type I.
- 3 3. Special-Shaped Insulation: ASTM C552, Type III.
- 4 4. Board Insulation: ASTM C552, Type IV.
- 5 5. Preformed Pipe Insulation without Jacket: Comply with ASTM C552, Type II, Class 1.
- 6 6. Preformed Pipe Insulation with Factory-Applied ASJ-SSL: Comply with ASTM C552,
- 7 Type II, Class 2.
- 8 7. Factory fabricate shapes according to ASTM C450 and ASTM C585.

9 G. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply
10 with ASTM C534, Type I for tubular materials.

11 1. Products: Subject to compliance with requirements, provide one of the following:

- 12 a. Aeroflex USA, Inc.; Aerocel.
- 13 b. Armocell LLC; AP Armaflex.
- 14 c. K-Flex USA; Insul-Lock, Insul-Tube, and K-FLEX LS.

15 2.2 ADHESIVES

16 A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding
17 insulation to itself and to surfaces to be insulated unless otherwise indicated.

18 B. Cellular-Glass Adhesive: Two-component, thermosetting urethane adhesive containing no
19 flammable solvents, with a service temperature range of minus 100 to plus 200 deg F (minus 73
20 to plus 93 deg C).

21 1. Manufacturers: Subject to compliance with requirements, provide products by the
22 following:

- 23 a. Foster Brand; H. B. Fuller Construction Products; 81-84.
- 24 2. Adhesives shall have a VOC content of 50 g/L or less.
- 25 3. Adhesive shall comply with the testing and product requirements of the California
26 Department of Public Health's "Standard Method for the Testing and Evaluation of
27 Volatile Organic Chemical Emissions from Indoor Sources Using Environmental
28 Chambers."

29 C. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.

30 1. Products: Subject to compliance with requirements, available products that may be
31 incorporated into the Work include, but are not limited to, the following:

- 32 a. Aeroflex USA, Inc.; Aero seal.
- 33 b. Armocell LLC; Armaflex 520 Adhesive.
- 34 c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller
35 Company; 85-75.
- 36 d. K-Flex USA; R-373 Contact Adhesive.

37 D. ASJ Adhesive Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding
38 insulation jacket lap seams and joints.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82.
 - b. 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. 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 Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

15 **2.3 MASTICS AND COATINGS**

- A. Materials shall be compatible with insulation materials, jackets, and substrates.
 1. VOC Content: 50 g/L or less.
 2. Low-Emitting Materials: Mastic coatings shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- B. Vapor-Retarder Mastic: Water based; suitable for indoor use on below-ambient services.
 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, 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: 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 (Minus 29 to plus 82 deg C).
 4. Comply with MIL-PRF-19565C, Type II, for permeance requirements.
 5. Color: White.
- C. Vapor-Retarder Mastic: Solvent based; suitable for outdoor use on below-ambient services.
 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Encacel.
 - b. Marathon Industries; 570.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 60-95 / 60-96.

- 1 2. Water-Vapor Permeance: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation
- 2 type and service conditions.
- 3 3. Service Temperature Range: Minus 50 to plus 220 deg F (Minus 46 to plus 104 deg C).
- 4 4. Color: White.

5 **2.4 SEALANTS**

6 A. Cellular-Glass Joint Sealants:

- 7 1. Subject to compliance with requirements, available products that may be incorporated
- 8 into the Work include, but are not limited to, the following:
- 9 a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller
- 10 Company; CP-76.
- 11 b. Marathon Industries; 405.
- 12 c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller
- 13 Company; 30-45.
- 14 d. Mon-Eco Industries, Inc.; 44-05.
- 15 e. Pittsburgh Corning Corporation; Pittseal 444.
- 16 2. Materials shall be compatible with insulation materials, jackets, and substrates.
- 17 3. Permanently flexible, elastomeric sealant.
- 18 4. Service Temperature Range: Minus 100 to plus 300 deg F (Minus 73 to plus 149 deg C).
- 19 5. Color: White or gray.
- 20 6. Sealant shall have a VOC content of 420 g/L or less.
- 21 7. Sealant shall comply with the testing and product requirements of the California
- 22 Department of Public Health's "Standard Method for the Testing and Evaluation of
- 23 Volatile Organic Chemical Emissions from Indoor Sources Using Environmental
- 24 Chambers."

25 B. ASJ Flashing Sealants:

- 26 1. Manufacturers: Subject to compliance with requirements, provide products by the
- 27 following:
- 28 a. Childers Brand; H. B. Fuller Construction Products; CP-76.
- 29 2. Materials shall be compatible with insulation materials, jackets, and substrates.
- 30 3. Fire- and water-resistant, flexible, elastomeric sealant.
- 31 4. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
- 32 5. Color: White.
- 33 6. Sealant shall have a VOC content of 420 g/L or less.
- 34 7. Sealant shall comply with the testing and product requirements of the California
- 35 Department of Public Health's "Standard Method for the Testing and Evaluation of
- 36 Volatile Organic Chemical Emissions from Indoor Sources Using Environmental
- 37 Chambers."

38 **2.5 FACTORY-APPLIED JACKETS**

- 39 A. Insulation system schedules indicate factory-applied jackets on various applications. When
- 40 factory-applied jackets are indicated, comply with the following:

- 1 1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing;
- 2 complying with ASTM C1136, Type I.
- 3 2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a
- 4 removable protective strip; complying with ASTM C1136, Type I.

5 **2.6 FIELD-APPLIED FABRIC-REINFORCING MESH**

- 6 A. Woven Glass-Fiber Fabric: Approximately 2 oz./sq. yd. (68 g/sq. m) with a thread count of 10
- 7 strands by 10 strands/sq. in. (4 strands by 4 strands/sq. mm) for covering pipe and pipe fittings.
- 8 1. Products: Subject to compliance with requirements, available products that may be
- 9 incorporated into the Work include, but are not limited to, the following:

10 **2.7 Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company;**

11 **Chil-Glas Number 10.FIELD-APPLIED JACKETS**

- 12 A. Field-applied jackets shall comply with ASTM C921, Type I, unless otherwise indicated.
- 13 B. Metal Jacket:
 - 14 1. Products: Subject to compliance with requirements, available products that may be
 - 15 incorporated into the Work include, but are not limited to, the following:
 - 16 a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller
 - 17 Company; Metal Jacketing Systems.
 - 18 b. ITW Insulation Systems; Aluminum and Stainless Steel Jacketing.
 - 19 c. RPR Products, Inc.; Insul-Mate.
 - 20 2. Aluminum Jacket: Comply with ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or
 - 21 5005, Temper H-14.
 - 22 a. Sheet and roll stock ready for shop or field sizing.
 - 23 b. Finish and thickness are indicated in field-applied jacket schedules.
 - 24 c. Moisture Barrier for Indoor Applications: 2.5-mil- (0.063-mm-) thick polysurlyn.
 - 25 d. Moisture Barrier for Outdoor Applications: .
 - 26 e. Factory-Fabricated Fitting Covers:
 - 27 1) Same material, finish, and thickness as jacket.
 - 28 2) Field fabricate fitting covers only if factory-fabricated fitting covers are not
 - 29 available.
- 30 C. Underground Direct-Buried Jacket: 125-mil- (3.2-mm-) thick vapor barrier and waterproofing
- 31 membrane consisting of a rubberized bituminous resin reinforced with a woven-glass fiber or
- 32 polyester scrim and laminated aluminum foil.
 - 33 1. Products: Subject to compliance with requirements, provide one of the following:
 - 34 a. Pittsburgh Corning Corporation; Pittwrap.
 - 35 b. Polyguard Products, Inc.; Insulrap No Torch 125.

1 **2.8 TAPES**

2 A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive,
3 complying with ASTM C1136.

4 1. Products: Subject to compliance with requirements, available products that may be
5 incorporated into the Work include, but are not limited to, the following:

- 6 a. ABI, Ideal Tape Division; 428 AWF ASJ.
- 7 b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
- 8 c. Compac Corporation; 104 and 105.
- 9 d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.

- 10 2. Width: 3 inches (75 mm).
- 11 3. Thickness: 11.5 mils (0.29 mm).
- 12 4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
- 13 5. Elongation: 2 percent.
- 14 6. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
- 15 7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

16 **2.9 SECUREMENTS**

17 A. Bands:

18 1. Products: Subject to compliance with requirements, available products that may be
19 incorporated into the Work include, but are not limited to, the following:

- 20 a. ITW Insulation Systems; Gerrard Strapping and Seals.
- 21 b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.

22 2. Stainless Steel: ASTM A167 or ASTM A240/A240M, Type 304; 0.015 inch (0.38 mm)
23 thick, 1/2 inch (13 mm) wide with wing seal.

24 B. Wire: 0.062-inch (1.6-mm) soft-annealed, stainless steel.

25 **PART 3 - EXECUTION**

26 **3.1 EXAMINATION**

27 A. Examine substrates and conditions for compliance with requirements for installation tolerances
28 and other conditions affecting performance of insulation application.

- 29 1. Verify that systems to be insulated have been tested and are free of defects.
- 30 2. Verify that surfaces to be insulated are clean and dry.
- 31 3. Proceed with installation only after unsatisfactory conditions have been corrected.

32 **3.2 PREPARATION**

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

1 B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements
2 for heat tracing that apply to insulation.

3 C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with
4 stainless-steel surfaces, use demineralized water.

5 **3.3 GENERAL INSTALLATION REQUIREMENTS**

6 A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces;
7 free of voids throughout the length of piping including fittings, valves, and specialties.

8 B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required
9 for each item of pipe system as specified in insulation system schedules.

10 C. Install accessories compatible with insulation materials and suitable for the service. Install
11 accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or
12 dry state.

13 D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

14 E. Install multiple layers of insulation with longitudinal and end seams staggered.

15 F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

16 G. Keep insulation materials dry during application and finishing.

17 H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with
18 adhesive recommended by insulation material manufacturer.

19 I. Install insulation with least number of joints practical.

20 J. Below Ambient Systems.

21 1. Provide continuous vapor barrier; seal joints, longitudinal seams, and penetrations in
22 insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic
23 and joint sealant.

24 2. Where mastic is indicated provide vapor-barrier mastic as required for indoor or outdoor
25 application.

26 3. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties

27 K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet
28 and dry film thicknesses.

29 L. Install insulation with factory-applied jackets as follows:

30 1. Draw jacket tight and smooth.

31 2. Cover joints and seams with tape, according to insulation material manufacturer's written
32 instructions, to maintain vapor seal.

33 M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal
34 thickness.

- 1 N. Repair damaged insulation facings by applying same facing material over damaged areas.
- 2 Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal
- 3 patches similar to butt joints.

4 **3.4 PENETRATIONS**

- 5 A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof
- 6 penetrations.

- 7 1. Seal penetrations with flashing sealant.
- 8 2. For applications requiring only indoor insulation, terminate insulation above roof surface
- 9 and seal with joint sealant. For applications requiring indoor and outdoor insulation, install
- 10 insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with
- 11 joint sealant.
- 12 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches (50 mm) below
- 13 top of roof flashing.
- 14 4. Seal jacket to roof flashing with flashing sealant.

- 15 B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with
- 16 sleeve seal. Seal terminations with flashing sealant.

- 17 C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously
- 18 through wall penetrations.

- 19 1. Seal penetrations with flashing sealant.
- 20 2. For applications requiring only indoor insulation, terminate insulation inside wall surface
- 21 and seal with joint sealant. For applications requiring indoor and outdoor insulation, install
- 22 insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with
- 23 joint sealant.
- 24 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least
- 25 2 inches (50 mm).
- 26 4. Seal jacket to wall flashing with flashing sealant.

- 27 D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated):
- 28 Install insulation continuously through walls and partitions.

- 29 E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation
- 30 continuously through penetrations of fire-rated walls and partitions.

- 31 1. Comply with requirements in Section 07 84 13 "Penetration Firestopping" for firestopping
- 32 and fire-resistive joint sealers.

- 33 F. Insulation Installation at Floor Penetrations:

- 34 1. Pipe: Install insulation continuously through floor penetrations.
- 35 2. Seal penetrations through fire-rated assemblies. Comply with requirements in
- 36 Section 07 84 13 "Penetration Firestopping."

37 **3.5 INSTALLATION OF CELLULAR-GLASS INSULATION**

- 38 A. Insulation Installation on Straight Pipes and Tubes:

- 39 1. Provide factory applied ASJ-SSL jacket.

1 2. Create a water stop between insulation and pipe by brushing vapor barrier mastic around
2 circumference of pipe every 3 feet.

3 B. Insulation Installation on Pipe Flanges, Fittings, Elbows, Valves and Pipe Specialties:
4

- 5 1. Provide insulation without factory applied jacket.
- 6 2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same
7 material and density as adjacent pipe insulation. Each piece shall be butted tightly
8 against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular
9 surfaces with insulating cement finished to a smooth, hard, and uniform contour that is
10 uniform with adjoining pipe insulation.
- 11 3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same
12 material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt
13 each section closely to the next and hold in place with tie wire. Bond pieces with
14 adhesive.
- 15 4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same
16 material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe
17 insulation by not less than two times the thickness of pipe insulation, or one pipe
18 diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve
19 stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with
20 insulating cement.
- 21 5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same
22 material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe
23 insulation by not less than two times the thickness of pipe insulation, or one pipe
24 diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating
25 cement. Insulate strainers so strainer basket flange or plug can be easily removed and
26 replaced without damaging the insulation and jacket. Provide a removable reusable
27 insulation cover. Provide a design that maintains vapor barrier.
- 28 6. Insulate flanges and unions using a section of oversized preformed pipe insulation.
29 Install preformed pipe insulation to outer diameter of pipe flange. Overlap adjoining pipe
30 insulation by not less than two times the thickness of pipe insulation, or one pipe
31 diameter, whichever is thicker. Fill voids between inner circumference of flange
32 insulation and outer circumference of adjacent straight pipe segments with insulating
33 cement.
- 34 7. Secure mitered sections or segmented insulation with wire or bands.
- 35 8. Cover pipe fittings, valves, strainers, flanges, unions, and other specialties and any
36 segmented insulated surfaces with a layer of finishing cement and install field-applied
37 glass-cloth jacket.
- 38 9. Apply vapor-barrier mastic at exposed ends of insulation at pipe flanges, unions, and
39 fittings.
- 40 10. Stencil or label the outside insulation jacket of each union with the word "union." Match
41 size and color of pipe labels.

42 **3.6 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION**

43 A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate
44 openings in insulation that allow passage of air to surface being insulated.

45 B. Insulation Installation on Instrument Connections:

- 46 1. Install insulation on instrument connections for thermometers, pressure gages, pressure
47 temperature taps, test connections, flow meters, sensors, switches, and transmitters on
48 insulated pipes.
- 49 2. Shape insulation at these connections by tapering it to and around the connection.

- 1 3. Secure insulation materials and seal seams with manufacturer's recommended adhesive
 2 to eliminate openings in insulation that allow passage of air to surface being insulated.

3 **3.7 FIELD-APPLIED JACKET INSTALLATION**

- 4 A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with
 5 factory-applied jackets.

- 6 1. Draw jacket smooth and tight to surface with 2-inch (50-mm) overlap at seams and joints.
 7 2. Embed glass cloth between two 0.062-inch- (1.6-mm-) thick coats of mastic.
 8 3. Completely encapsulate insulation with coating, leaving no exposed insulation.
 9 4. Finish to achieve smooth, uniform finish.

- 10 B. Where metal jackets are indicated, install with 2-inch (50-mm) overlap at longitudinal seams and
 11 end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with
 12 weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-
 13 steel bands 12 inches (300 mm) o.c. and at end joints.

- 14 C. Do not install metal jacket over field-applied glass-cloth jacket unless indicated in schedule.

15 **3.8 FINISHES**

- 16 A. Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint
 17 system identified below.

- 18 1. Semi-glass Acrylic Finish: Two finish coats over a primer that is compatible with jacket
 19 material and finish coat paint. Add fungicidal agent to render fabric mildew proof. Color
 20 per schedule below.

- 21 a. Finish Coat Material: Interior, semi-gloss, latex-emulsion size.

- 22 2. Paint exposed piping without field applied metal jacket.

- 23 B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of
 24 insulation manufacturer's recommended protective coating. Color per schedule below.

- 25 C. Color: Final color as selected by Engineer. Vary first and second coats to allow visual inspection
 26 of the completed Work.

- 27 1. Chilled Water: Dark Green.
 28 2. Process Cooling: Light Green.

- 29 D. Do not field paint aluminum jackets.

30 **3.9 PIPING INSULATION SCHEDULE, GENERAL**

- 31 A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for
 32 each piping system and pipe size range. If more than one material is listed for a piping system,
 33 selection from materials listed is Contractor's option.

1 **3.10 INDOOR PIPING INSULATION SCHEDULE**

2 A. Chilled Water, above 40 Deg F (5 Deg C):

- 3 1. Insulation in conditioned spaces without metal shall be the following:
- 4 a. Cellular Glass: 2 inches (50 mm) thick.
- 5 2. Insulation in conditioned spaces with metal jacket shall be the following:
- 6 a. Cellular Glass: 2-1/2 inches (63 mm) thick.
- 7 3. Insulation in unconditioned spaces such as ventilated attics and non-conditioned
- 8 equipment rooms shall be the following:
- 9 a. Cellular Glass: 2-1/2 inches (63 mm) thick.
- 10 4. Instrument Connections:
- 11 a. Flexible Elastomeric: 1 inch (25 mm) thick.

12 B. Process Cooling Water, above 40 Deg F (5 Deg C):

- 13 1. Insulation in conditioned spaces without metal shall be the following:
- 14 a. Cellular Glass: 2 inches (50 mm) thick.
- 15 2. Insulation in conditioned spaces with metal jacket shall be the following:
- 16 a. Cellular Glass: 2-1/2 inches (63 mm) thick.
- 17 3. Insulation in unconditioned spaces such as ventilated attics and non-conditioned
- 18 equipment rooms shall be the following:
- 19 a. Cellular Glass: 2-1/2 inches (63 mm) thick.
- 20 4. Instrument Connections:
- 21 a. Flexible Elastomeric: 1 inch (25 mm) thick.

22 **3.11 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE**

23 A. Chilled Water:

- 24 1. All Pipe Sizes: Insulation shall be the following:
- 25 a. Cellular Glass: 2-1/2 inches (63 mm) thick.
- 26 2. Instrument Connections:
- 27 a. Flexible Elastomeric: 1 inch (25 mm) thick.

1 **3.12 OUTDOOR, UNDERGROUND PIPING INSULATION SCHEDULE**

2 A. Loose-fill insulation, for belowground piping, is specified in Section 23 21 13.13 "Underground
3 Hydronic Piping".

4 **3.13 WITHIN MANHOLE AND TUNNEL, PIPING INSULATION SCHEDULE**

5 A. Chilled Water, All Sizes: Cellular glass, 2 inches (50 mm) thick.

6 **3.14 INDOOR, FIELD-APPLIED JACKET SCHEDULE**

7 A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-
8 applied jacket over the factory-applied jacket.

9 B. Piping, Concealed:

10 1. None.

11 C. Piping, Exposed:

12 1. Aluminum, Corrugated: 0.016 inch (0.41 mm) thick.

13 D. Fittings, valves, strainers, flanges, unions, and other specialties, Concealed:

14 1. None.

15 E. Fittings, valves, strainers, flanges, unions, and other specialties, Exposed:

16 1. Glass cloth jacket.

17 **3.15 OUTDOOR, ABOVE GROUND, FIELD-APPLIED JACKET SCHEDULE**

18 A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-
19 applied jacket over the factory-applied jacket.

20 B. If more than one material is listed, selection from materials listed is Contractor's option.

21 C. Piping, Concealed:

22 1. Aluminum, Corrugated: 0.024 inch (0.61 mm) thick.

23 D. Piping, Exposed:

24 1. Aluminum, Corrugated: 0.024 inch (0.61 mm) thick.

25 E. Fittings, valves, strainers, flanges, unions, and other specialties, Exposed:

26 1. Glass cloth jacket. Install metal jacket over finished glass-cloth jacket.

1 **3.16 UNDERGROUND, FIELD-INSTALLED INSULATION JACKET**

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

4 **3.17 WITHIN MANHOLE AND TUNNEL, FIELD-INSTALLED INSULATION JACKET**

5 A. Chilled Water, All Sizes: Within utility manholes install field applied glass-cloth jacket over
6 insulation material. Install aluminum, corrugated 0.024 inch (0.61 mm) thick metal jacket over
7 finished glass cloth jacket.

8 **END OF SECTION 23 07 19.12**

1 **SECTION 23 07 19.14 - INSULATION FOR HEATING HOT WATER PIPING**

2 **PART 1 - GENERAL**

3 **1.1 RELATED DOCUMENTS**

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

6 **1.2 SUMMARY**

- 7 A. Section includes insulating the following HVAC piping systems:
8 1. Heating hot-water piping, indoors and outdoors.
9 2. Heat recovery water piping, indoors.

10 **1.3 ACTION SUBMITTALS**

- 11 A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor
12 permeance thickness, and jackets (both factory and field applied if any).

- 13 B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

- 14 1. Detail application of protective shields, saddles, and inserts at hangers for each type of
15 insulation and hanger.
16 2. Detail attachment and covering of heat tracing inside insulation.
17 3. Detail insulation application at pipe expansion joints for each type of insulation.
18 4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each
19 type of insulation.
20 5. Detail removable insulation at piping specialties.
21 6. Detail application of field-applied jackets.
22 7. Detail application at linkages of control devices.
23 8. Fabrication drawings for reusable thermal insulation covers.

24 **1.4 QUALITY ASSURANCE**

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

- 28 B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing
29 identical products according to ASTM E84, by a testing and inspecting agency acceptable to
30 authorities having jurisdiction. Factory label insulation and jacket materials and adhesive,
31 mastic, tapes, and cement material containers, with appropriate markings of applicable testing
32 agency.

- 33 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed
34 index of 50 or less.
35 2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed
36 index of 150 or less.

1 **1.5 DELIVERY, STORAGE, AND HANDLING**

2 A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate
 3 ASTM standard designation, type and grade, and maximum use temperature.

4 **1.6 COORDINATION**

5 A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in
 6 Section 23 05 29 "Hangers and Supports for HVAC Piping and Equipment."

7 B. Coordinate clearance requirements with piping Installer for piping insulation application. Before
 8 preparing piping Shop Drawings, establish and maintain clearance requirements for installation
 9 of insulation and field-applied jackets and finishes and for space required for maintenance.

10 C. Coordinate installation and testing of heat tracing.

11 **1.7 SCHEDULING**

12 A. Schedule insulation application after pressure testing systems and, where required, after
 13 installing and testing heat tracing. Insulation application may begin on segments that have
 14 satisfactory test results.

15 B. Complete installation and concealment of plastic materials as rapidly as possible in each area of
 16 construction.

17 **PART 2 - PRODUCTS**

18 **2.1 INSULATION MATERIALS**

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

22 B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

23 C. Products that come in contact with stainless steel shall have a leachable chloride content of less
 24 than 50 ppm when tested according to ASTM C871.

25 D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable
 26 according to ASTM C795.

27 E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing
 28 process.

29 F. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid,
 30 hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied
 31 Jackets" Article.

32 1. Products: Subject to compliance with requirements, available products that may be
 33 incorporated into the Work include, but are not limited to, the following:

- 1 a. Pittsburgh Corning Corporation; Foamglas.
- 2 2. Block Insulation: ASTM C552, Type I.
- 3 3. Special-Shaped Insulation: ASTM C552, Type III.
- 4 4. Board Insulation: ASTM C552, Type IV.
- 5 5. Preformed Pipe Insulation without Jacket: Comply with ASTM C552, Type II, Class 1.
- 6 6. Preformed Pipe Insulation with Factory-Applied ASJ-SSL: Comply with ASTM C552,
- 7 Type II, Class 2.
- 8 7. Factory fabricate shapes according to ASTM C450 and ASTM C585.

- 9 G. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply
- 10 with ASTM C534, Type I for tubular materials.

- 11 1. Products: Subject to compliance with requirements, provide one of the following:
- 12 a. Aeroflex USA, Inc.; Aerocel.
- 13 b. Armacell LLC; AP Armaflex.
- 14 c. K-Flex USA; Insul-Lock, Insul-Tube, and K-FLEX LS.

- 15 H. Mineral-Fiber, Preformed Pipe Insulation:
- 16 1. Products: Subject to compliance with requirements, provide one of the following:
- 17 a. Johns Manville; Micro-Lok.
- 18 b. Knauf Insulation; 1000-Degree Pipe Insulation.
- 19 c. Owens Corning; Fiberglas Pipe Insulation.

- 20 2. Type I, 850 deg F (454 deg C) Materials: Mineral or glass fibers bonded with a
- 21 thermosetting resin. Comply with ASTM C547, Type I, Grade A, with factory-applied ASJ-
- 22 SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets"
- 23 Article.

24 **2.2 INSULATING CEMENTS**

- 25 A. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C449.
- 26 1. Products: Subject to compliance with requirements, available products that may be
- 27 incorporated into the Work include, but are not limited to, the following:
- 28 a. Ramco Insulation, Inc.; Ramcote 1200 and Quik-Cote.

29 **2.3 ADHESIVES**

- 30 A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding
- 31 insulation to itself and to surfaces to be insulated unless otherwise indicated.

- 32 B. Cellular-Glass Adhesive: Two-component, thermosetting urethane adhesive containing no
- 33 flammable solvents, with a service temperature range of minus 100 to plus 200 deg F (minus 73
- 34 to plus 93 deg C).

- 35 1. Manufacturers: Subject to compliance with requirements, provide products by the
- 36 following:

- 1 a. Foster Brand; H. B. Fuller Construction Products; 81-84.
- 2 2. Adhesives shall have a VOC content of 50 g/L or less.
- 3 3. Adhesive shall comply with the testing and product requirements of the California
4 Department of Public Health's "Standard Method for the Testing and Evaluation of
5 Volatile Organic Chemical Emissions from Indoor Sources Using Environmental
6 Chambers."
- 7 C. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.
- 8 1. Products: Subject to compliance with requirements, available products that may be
9 incorporated into the Work include, but are not limited to, the following:
- 10 a. Aeroflex USA, Inc.; Aeroseal.
- 11 b. ArmaceLL LLC; Armaflex 520 Adhesive.
- 12 c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller
13 Company; 85-75.
- 14 d. K-Flex USA; R-373 Contact Adhesive.
- 15 D. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
- 16 1. Products: Subject to compliance with requirements, available products that may be
17 incorporated into the Work include, but are not limited to, the following:
- 18 a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller
19 Company; CP-127.
- 20 b. - Marathon Industries; 225.
- 21 c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller
22 Company; 85-60/85-70.
- 23 d. Mon-Eco Industries, Inc.; 22-25.
- 24 2. Fiberglass adhesive shall have a VOC content of 80 g/L or less when calculated
25 according to 40 CFR 59, Subpart D (EPA Method 24).
- 26 3. Adhesive shall comply with the testing and product requirements of the California
27 Department of Public Health's "Standard Method for the Testing and Evaluation of
28 Volatile Organic Chemical Emissions from Indoor Sources Using Environmental
29 Chambers."
- 30 E. ASJ Adhesive Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding
31 insulation jacket lap seams and joints.
- 32 1. Products: Subject to compliance with requirements, available products that may be
33 incorporated into the Work include, but are not limited to, the following:
- 34 a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller
35 Company; CP-82.
- 36 b. Marathon Industries; 225.
- 37 c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller
38 Company; 85-50.
- 39 d. Mon-Eco Industries, Inc.; 22-25.
- 40 2. Adhesive shall have a VOC content of 80 g/L or less when calculated according to
41 40 CFR 59, Subpart D (EPA Method 24).
- 42 3. Adhesive shall comply with the testing and product requirements of the California
43 Department of Public Health's "Standard Method for the Testing and Evaluation of

1 Volatile Organic Chemical Emissions from Indoor Sources Using Environmental
 2 Chambers."

3 **2.4 MASTICS AND COATINGS**

- 4 A. Materials shall be compatible with insulation materials, jackets, and substrates.
- 5 1. VOC Content: 50 g/L or less.
 6 2. Low-Emitting Materials: Mastic coatings shall comply with the testing and product
 7 requirements of the California Department of Public Health's "Standard Method for the
 8 Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources
 9 Using Environmental Chambers."
- 10 B. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.
- 11 1. Products: Subject to compliance with requirements, available products that may be
 12 incorporated into the Work include, but are not limited to, the following:
- 13 a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller
 14 Company; CP-10.
 15 b. Marathon Industries; 550.
 16 c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller
 17 Company; 46-50.
 18 d. Mon-Eco Industries, Inc.; 55-50.
 19 e. Vimasco Corporation; WC-1/WC-5.
- 20 2. Water-Vapor Permeance: ASTM E96, greater than 1.0 perm (0.66 metric perms) at
 21 manufacturer's recommended dry film thickness.
 22 3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
 23 4. Color: White.

24 **2.5 SEALANTS**

- 25 A. Cellular-Glass Joint Sealants:
- 26 1. Subject to compliance with requirements, available products that may be incorporated
 27 into the Work include, but are not limited to, the following:
- 28 a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller
 29 Company; CP-76.
 30 b. Marathon Industries; 405.
 31 c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller
 32 Company; 30-45.
 33 d. Mon-Eco Industries, Inc.; 44-05.
 34 e. Pittsburgh Corning Corporation; Pittseal 444.
- 35 2. Materials shall be compatible with insulation materials, jackets, and substrates.
 36 3. Permanently flexible, elastomeric sealant.
 37 4. Service Temperature Range: Minus 100 to plus 300 deg F (Minus 73 to plus 149 deg C).
 38 5. Color: White or gray.
 39 6. Sealant shall have a VOC content of 420 g/L or less.
 40 7. Sealant shall comply with the testing and product requirements of the California
 41 Department of Public Health's "Standard Method for the Testing and Evaluation of

1 Volatile Organic Chemical Emissions from Indoor Sources Using Environmental
2 Chambers."

3 B. ASJ Flashing Sealants and PVC Jacket Flashing Sealants:

4 1. Manufacturers: Subject to compliance with requirements, provide products by the
5 following:

6 a. Childers Brand; H. B. Fuller Construction Products; CP-76.

7 2. Materials shall be compatible with insulation materials, jackets, and substrates.

8 3. Fire- and water-resistant, flexible, elastomeric sealant.

9 4. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).

10 5. Color: White.

11 6. Sealant shall have a VOC content of 420 g/L or less.

12 7. Sealant shall comply with the testing and product requirements of the California
13 Department of Public Health's "Standard Method for the Testing and Evaluation of
14 Volatile Organic Chemical Emissions from Indoor Sources Using Environmental
15 Chambers."

16 **2.6 FACTORY-APPLIED JACKETS**

17 A. Insulation system schedules indicate factory-applied jackets on various applications. When
18 factory-applied jackets are indicated, comply with the following:

19 1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing;
20 complying with ASTM C1136, Type I.

21 2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a
22 removable protective strip; complying with ASTM C1136, Type I.

23 **2.7 FIELD-APPLIED FABRIC-REINFORCING MESH**

24 A. Woven Glass-Fiber Fabric: Approximately 2 oz./sq. yd. (68 g/sq. m) with a thread count of 10
25 strands by 10 strands/sq. in. (4 strands by 4 strands/sq. mm) for covering pipe and pipe fittings.

26 1. Products: Subject to compliance with requirements, available products that may be
27 incorporated into the Work include, but are not limited to, the following:

28 a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller
29 Company; Chil-Glas Number 10

30 **2.8 FIELD-APPLIED JACKETS**

31 A. Field-applied jackets shall comply with ASTM C921, Type I, unless otherwise indicated.

32 B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D1784,
33 Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming.
34 Thickness is indicated in field-applied jacket schedules.

35 1. Products: Subject to compliance with requirements, provide one of the following :

36 a. Johns Manville; Zeston.

- 1 b. P.I.C. Plastics, Inc.; FG Series.
- 2 c. Proto Corporation; LoSmoke.
- 3 d. Speedline Corporation; SmokeSafe.

- 4 2. Adhesive: As recommended by jacket material manufacturer.
- 5 3. Color: White.
- 6 4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.

- 7 a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges,
- 8 unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap
- 9 and supply covers for lavatories.

10 C. Metal Jacket:

- 11 1. Products: Subject to compliance with requirements, available products that may be
- 12 incorporated into the Work include, but are not limited to, the following:

- 13 a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller
- 14 Company; Metal Jacketing Systems.
- 15 b. ITW Insulation Systems; Aluminum and Stainless Steel Jacketing.
- 16 c. RPR Products, Inc.; Insul-Mate.

- 17 2. Aluminum Jacket: Comply with ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or
- 18 5005, Temper H-14.

- 19 a. Sheet and roll stock ready for shop or field sizing.
- 20 b. Finish and thickness are indicated in field-applied jacket schedules.
- 21 c. Moisture Barrier for Indoor Applications: 2.5-mil- (0.063-mm-) thick polysurlyn.
- 22 d. Moisture Barrier for Outdoor Applications: .
- 23 e. Factory-Fabricated Fitting Covers:

- 24 1) Same material, finish, and thickness as jacket.
- 25 2) Field fabricate fitting covers only if factory-fabricated fitting covers are not
- 26 available.

27 D. Underground Direct-Buried Jacket: 125-mil- (3.2-mm-) thick vapor barrier and waterproofing

28 membrane consisting of a rubberized bituminous resin reinforced with a woven-glass fiber or

29 polyester scrim and laminated aluminum foil.

- 30 1. Products: Subject to compliance with requirements, provide one of the following:

- 31 a. Pittsburgh Corning Corporation; Pittwrap.
- 32 b. Polyguard Products, Inc.; Insulrap No Torch 125.

33 **2.9 TAPES**

34 A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive,

35 complying with ASTM C1136.

- 36 1. Products: Subject to compliance with requirements, available products that may be
- 37 incorporated into the Work include, but are not limited to, the following:

- 38 a. ABI, Ideal Tape Division; 428 AWF ASJ.
- 39 b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.

- 1 c. Compac Corporation; 104 and 105.
- 2 d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.
- 3 2. Width: 3 inches (75 mm).
- 4 3. Thickness: 11.5 mils (0.29 mm).
- 5 4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
- 6 5. Elongation: 2 percent.
- 7 6. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
- 8 7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- 9 B. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive;
- 10 suitable for indoor and outdoor applications.
- 11 1. Products: Subject to compliance with requirements, available products that may be
- 12 incorporated into the Work include, but are not limited to, the following:
- 13 a. ABI, Ideal Tape Division; 370 White PVC tape.
- 14 b. Compac Corporation; 130.
- 15 c. Venture Tape; 1506 CW NS.
- 16 2. Width: 2 inches (50 mm).
- 17 3. Thickness: 6 mils (0.15 mm).
- 18 4. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
- 19 5. Elongation: 500 percent.
- 20 6. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.

21 **2.10 SECUREMENTS**

- 22 A. Bands:
- 23 1. Products: Subject to compliance with requirements, available products that may be
- 24 incorporated into the Work include, but are not limited to, the following:
- 25 a. ITW Insulation Systems; Gerrard Strapping and Seals.
- 26 b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.
- 27 2. Stainless Steel: ASTM A167 or ASTM A240/A240M, Type 304; 0.015 inch (0.38 mm)
- 28 thick, 1/2 inch (13 mm) wide with wing seal.
- 29 B. Wire: 0.062-inch (1.6-mm) soft-annealed, stainless steel.

30 **PART 3 - EXECUTION**

31 **3.1 EXAMINATION**

- 32 A. Examine substrates and conditions for compliance with requirements for installation tolerances
- 33 and other conditions affecting performance of insulation application.
- 34 1. Verify that systems to be insulated have been tested and are free of defects.
- 35 2. Verify that surfaces to be insulated are clean and dry.
- 36 3. Proceed with installation only after unsatisfactory conditions have been corrected.

1 **3.2 PREPARATION**

- 2 A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will
3 adversely affect insulation application.
- 4 B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements
5 for heat tracing that apply to insulation.
- 6 C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with
7 stainless-steel surfaces, use demineralized water.

8 **3.3 GENERAL INSTALLATION REQUIREMENTS**

- 9 A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces;
10 free of voids throughout the length of piping including fittings, valves, and specialties.
- 11 B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required
12 for each item of pipe system as specified in insulation system schedules.
- 13 C. Install accessories compatible with insulation materials and suitable for the service. Install
14 accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or
15 dry state.
- 16 D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- 17 E. Install multiple layers of insulation with longitudinal and end seams staggered.
- 18 F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- 19 G. Keep insulation materials dry during application and finishing.
- 20 H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with
21 adhesive recommended by insulation material manufacturer.
- 22 I. Install insulation with least number of joints practical.
- 23 J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet
24 and dry film thicknesses.
- 25 K. Install insulation with factory-applied jackets as follows:
 - 26 1. Draw jacket tight and smooth.
 - 27 2. Cover joints and seams with tape, according to insulation material manufacturer's written
28 instructions, to maintain vapor seal.
- 29 L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal
30 thickness.
- 31 M. Repair damaged insulation facings by applying same facing material over damaged areas.
32 Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal
33 patches similar to butt joints.
- 34 N. For above-ambient services, do not install insulation to the following:

- 1 1. Vibration-control devices.
- 2 2. Testing agency labels and stamps.
- 3 3. Nameplates and data plates.
- 4 4. Manholes.
- 5 5. Handholes.
- 6 6. Cleanouts.

7 **3.4 PENETRATIONS**

8 A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof
9 penetrations.

- 10 1. Seal penetrations with flashing sealant.
- 11 2. For applications requiring only indoor insulation, terminate insulation above roof surface
12 and seal with joint sealant. For applications requiring indoor and outdoor insulation, install
13 insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with
14 joint sealant.
- 15 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches (50 mm) below
16 top of roof flashing.
- 17 4. Seal jacket to roof flashing with flashing sealant.

18 B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with
19 sleeve seal. Seal terminations with flashing sealant.

20 C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously
21 through wall penetrations.

- 22 1. Seal penetrations with flashing sealant.
- 23 2. For applications requiring only indoor insulation, terminate insulation inside wall surface
24 and seal with joint sealant. For applications requiring indoor and outdoor insulation, install
25 insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with
26 joint sealant.
- 27 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least
28 2 inches (50 mm).
- 29 4. Seal jacket to wall flashing with flashing sealant.

30 D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated):
31 Install insulation continuously through walls and partitions.

32 E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation
33 continuously through penetrations of fire-rated walls and partitions.

- 34 1. Comply with requirements in Section 07 84 13 "Penetration Firestopping" for firestopping
35 and fire-resistive joint sealers.

36 F. Insulation Installation at Floor Penetrations:

- 37 1. Pipe: Install insulation continuously through floor penetrations.
- 38 2. Seal penetrations through fire-rated assemblies. Comply with requirements in
39 Section 07 84 13 "Penetration Firestopping."

1 **3.5 INSTALLATION OF CELLULAR-GLASS INSULATION**

2 A. Insulation Installation on Straight Pipes and Tubes:

- 3 1. Provide factory applied ASJ-SSL jacket.
 4 2. Create a water stop between insulation and pipe by brushing vapor barrier mastic around
 5 circumference of pipe every 3 feet.

6 B. Insulation Installation on Pipe Flanges, Fittings, Elbows, Valves and Pipe Specialties:

- 7
 8 1. Provide insulation without factory applied jacket.
 9 2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same
 10 material and density as adjacent pipe insulation. Each piece shall be butted tightly
 11 against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular
 12 surfaces with insulating cement finished to a smooth, hard, and uniform contour that is
 13 uniform with adjoining pipe insulation.
 14 3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same
 15 material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt
 16 each section closely to the next and hold in place with tie wire. Bond pieces with
 17 adhesive.
 18 4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same
 19 material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe
 20 insulation by not less than two times the thickness of pipe insulation, or one pipe
 21 diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve
 22 stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with
 23 insulating cement.
 24 5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same
 25 material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe
 26 insulation by not less than two times the thickness of pipe insulation, or one pipe
 27 diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating
 28 cement. Insulate strainers so strainer basket flange or plug can be easily removed and
 29 replaced without damaging the insulation and jacket. Provide a removable reusable
 30 insulation cover. Provide a design that maintains vapor barrier.
 31 6. Insulate flanges and unions using a section of oversized preformed pipe insulation.
 32 Install preformed pipe insulation to outer diameter of pipe flange. Overlap adjoining pipe
 33 insulation by not less than two times the thickness of pipe insulation, or one pipe
 34 diameter, whichever is thicker. Fill voids between inner circumference of flange
 35 insulation and outer circumference of adjacent straight pipe segments with insulating
 36 cement.
 37 7. Secure mitered sections or segmented insulation with wire or bands.
 38 8. Cover pipe fittings, valves, strainers, flanges, unions, and other specialties and any
 39 segmented insulated surfaces with a layer of finishing cement and install field-applied
 40 glass-cloth jacket.
 41 9. Apply vapor-barrier mastic at exposed ends of insulation at pipe flanges, unions, and
 42 fittings.
 43 10. Stencil or label the outside insulation jacket of each union with the word "union." Match
 44 size and color of pipe labels.

45 **3.6 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION**

- 46 A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate
 47 openings in insulation that allow passage of air to surface being insulated.

48 B. Insulation Installation on Instrument Connections:

- 1 1. Install insulation on instrument connections for thermometers, pressure gages, pressure
- 2 temperature taps, test connections, flow meters, sensors, switches, and transmitters on
- 3 insulated pipes.
- 4 2. Shape insulation at these connections by tapering it to and around the connection.
- 5 3. Secure insulation materials and seal seams with manufacturer's recommended adhesive
- 6 to eliminate openings in insulation that allow passage of air to surface being insulated.

7 **3.7 INSTALLATION OF MINERAL-FIBER INSULATION**

8 A. Insulation Installation on Straight Pipes and Tubes:

- 9 1. Provide factory applied ASJ-SSL jacket.

10 B. Insulation Installation on Pipe Flanges, Fittings, Elbows, Valves and Pipe Specialties:

- 11 1. Insulate pipe elbows and tee fittings using preformed fitting insulation. Each piece shall
- 12 be butted tightly against adjoining piece.
- 13 2. Insulate flanges and unions using a section of oversized preformed pipe insulation. Install
- 14 preformed pipe insulation to outer diameter of pipe flange. Overlap adjoining pipe
- 15 insulation by not less than two times the thickness of pipe insulation, or one pipe
- 16 diameter, whichever is thicker. Fill voids between inner circumference of flange
- 17 insulation and outer circumference of adjacent straight pipe segments with insulating
- 18 cement.
- 19 3. Insulate strainers, valves, and other pipe specialties using preformed fitting insulation.
- 20 When preformed sections are not available, install mitered sections of pipe insulation.
- 21 Secure mitered sections with wire or bands.
- 22 4. Arrange valve insulation to permit access to packing and to allow valve operation without
- 23 disturbing insulation.
- 24 5. In concealed locations install fitted PVC cover over preformed fitting insulation. Terminate
- 25 ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC
- 26 tape.
- 27 6. Cover pipe fittings, valves, strainers, flanges, unions, and other specialties in exposed
- 28 locations and any segmented insulated surfaces with a layer of finishing cement and
- 29 install field-applied glass-cloth jacket.
- 30 7. Apply breather mastic at exposed ends of insulation at pipe flanges, unions, and fittings.
- 31 8. Stencil or label the outside insulation jacket of each union with the word "union." Match
- 32 size and color of pipe labels.

33 C. Insulation Installation on Instrument Connections:

- 34 1. Install insulation on instrument connections for thermometers, pressure gages, pressure
- 35 temperature taps, test connections, flow meters, sensors, switches, and transmitters on
- 36 insulated pipes.
- 37 2. Shape insulation at these connections by tapering it to and around the connection with
- 38 insulating cement and finish with mastic.
- 39 3. Secure insulation materials and seal seams with manufacturer's recommended adhesive
- 40 to eliminate openings in insulation that allow passage of air to surface being insulated.

41 **3.8 FIELD-APPLIED JACKET INSTALLATION**

- 42 A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with
- 43 factory-applied jackets.

- 1 1. Draw jacket smooth and tight to surface with 2-inch (50-mm) overlap at seams and joints.
- 2 2. Embed glass cloth between two 0.062-inch- (1.6-mm-) thick coats of mastic.
- 3 3. Completely encapsulate insulation with coating, leaving no exposed insulation.
- 4 4. Finish to achieve smooth, uniform finish.

- 5 B. Where PVC jackets are indicated, install with 1-inch (25-mm) overlap at longitudinal seams and
- 6 end joints; for horizontal applications. Seal with manufacturer's recommended adhesive.

- 7 1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the
- 8 finish bead along seam and joint edge.

- 9 C. Where metal jackets are indicated, install with 2-inch (50-mm) overlap at longitudinal seams and
- 10 end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with
- 11 weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-
- 12 steel bands 12 inches (300 mm) o.c. and at end joints.

- 13 D. Do not install metal jacket over field-applied glass-cloth jacket unless indicated in schedule.

14 **3.9 FINISHES**

- 15 A. Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint
- 16 system identified below.

- 17 1. Semi-glass Acrylic Finish: Two finish coats over a primer that is compatible with jacket
- 18 material and finish coat paint. Add fungicidal agent to render fabric mildew proof. Color
- 19 per schedule below.

- 20 a. Finish Coat Material: Interior, semi-gloss, latex-emulsion size.

- 21 2. Paint exposed piping without field applied metal jacket.

- 22 B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of
- 23 insulation manufacturer's recommended protective coating. Color per schedule below.

- 24 C. Color: Final color as selected by Engineer. Vary first and second coats to allow visual inspection
- 25 of the completed Work.

- 26 1. Heating Hot Water and Heat Recovery: Yellow.

- 27 D. Do not field paint aluminum jackets.

28 **3.10 PIPING INSULATION SCHEDULE, GENERAL**

- 29 A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for
- 30 each piping system and pipe size range. If more than one material is listed for a piping system,
- 31 selection from materials listed is Contractor's option.

32 **3.11 INDOOR PIPING INSULATION SCHEDULE**

- 33 A. Heating-Hot-Water Supply and Return:

- 34 1. NPS 12 (DN 300) and Smaller: Insulation shall be the following:

1 a. Mineral-Fiber, Preformed Pipe, Type I: 2 inches (50 mm) thick.

2 2. Instrument Connections:

3 a. Mineral-Fiber, Preformed Pipe, Type I: 1 inch (25 mm) thick

4 B. Heat Recovery Supply and Return:

5 1. NPS 12 (DN 300) and Smaller: Insulation shall be the following:

6 a. Mineral-Fiber, Preformed Pipe, Type I: 2 inches (50 mm) thick.

7 2. Instrument Connections:

8 a. Mineral-Fiber, Preformed Pipe, Type I: 1 inch (25 mm) thick

9 **3.12 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE**

10 A. Heating-Hot-Water Supply and Return:

11 1. All Pipe Sizes: Insulation shall be the following:

12 a. Cellular Glass: 2 inches (50 mm) thick.

13 2. Instrument Connections:

14 a. Flexible Elastomeric: 1 inch (25 mm) thick.

15 **3.13 OUTDOOR, UNDERGROUND PIPING INSULATION SCHEDULE**

16 A. Loose-fill insulation, for belowground pre-insulated piping, is specified in Section 23 21 13.13
17 "Underground Hydronic Piping".

18 **3.14 WITHIN MANHOLE AND TUNNEL, PIPING INSULATION SCHEDULE**

19 A. Heating-Hot-Water Supply and Return, All Sizes, 200 Deg F (93 Deg C) and Below: Cellular
20 glass, 2 inches (50 mm) thick.

21 **3.15 INDOOR, FIELD-APPLIED JACKET SCHEDULE**

22 A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-
23 applied jacket over the factory-applied jacket.

24 B. Piping, Concealed:

25 1. None.

26 C. Piping, Exposed:

27 1. Aluminum, Corrugated: 0.016 inch (0.41 mm) thick.

1 D. Fittings, valves, strainers, flanges, unions, and other specialties, Concealed:

2 1. PVC jacket.

3 E. Fittings, valves, strainers, flanges, unions, and other specialties, Exposed:

4 1. Glass cloth jacket.

5 **3.16 UNDERGROUND, FIELD-INSTALLED INSULATION JACKET**

6 A. Heating Hot Water, All Sizes: For underground direct-buried piping applications, install
7 underground direct-buried jacket over insulation material.

8 **3.17 WITHIN MANHOLE AND TUNNEL, FIELD-INSTALLED INSULATION JACKET**

9 A. Heating Hot Water, All Sizes: Within utility manholes install field applied glass-cloth jacket over
10 insulation material. Install aluminum, corrugated 0.024 inch (0.61 mm) thick metal jacket over
11 finished glass cloth jacket.

12 **END OF SECTION 23 07 19.14**

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1 **SECTION 23 07 19.16 - INSULATION FOR REFRIGERANT PIPING**

2 **PART 1 - GENERAL**

3 **1.1 RELATED DOCUMENTS**

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

6 **1.2 SUMMARY**

- 7 A. Section includes insulating the following HVAC piping systems:
8 1. Refrigerant suction and hot-gas piping, indoors and outdoors.

9 **1.3 ACTION SUBMITTALS**

- 10 A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor
11 permeance thickness, and jackets (both factory and field applied if any).
- 12 B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
- 13 1. Detail application of protective shields, saddles, and inserts at hangers for each type of
14 insulation and hanger.
- 15 2. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each
16 type of insulation.
- 17 3. Detail application of field-applied jackets.

18 **1.4 QUALITY ASSURANCE**

- 19 A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship
20 program or another craft training program certified by the Department of Labor, Bureau of
21 Apprenticeship and Training.
- 22 B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing
23 identical products according to ASTM E84, by a testing and inspecting agency acceptable to
24 authorities having jurisdiction. Factory label insulation and jacket materials and adhesive,
25 mastic, tapes, and cement material containers, with appropriate markings of applicable testing
26 agency.
- 27 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed
28 index of 50 or less.
- 29 2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed
30 index of 150 or less.

31 **1.5 DELIVERY, STORAGE, AND HANDLING**

- 32 A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate
33 ASTM standard designation, type and grade, and maximum use temperature.

1 **1.6 COORDINATION**

- 2 A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in
3 Section 23 05 29 "Hangers and Supports for HVAC Piping and Equipment."
- 4 B. Coordinate clearance requirements with piping Installer for piping insulation application. Before
5 preparing piping Shop Drawings, establish and maintain clearance requirements for installation
6 of insulation and field-applied jackets and finishes and for space required for maintenance.

7 **1.7 SCHEDULING**

- 8 A. Schedule insulation application after pressure testing systems and, where required, after
9 installing and testing heat tracing. Insulation application may begin on segments that have
10 satisfactory test results.
- 11 B. Complete installation and concealment of plastic materials as rapidly as possible in each area of
12 construction.

13 **PART 2 - PRODUCTS**

14 **2.1 INSULATION MATERIALS**

- 15 A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation
16 Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground
17 Piping Insulation Schedule" articles for where insulating materials shall be applied.
- 18 B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- 19 C. Products that come in contact with stainless steel shall have a leachable chloride content of less
20 than 50 ppm when tested according to ASTM C871.
- 21 D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable
22 according to ASTM C795.
- 23 E. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply
24 with ASTM C534, Type I for tubular materials.
- 25 1. Products: Subject to compliance with requirements, provide one of the following:
- 26 a. Aeroflex USA, Inc.; Aerocel.
- 27 b. Armacell LLC; AP Armaflex.
- 28 c. K-Flex USA; Insul-Lock, Insul-Tube, and K-FLEX LS.

29 **2.2 ADHESIVES**

- 30 A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding
31 insulation to itself and to surfaces to be insulated unless otherwise indicated.
- 32 B. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.

- 1 1. Products: Subject to compliance with requirements, available products that may be
 2 incorporated into the Work include, but are not limited to, the following:
- 3 a. Aeroflex USA, Inc.; Aero seal.
 4 b. Armacell LLC; Armaflex 520 Adhesive.
 5 c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller
 6 Company; 85-75.
 7 d. K-Flex USA; R-373 Contact Adhesive.

8 **2.3 MASTICS AND COATINGS**

- 9 A. Materials shall be compatible with insulation materials, jackets, and substrates.
- 10 1. VOC Content: 50 g/L or less.
 11 2. Low-Emitting Materials: Mastic coatings shall comply with the testing and product
 12 requirements of the California Department of Public Health's "Standard Method for the
 13 Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources
 14 Using Environmental Chambers."

- 15 B. Vapor-Retarder Mastic: Water based; suitable for indoor use on below-ambient services.

- 16 1. Products: Subject to compliance with requirements, available products that may be
 17 incorporated into the Work include, but are not limited to, the following:

- 18 a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller
 19 Company; 30-80 / 30-90.
 20 b. Vimasco Corporation; 749.

- 21 2. Water-Vapor Permeance: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation
 22 type and service conditions.

- 23 3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).

- 24 4. Comply with MIL-PRF-19565C, Type II, for permeance requirements.

- 25 5. Color: White.

- 26 C. Vapor-Retarder Mastic: Solvent based; suitable for outdoor use on below-ambient services.

- 27 1. Products: Subject to compliance with requirements, available products that may be
 28 incorporated into the Work include, but are not limited to, the following:

- 29 a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller
 30 Company; Encacel.

- 31 b. Marathon Industries; 570.

- 32 c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller
 33 Company; 60-95 / 60-96.

- 34 2. Water-Vapor Permeance: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation
 35 type and service conditions.

- 36 3. Service Temperature Range: Minus 50 to plus 220 deg F (Minus 46 to plus 104 deg C).

- 37 4. Color: White.

38 **2.4 FIELD-APPLIED JACKETS**

- 39 A. Field-applied jackets shall comply with ASTM C921, Type I, unless otherwise indicated.

- 1 B. Metal Jacket:
- 2 1. Products: Subject to compliance with requirements, available products that may be
- 3 incorporated into the Work include, but are not limited to, the following:
- 4 a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller
- 5 Company; Metal Jacketing Systems.
- 6 b. ITW Insulation Systems; Aluminum and Stainless Steel Jacketing.
- 7 c. RPR Products, Inc.; Insul-Mate.
- 8 2. Aluminum Jacket: Comply with ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or
- 9 5005, Temper H-14.
- 10 a. Sheet and roll stock ready for shop or field sizing.
- 11 b. Finish and thickness are indicated in field-applied jacket schedules.
- 12 c. Moisture Barrier for Indoor Applications: 2.5-mil- (0.063-mm-) thick polysurlyn.
- 13 d. Moisture Barrier for Outdoor Applications: .
- 14 e. Factory-Fabricated Fitting Covers:
- 15 1) Same material, finish, and thickness as jacket.
- 16 2) Field fabricate fitting covers only if factory-fabricated fitting covers are not
- 17 available.

18 2.5 SECUREMENTS

- 19 A. Bands:
- 20 1. Products: Subject to compliance with requirements, available products that may be
- 21 incorporated into the Work include, but are not limited to, the following:
- 22 a. ITW Insulation Systems; Gerrard Strapping and Seals.
- 23 b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.
- 24 2. Stainless Steel: ASTM A167 or ASTM A240/A240M, Type 304; 0.015 inch (0.38 mm)
- 25 thick, 1/2 inch (13 mm) wide with wing seal.
- 26 B. Wire: 0.062-inch (1.6-mm) soft-annealed, stainless steel.

27 PART 3 - EXECUTION

28 3.1 EXAMINATION

- 29 A. Examine substrates and conditions for compliance with requirements for installation tolerances
- 30 and other conditions affecting performance of insulation application.
- 31 1. Verify that systems to be insulated have been tested and are free of defects.
- 32 2. Verify that surfaces to be insulated are clean and dry.
- 33 3. Proceed with installation only after unsatisfactory conditions have been corrected.

1 **3.2 PREPARATION**

- 2 A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will
3 adversely affect insulation application.
- 4 B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements
5 for heat tracing that apply to insulation.
- 6 C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with
7 stainless-steel surfaces, use demineralized water.

8 **3.3 GENERAL INSTALLATION REQUIREMENTS**

- 9 A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces;
10 free of voids throughout the length of piping including fittings, valves, and specialties.
- 11 B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required
12 for each item of pipe system as specified in insulation system schedules.
- 13 C. Install accessories compatible with insulation materials and suitable for the service. Install
14 accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or
15 dry state.
- 16 D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- 17 E. Install multiple layers of insulation with longitudinal and end seams staggered.
- 18 F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- 19 G. Keep insulation materials dry during application and finishing.
- 20 H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with
21 adhesive recommended by insulation material manufacturer.
- 22 I. Install insulation with least number of joints practical.
- 23 J. Below Ambient Systems.
 - 24 1. Provide continuous vapor barrier; seal joints, longitudinal seams, and penetrations in
25 insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic
26 and joint sealant.
 - 27 2. Where mastic is indicated provide vapor-barrier mastic as required for indoor or outdoor
28 application.
 - 29 3. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties
- 30 K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet
31 and dry film thicknesses.
- 32 L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal
33 thickness.
- 34 M. Repair damaged insulation facings by applying same facing material over damaged areas.
35 Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal
36 patches similar to butt joints.

1 **3.4 PENETRATIONS**

- 2 A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof
3 penetrations.
- 4 1. Seal penetrations with flashing sealant.
5 2. For applications requiring only indoor insulation, terminate insulation above roof surface
6 and seal with joint sealant. For applications requiring indoor and outdoor insulation, install
7 insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with
8 joint sealant.
9 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches (50 mm) below
10 top of roof flashing.
11 4. Seal jacket to roof flashing with flashing sealant.
- 12 B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with
13 sleeve seal. Seal terminations with flashing sealant.
- 14 C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously
15 through wall penetrations.
- 16 1. Seal penetrations with flashing sealant.
17 2. For applications requiring only indoor insulation, terminate insulation inside wall surface
18 and seal with joint sealant. For applications requiring indoor and outdoor insulation, install
19 insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with
20 joint sealant.
21 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least
22 2 inches (50 mm).
23 4. Seal jacket to wall flashing with flashing sealant.
- 24 D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated):
25 Install insulation continuously through walls and partitions.
- 26 E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation
27 continuously through penetrations of fire-rated walls and partitions.
- 28 1. Comply with requirements in Section 07 84 13 "Penetration Firestopping" for firestopping
29 and fire-resistive joint sealers.
- 30 F. Insulation Installation at Floor Penetrations:
- 31 1. Pipe: Install insulation continuously through floor penetrations.
32 2. Seal penetrations through fire-rated assemblies. Comply with requirements in
33 Section 07 84 13 "Penetration Firestopping."

34 **3.5 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION**

- 35 A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate
36 openings in insulation that allow passage of air to surface being insulated.
- 37 B. Insulation Installation on Pipe Flanges:
- 38 1. Install pipe insulation to outer diameter of pipe flange.
39 2. Make width of insulation section same as overall width of flange and bolts, plus twice the
40 thickness of pipe insulation.

- 1 3. Fill voids between inner circumference of flange insulation and outer circumference of
- 2 adjacent straight pipe segments with cut sections of sheet insulation of same thickness
- 3 as pipe insulation.
- 4 4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive
- 5 to eliminate openings in insulation that allow passage of air to surface being insulated.

- 6 C. Insulation Installation on Pipe Fittings and Elbows:

- 7 1. Install mitered sections of pipe insulation.
- 8 2. Secure insulation materials and seal seams with manufacturer's recommended adhesive
- 9 to eliminate openings in insulation that allow passage of air to surface being insulated.

- 10 D. Insulation Installation on Valves and Pipe Specialties:

- 11 1. Install preformed valve covers manufactured of same material as pipe insulation when
- 12 available.
- 13 2. When preformed valve covers are not available, install cut sections of pipe and sheet
- 14 insulation to valve body. Arrange insulation to permit access to packing and to allow
- 15 valve operation without disturbing insulation.
- 16 3. Install insulation to flanges as specified for flange insulation application.
- 17 4. Secure insulation to valves and specialties and seal seams with manufacturer's
- 18 recommended adhesive to eliminate openings in insulation that allow passage of air to
- 19 surface being insulated.

20 3.6 FIELD-APPLIED JACKET INSTALLATION

- 21 A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with
- 22 factory-applied jackets.

- 23 1. Draw jacket smooth and tight to surface with 2-inch (50-mm) overlap at seams and joints.
- 24 2. Embed glass cloth between two 0.062-inch- (1.6-mm-) thick coats of mastic.
- 25 3. Completely encapsulate insulation with coating, leaving no exposed insulation.
- 26 4. Finish to achieve smooth, uniform finish.

- 27 B. Where metal jackets are indicated, install with 2-inch (50-mm) overlap at longitudinal seams and
- 28 end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with
- 29 weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-
- 30 steel bands 12 inches (300 mm) o.c. and at end joints.

31 3.7 FINISHES

- 32 A. Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint
- 33 system identified below .

- 34 1. Semi-glass Acrylic Finish: Two finish coats over a primer that is compatible with jacket
- 35 material and finish coat paint. Add fungicidal agent to render fabric mildew proof. Color
- 36 per schedule below.

- 37 a. Finish Coat Material: Interior, semi-gloss, latex-emulsion size.

- 38 2. Paint exposed piping without field applied metal jacket.

- 1 B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of
- 2 insulation manufacturer's recommended protective coating. Color per schedule below.
- 3 C. Color: Final color as selected by Engineer. Vary first and second coats to allow visual inspection
- 4 of the completed Work.
- 5 1. White.
- 6 D. Do not field paint aluminum jackets.

7 **3.8 PIPING INSULATION SCHEDULE, GENERAL**

- 8 A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for
- 9 each piping system and pipe size range. If more than one material is listed for a piping system,
- 10 selection from materials listed is Contractor's option.

11 **3.9 INDOOR PIPING INSULATION SCHEDULE**

- 12 A. Refrigerant Suction and Hot-Gas Piping:
- 13 1. All Pipe Sizes: Insulation shall be the following:
- 14 a. Flexible Elastomeric: 1 inch (25 mm) thick.
- 15 B. Refrigerant Suction and Hot-Gas Flexible Tubing:
- 16 1. All Pipe Sizes: Insulation shall be the following:
- 17 a. Flexible Elastomeric: 1 inch (25 mm) thick.

18 **3.10 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE**

- 19 A. Refrigerant Suction and Hot-Gas Piping:
- 20 1. All Pipe Sizes: Insulation shall be the following:
- 21 a. Flexible Elastomeric: 1 inch (25 mm) thick.
- 22 B. Refrigerant Suction and Hot-Gas Flexible Tubing:
- 23 1. All Pipe Sizes: Insulation shall be the following:
- 24 a. Flexible Elastomeric: 1 inch (25 mm) thick.

25 **3.11 INDOOR, FIELD-APPLIED JACKET SCHEDULE**

- 26 A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-
- 27 applied jacket over the factory-applied jacket.
- 28 B. Piping, Concealed:

1 1. None.

2 C. Piping, Exposed:

3 1. Aluminum, Corrugated: 0.016 inch (0.41 mm) thick.

4 **3.12 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE**

5 A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-
6 applied jacket over the factory-applied jacket.

7 B. If more than one material is listed, selection from materials listed is Contractor's option.

8 C. Piping, Concealed:

9 1. Aluminum, Corrugated: 0.024 inch (0.61 mm) thick.

10 D. Piping, Exposed:

11 1. Aluminum, Corrugated: 0.024 inch (0.61 mm) thick.

12 **END OF SECTION 23 07 19.16**

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1 **SECTION 23 21 13.11 - CONDENSATE DRAIN PIPING**

2 **PART 1 - GENERAL**

3 **1.1 SUMMARY**

4 A. Section Includes:

- 5 1. Copper tube and fittings.
- 6 2. Piping joining materials.
- 7 3. Dielectric fittings.

8 **1.2 ACTION SUBMITTALS**

9 A. Product Data: For each type of the following:

- 10 1. Pipe and tube.
- 11 2. Fittings.
- 12 3. Joining materials.
- 13 4. Transition fittings.

14 **PART 2 - PRODUCTS**

15 **2.1 PERFORMANCE REQUIREMENTS**

- 16 A. Hydronic piping components and installation are to be capable of withstanding the following
- 17 minimum working pressures and temperatures unless otherwise indicated:
- 18 1. Condensate-Drain Piping: 150 deg F (66 deg C).

19 **2.2 COPPER TUBE AND FITTINGS**

- 20 A. Drawn-Temper Copper Tube: ASTM B88, Type L (ASTM B88M, Type B).
- 21 B. Wrought-Copper, Solder-Joint Fittings: ASME B16.22 pressure fittings. Do not use solder joints
- 22 on pipe sizes greater than NPS 4 (DN 100).
- 23 C. Wrought-Copper Unions: ASME B16.22. Do not use solder joints on pipe sizes greater than
- 24 NPS 4 (DN 100).
- 25 D. Copper-Tube, Pressure-Seal-Joint Fittings - Copper or Bronze:
- 26 1. Manufacturers: Subject to compliance with requirements, provide products by one of the
- 27 following:
- 28 a. Mueller Streamline Co.; a company of Mueller Industries.
- 29 b. Victaulic Company.
- 30 c. Viega LLC.

- 1 2. Source Limitations: Obtain copper-tube pressure-seal-joint fittings from single
- 2 manufacturer.
- 3 3. Housing: Copper or bronze.
- 4 4. O-Rings and Pipe Stops: EPDM.
- 5 5. Tools: Manufacturer's special tools.
- 6 6. Minimum 200 psig (1370 kPa) working pressure rating at 250 deg F (121 deg C).

7 **PART 3 - EXECUTION**

8 **3.1 PIPING APPLICATIONS**

9 A. Condensate-Drain Piping Installed Aboveground to Be Any of the Following:

- 10 1. Type L (Type B), drawn-temper copper tubing, wrought-copper fittings, and soldered
- 11 joints.
- 12 2. Schedule 40, PVC plastic pipe and fittings and solvent-welded joints.

13 **3.2 INSTALLATION OF PIPING**

14 A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping

15 systems. Indicated locations and arrangements are used to size pipe and calculate friction loss,

16 expansion, and other design considerations. Install piping as indicated unless deviations to

17 layout are approved on coordination drawings.

18 B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms

19 and service areas.

20 C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right

21 angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated

22 otherwise.

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

24 E. Install piping to permit valve servicing.

25 F. Install piping at indicated slopes.

26 G. Install piping free of sags and bends.

27 H. Install fittings for changes in direction and branch connections.

28 I. Install piping to allow application of insulation.

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

30 pressure.

31 K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing

32 of valves.

33 L. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

- 1 M. Install branch connections to mains using tee fittings in main pipe, with the branch connected to
2 the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.
- 3 N. Install valves according to the following:
4 1. Section 23 05 23.12 "Ball Valves for HVAC Piping."
- 5 O. Install unions in piping, NPS 2 (DN 50) and smaller, adjacent to valves, at final connections of
6 equipment, and elsewhere as indicated.
- 7 P. Comply with requirements in Section 23 05 53 "Identification for HVAC Piping and Equipment"
8 for identifying piping.
- 9 Q. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for
10 sleeves specified in Section 23 05 17 "Sleeves and Sleeve Seals for HVAC Piping."
- 11 R. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with
12 requirements for sleeve seals specified in Section 23 05 17 "Sleeves and Sleeve Seals for
13 HVAC Piping."
- 14 S. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with
15 requirements for escutcheons specified in Section 23 05 18 "Escutcheons for HVAC Piping."

16 3.3 JOINT CONSTRUCTION

- 17 A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- 18 B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before
19 assembly.
- 20 C. Soldered Joints: Apply ASTM B813, water-flushable flux, unless otherwise indicated, to tube
21 end. Construct joints in accordance with ASTM B828 or CDA's "Copper Tube Handbook," using
22 lead-free solder alloy complying with ASTM B32.

23 3.4 INSTALLATION OF HANGERS AND SUPPORTS

- 24 A. Comply with requirements in Section 23 05 29 "Hangers and Supports for HVAC Piping and
25 Equipment" for hangers, supports, and anchor devices.
- 26 B. Install hangers for copper tubing , with maximum horizontal spacing and minimum rod
27 diameters, to comply with MSS SP-58, locally enforced codes, and authorities having
28 jurisdiction requirements, whichever are most stringent.
- 29 C. Install hangers for plastic piping, with maximum horizontal spacing and minimum rod diameters,
30 to comply with manufacturer's written instructions, locally enforced codes, and authorities
31 having jurisdiction requirements, whichever are most stringent.
- 32 D. Support horizontal piping within 12 inches (300 mm) of each fitting and coupling.
- 33 E. Support vertical runs of copper tubing to comply with MSS SP-58, locally enforced codes, and
34 authorities having jurisdiction requirements, whichever are most stringent.
- 35 F. Support vertical runs of PVC piping to comply with manufacturer's written instructions, locally
36 enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

1 **3.5 IDENTIFICATION**

- 2 A. Identify system components. Comply with requirements for identification materials and
3 installation in Section 23 05 53 "Identification for HVAC Piping and Equipment."

4 **3.6 FIELD QUALITY CONTROL**

- 5 A. Prepare hydronic piping in accordance with ASME B31.9 and as follows:

- 6 1. Leave joints uninsulated and exposed for examination during test.
7 2. Flush hydronic piping systems with clean water; then remove and clean or replace
8 strainer screens.

- 9 B. Perform the following tests on hydronic piping:

- 10 1. Use ambient-temperature water as a testing medium unless there is risk of damage due
11 to freezing. Another liquid that is safe for workers and compatible with piping may be
12 used.
13 2. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the
14 system's working pressure. Test pressure is not to exceed maximum pressure for any
15 vessel, pump, valve, or other component in system under test. Verify that stress due to
16 pressure at bottom of vertical runs does not exceed 90 percent of specified minimum
17 yield strength or 1.7 times the "SE" value in Appendix A in ASME B31.9.
18 3. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping,
19 joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing
20 components, and repeat hydrostatic test until there are no leaks.
21 4. Prepare written report of testing.

22 **END OF SECTION 23 21 13.11**

1 **SECTION 23 21 13.12 - ABOVEGROUND HYDRONIC PIPING**

2 **PART 1 - GENERAL**

3 **1.1 SUMMARY**

4 A. Section Includes:

- 5 1. Copper tube and fittings.
- 6 2. Steel pipe and fittings.
- 7 3. Piping joining materials.
- 8 4. Transition fittings.
- 9 5. Dielectric fittings.

10 **1.2 ACTION SUBMITTALS**

11 A. Product Data: For each type of the following:

- 12 1. Pipe and tube.
- 13 2. Fittings.
- 14 3. Joining materials.
- 15 4. Transition fittings.

16 **1.3 QUALITY ASSURANCE**

17 A. Pipe Welding: Qualify procedures and operators in accordance with ASME Boiler and Pressure
18 Vessel Code: Section IX.

- 19 1. Comply with ASME B31.9 for materials, products, and installation.
- 20 2. Certify that each welder has passed AWS qualification tests for welding processes
21 involved and that certification is current.

22 **PART 2 - PRODUCTS**

23 **2.1 PERFORMANCE REQUIREMENTS**

24 A. Hydronic piping components and installation are to be capable of withstanding the following
25 minimum working pressures and temperatures unless otherwise indicated:

- 26 1. Hot-Water Heating Piping: 150 psig (1034 kPa) at 200 deg F (93 deg C).
- 27 2. Chilled-Water Piping: 150 psig (1034 kPa) at 200 deg F (93 deg C).
- 28 3. Makeup-Water Piping: 150 psig (1034 kPa) at 150 deg F (66 deg C).
- 29 4. Air-Vent Piping: 200 deg F (93 deg C).

30 **2.2 COPPER TUBE AND FITTINGS**

31 A. Drawn-Temper Copper Tube: ASTM B88, Type L (ASTM B88M, Type B).

- 1 B. Annealed-Temper Copper Tube: ASTM B88, Type K (ASTM B88M, Type A).
- 2 C. Wrought-Copper, Solder-Joint Fittings: ASME B16.22 pressure fittings. Do not use solder joints
- 3 on pipe sizes greater than NPS 4 (DN 100).
- 4 D. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends. Do not use solder joints on
- 5 pipe sizes greater than NPS 4 (DN 100).
- 6 E. Wrought-Copper Unions: ASME B16.22. Do not use solder joints on pipe sizes greater than
- 7 NPS 4 (DN 100).

8 **2.3 STEEL PIPE AND FITTINGS**

- 9 A. Steel Pipe: ASTM A53/A53M black steel with plain ends; welded and seamless, Grade B, and
- 10 schedule number as indicated in Part 3, "Piping Applications" Article.
- 11 B. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in Part 3,
- 12 "Piping Applications" Article.
- 13 C. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in Part 3, "Piping
- 14 Applications" Article.
- 15 D. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised
- 16 ground face, and bolt holes spot faced as indicated in "Piping Applications" Article.
- 17 E. Wrought-Steel Fittings: ASTM A234/A234M; wall thickness to match adjoining pipe.
- 18 F. Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and
- 19 gaskets of the following material group, end connections, and facings:
 - 20 1. Material Group: 1.1.
 - 21 2. End Connections: Butt welding.
 - 22 3. Facings: Raised face.
- 23 G. Steel Pipe Nipples: ASTM A733, made of same materials and wall thicknesses as pipe in which
- 24 they are installed.

25 **2.4 PIPING JOINING MATERIALS**

- 26 A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system
- 27 contents.
 - 28 1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch (3.2-mm) maximum thickness
 - 29 unless otherwise indicated.
 - 30 a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
 - 31 b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
- 32 B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
- 33 C. Solder Filler Metals: ASTM B32, lead-free alloys.
- 34 D. Flux: ASTM B813, water flushable.

- 1 E. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for
 2 wall thickness and chemical analysis of steel pipe being welded.

3 **2.5 DIELECTRIC FITTINGS**

- 4 A. General Requirements: Assembly of copper alloy and ferrous materials with separating
 5 nonconductive insulating material. Include end connections compatible with pipes to be joined.

- 6 B. Dielectric Unions:

- 7 1. Source Limitations: Obtain dielectric unions from single manufacturer.
 8 2. Description:

- 9 a. Standard: ASSE 1079.
 10 b. Pressure Rating: 125 psig (860 kPa) minimum at 180 deg F (82 deg C).
 11 c. End Connections: Solder-joint copper alloy and threaded ferrous. Solder joints are
 12 not to be used on pipe sizes greater than NPS 4 (DN 100).

- 13 C. Dielectric-Flange Insulating Kits:

- 14 1. Source Limitations: Obtain dielectric-flange insulating kits from single manufacturer.
 15 2. Description:

- 16 a. Nonconducting materials for field assembly of companion flanges.
 17 b. Pressure Rating: 150 psig (1035 kPa).
 18 c. Gasket: Neoprene or phenolic.
 19 d. Bolt Sleeves: Phenolic or polyethylene.
 20 e. Washers: Phenolic with steel backing washers.

21 **PART 3 - EXECUTION**

22 **3.1 PIPING APPLICATIONS**

- 23 A. Hot-Water Heating Piping, Aboveground, NPS 2 (DN 50) and Smaller, to Be Any of the
 24 Following:

- 25 1. Type L (Type B), drawn-temper copper tubing, wrought-copper fittings, and soldered
 26 joints.
 27 2. Schedule 40, Grade B, steel pipe; Class 150, malleable-iron fittings; and threaded joints.

- 28 B. Hot-Water Heating Piping, Aboveground, NPS 2-1/2 (DN 65) and Larger, to Be Any of the
 29 Following:

- 30 1. Type L (Type B), drawn-temper copper tubing, wrought-copper fittings, and soldered
 31 joints.
 32 2. Schedule 40, Grade B, steel pipe; Class 150, malleable-iron fittings; welded joints, cast-
 33 iron flanges, flange-fittings, and flanged joints.

- 34 C. Chilled-Water Piping, Aboveground, NPS 2 (DN 50) and Smaller, to be Any of the Following:

- 35 1. Type L (Type B), drawn-temper copper tubing, wrought-copper fittings, and soldered
 36 joints.
 37 2. Schedule 40, Grade B steel pipe; Class 150, malleable-iron fittings; and threaded joints.

- 1 D. Chilled-Water Piping, Aboveground, NPS 2-1/2 (DN 65) and Larger, to Be Any of the Following:
- 2 1. Type L (Type B), drawn-temper copper tubing, wrought-copper fittings, and soldered
3 joints.
- 4 2. Schedule 40, Grade B, steel pipe, wrought-steel fittings and wrought-cast or forged-steel
5 flanges and flange fittings, and welded and flanged joints.
- 6 E. Air-Vent Piping:
- 7 1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic
8 piping systems, according to piping manufacturer's written instructions.
- 9 2. Outlet: Type K (Type A), annealed-temper copper tubing with soldered or flared joints.
- 10 **3.2 INSTALLATION OF PIPING**
- 11 A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping
12 systems. Indicated locations and arrangements are used to size pipe and calculate friction loss,
13 expansion, and other design considerations. Install piping as indicated unless deviations to
14 layout are approved on coordination drawings.
- 15 B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms
16 and service areas.
- 17 C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right
18 angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated
19 otherwise.
- 20 D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- 21 E. Install piping to permit valve servicing.
- 22 F. Install piping at indicated slopes.
- 23 G. Install piping free of sags and bends.
- 24 H. Install fittings for changes in direction and branch connections.
- 25 I. Install piping to allow application of insulation.
- 26 J. Select system components with pressure rating equal to or greater than system operating
27 pressure.
- 28 K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing
29 of valves.
- 30 L. Install drains, consisting of a tee fitting, NPS 3/4 (DN 20) ball valve, and short NPS 3/4 (DN 20)
31 threaded nipple with cap, at low points in piping system mains and elsewhere as required for
32 system drainage.
- 33 M. Install piping at a uniform grade of 0.2 percent upward in direction of flow.
- 34 N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

- 1 O. Install branch connections to mains using tee fittings in main pipe, with the branch connected to
2 the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.
- 3 P. Install valves according to the following:
- 4 1. Section 23 05 23.11 "Globe Valves for HVAC Piping."
5 2. Section 23 05 23.12 "Ball Valves for HVAC Piping."
6 3. Section 23 05 23.13 "Butterfly Valves for HVAC Piping."
7 4. Section 23 05 23.14 "Check Valves for HVAC Piping."
- 8 Q. Install air vents and pressure-relief valves in accordance with Section 23 21 16 "Hydronic Piping
9 Specialties."
- 10 R. Install unions in piping, NPS 2 (DN 50) and smaller, adjacent to valves, at final connections of
11 equipment, and elsewhere as indicated.
- 12 S. Install flanges in piping, NPS 2-1/2 (DN 65) and larger, at final connections of equipment and
13 elsewhere as indicated.
- 14 T. Install shutoff valve immediately upstream of each dielectric fitting.
- 15 U. Comply with requirements in Section 23 05 16 "Expansion Fittings and Loops for HVAC Piping"
16 for installation of expansion loops, expansion joints, anchors, and pipe alignment guides.
- 17 V. Comply with requirements in Section 23 05 53 "Identification for HVAC Piping and Equipment"
18 for identifying piping.
- 19 W. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for
20 sleeves specified in Section 23 05 17 "Sleeves and Sleeve Seals for HVAC Piping."
- 21 X. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with
22 requirements for sleeve seals specified in Section 23 05 17 "Sleeves and Sleeve Seals for
23 HVAC Piping."
- 24 Y. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with
25 requirements for escutcheons specified in Section 23 05 18 "Escutcheons for HVAC Piping."

26 **3.3 JOINT CONSTRUCTION**

- 27 A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- 28 B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before
29 assembly.
- 30 C. Soldered Joints: Apply ASTM B813, water-flushable flux, unless otherwise indicated, to tube
31 end. Construct joints in accordance with ASTM B828 or CDA's "Copper Tube Handbook," using
32 lead-free solder alloy complying with ASTM B32.
- 33 D. Threaded Joints: Thread pipe with tapered pipe threads in accordance with ASME B1.20.1. Cut
34 threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore
35 full ID. Join pipe fittings and valves as follows:
- 36 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal
37 threading is specified.

- 1 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or
2 damaged. Do not use pipe sections that have cracked or open welds.
- 3 E. Welded Joints: Construct joints in accordance with AWS D10.12M/D10.12, using qualified
4 processes and welding operators in accordance with "Quality Assurance" Article.
- 5 F. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service
6 application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

7 **3.4 INSTALLATION OF DIELECTRIC FITTINGS**

- 8 A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
- 9 B. Dielectric Fittings for NPS 2 (DN 50) and Smaller: Use dielectric unions.
- 10 C. Dielectric Fittings for NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Use dielectric flange kits.
- 11 D. Dielectric Fittings for NPS 5 (DN 125) and Larger: Use dielectric flange kits.

12 **3.5 INSTALLATION OF HANGERS AND SUPPORTS**

- 13 A. Comply with requirements in Section 23 05 29 "Hangers and Supports for HVAC Piping and
14 Equipment" for hangers, supports, and anchor devices.
- 15 B. Install hangers for copper tubing and steel piping, with maximum horizontal spacing and
16 minimum rod diameters, to comply with MSS SP-58, locally enforced codes, and authorities
17 having jurisdiction requirements, whichever are most stringent.
- 18 C. Support horizontal piping within 12 inches (300 mm) of each fitting and coupling.
- 19 D. Support vertical runs of copper tubing and steel piping to comply with MSS SP-58, locally
20 enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- 21 E. Support vertical runs of fiberglass piping to comply with manufacturer's written instructions,
22 locally enforced codes, and authorities having jurisdiction requirements, whichever are most
23 stringent.

24 **3.6 TERMINAL EQUIPMENT CONNECTIONS**

- 25 A. Sizes for supply and return piping connections are to be the same as or larger than equipment
26 connections.
- 27 B. Install control valves in accessible locations close to connected equipment.
- 28 C. Install bypass piping with globe valve around control valve. If parallel control valves are
29 installed, only one bypass is required.
- 30 D. Install ports for pressure gauges and thermometers at coil inlet and outlet connections. Comply
31 with requirements in Section 23 05 19 "Meters and Gauges for HVAC Piping."

1 **3.7 IDENTIFICATION**

- 2 A. Identify system components. Comply with requirements for identification materials and
3 installation in Section 23 05 53 "Identification for HVAC Piping and Equipment."

4 **3.8 SYSTEM STARTUP**

- 5 A. Perform the following before operating the system:

- 6 1. Open manual valves fully.
7 2. Inspect pumps for proper rotation.
8 3. Set makeup pressure-reducing valves for required system pressure.
9 4. Inspect air vents at high points of system and determine if all are installed and operating
10 freely (automatic type), or bleed air completely (manual type).
11 5. Set temperature controls so all coils are calling for full flow.
12 6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers,
13 cooling towers, to specified values.
14 7. Verify lubrication of motors and bearings.

15 **3.9 FIELD QUALITY CONTROL**

- 16 A. Prepare hydronic piping in accordance with ASME B31.9 and as follows:

- 17 1. Leave joints, including welds, uninsulated and exposed for examination during test.
18 2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test
19 pressure. If temporary restraints are impractical, isolate expansion joints from testing.
20 3. Flush hydronic piping systems with clean water; then remove and clean or replace
21 strainer screens.
22 4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure is to be
23 capable of sealing against test pressure without damage to valve. Install blinds in flanged
24 joints to isolate equipment.
25 5. Install pressure-relief valve, set at a pressure no more than one-third higher than test
26 pressure, to protect against damage by expanding liquid or other source of overpressure
27 during test.

- 28 B. Perform the following tests on hydronic piping:

- 29 1. Use ambient-temperature water as a testing medium unless there is risk of damage due
30 to freezing. Another liquid that is safe for workers and compatible with piping may be
31 used.
32 2. While filling system, use vents installed at high points of system to release air. Use drains
33 installed at low points for complete draining of test liquid.
34 3. Isolate expansion tanks and determine that hydronic system is full of water.
35 4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the
36 system's working pressure. Test pressure is not to exceed maximum pressure for any
37 vessel, pump, valve, or other component in system under test. Verify that stress due to
38 pressure at bottom of vertical runs does not exceed 90 percent of specified minimum
39 yield strength or 1.7 times the "SE" value in Appendix A in ASME B31.9.
40 5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping,
41 joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing
42 components, and repeat hydrostatic test until there are no leaks.
43 6. Prepare written report of testing.

1 **END OF SECTION 23 21 13.12**

1 **SECTION 23 21 16 - HYDRONIC PIPING SPECIALTIES**

2 **PART 1 - GENERAL**

3 **1.1 SUMMARY**

4 A. Section Includes:

- 5 1. Hydronic specialty valves.
- 6 2. Hydronic coil packages.
- 7 3. Air vents.
- 8 4. Strainers.

9 B. Related Requirements:

- 10 1. Division 22 for specification and installation requirements for domestic water specialties common to makeup water piping systems.
- 11 2. Division 23 for specification and installation requirements for general duty valves and expansion fittings common to most piping systems.
- 12 3. Division 25 for specification and installation requirements for automatic control valves.

15 **1.2 ACTION SUBMITTALS**

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

- 17 1. Include construction details and material descriptions for hydronic piping specialties.
- 18 2. Include rated capacities, operating characteristics, and furnished specialties and accessories.
- 19 3. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.

22 **1.3 CLOSEOUT SUBMITTALS**

- 23 A. Operation and Maintenance Data: For hydronic piping specialties to include in emergency, operation, and maintenance manuals.

25 **1.4 MAINTENANCE MATERIAL SUBMITTALS**

- 26 A. Differential Pressure Meter: For each type of balancing valve and automatic flow control valve, include flowmeter, probes, hoses, flow charts, and carrying case.

28 **1.5 QUALITY ASSURANCE**

- 29 A. Pipe Welding: Qualify procedures and operators in accordance with ASME BPVC, Section IX.
- 30 B. Pressure-relief and safety-relief valves and pressure vessels bear the appropriate ASME label.
- 31 Fabricate and stamp air separators and expansion tanks to comply with ASME BPVC,
- 32 Section VIII, Division 1.

1 **PART 2 - PRODUCTS**

2 **2.1 HYDRONIC SPECIALTY VALVES**

3 A. Bronze, Calibrated-Orifice, Balancing Valves:

- 4 1. Basis-of-Design Product: Subject to compliance with requirements, provide Taco Comfort
 5 Solutions; Accu-Flo or a comparable product by one of the following:
- 6 a. Bell & Gossett; a Xylem brand.
 7 b. Griswold Controls, LLC.
- 8 2. Body: Bronze, ball or plug type with calibrated orifice or venturi.
 9 3. Ball: Brass or stainless steel.
 10 4. Plug: Resin.
 11 5. Seat: PTFE.
 12 6. End Connections: Threaded or socket.
 13 7. Pressure Gauge Connections: Integral seals for portable differential pressure meter.
 14 8. Handle Style: Lever, with memory stop to retain set position.
 15 9. CWP Rating: Minimum 125 psig (860 kPa).
 16 10. Maximum Operating Temperature: 250 deg F (121 deg C).

17 B. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:

- 18 1. Basis-of-Design Product: Subject to compliance with requirements, provide Bell & Gossett;
 19 CB or a comparable product by one of the following:
- 20 a. Taco Comfort Solutions; Accu-flo
 21 b. Watts; CSM-81-F.
 22 c. Wheatley; PSV
- 23 2. Body: Cast-iron or steel body, ball, butterfly, plug, or globe pattern with calibrated orifice or
 24 venturi.
 25 3. Ball: Brass or stainless steel.
 26 4. Stem Seals: EPDM O-rings.
 27 5. Disc: Glass- and carbon-filled PTFE.
 28 6. Seat: PTFE.
 29 7. End Connections: Flanged or grooved.
 30 8. Pressure Gauge Connections: Integral seals for portable differential pressure meter.
 31 9. Handle Style: Lever, with memory stop to retain set position.
 32 10. CWP Rating: Minimum 125 psig (860 kPa).
 33 11. Maximum Operating Temperature: 250 deg F (121 deg C).

34 C. Automatic Flow-Control Valves:

- 35 1. Basis-of-Design Product: Subject to compliance with requirements, provide FlowCon
 36 International; ABV (NPS 1-1/2 and smaller) and SH (NPS 2 and smaller) or a comparable
 37 product by one of the following:
- 38 a. Bell & Gossett; a Xylem brand.
 39 b. Griswold Controls, LLC.
- 40 2. Body: Brass or ferrous metal.
 41 3. Dual pressure / temperature test plugs across flow control cartridge.

- 1 4. External adjustable flow control cartridge.
- 2 5. Combination Assemblies: Include bronze or brass-alloy ball valve.
- 3 6. Identification Tag: Marked with zone identification, valve number, and flow rate.
- 4 7. Size and Capacity: For each application, provide a valve with rated capacity equal to or
- 5 greater than capacity of device being served.
- 6 8. Performance: Maintain constant flow within plus or minus 10 percent, regardless of system
- 7 pressure fluctuations.
- 8 9. Minimum CWP Rating: 175 psig (1207 kPa).
- 9 10. Maximum Operating Temperature: 250 deg F (121 deg C).

10 2.2 HYDRONIC COIL PACKAGES

11 A. Combination Strainer / Isolation Ball Valve:

- 12 1. Body: Forged or cast brass.
- 13 2. Connections: Threaded with union inlet.
- 14 3. Combination Assemblies: Include bronze ball valve, union and strainer.
- 15 4. Strainer: 20 mesh stainless steel; provide drain valve with hose bibb adaptor and cap on
- 16 strainer port. Provide a pressure/temperature test plug at the strainer inlet and outlet.
- 17 5. Valve: Bronze ball valve with stainless-steel trim.
- 18 6. Size: NPS 2 (DN 50) and smaller.
- 19 7. Minimum CWP Rating: 275 psig (1896 kPa).
- 20 8. Maximum Operating Temperature: 250 deg F (121 deg C).

21 B. Combination Union / Isolation Ball Valve:

- 22 1. Body: Forged or cast brass.
- 23 2. Connections: Threaded with union inlet.
- 24 3. Combination Assemblies: Include bronze ball valve and union.
- 25 4. Union: Provide union with four 1/4-inch body tappings with brass end connections. Union
- 26 seal shall be EPDM O-rings. Provide an automatic air vent in the top tapping and a
- 27 pressure / temperature test plug.
- 28 5. Valve: Bronze ball valve with stainless-steel trim.
- 29 6. Size: NPS 2 (DN 50) and smaller.
- 30 7. Minimum CWP Rating: 275 psig (1896 kPa).
- 31 8. Maximum Operating Temperature: 250 deg F (121 deg C).

32 C. Isolation Union:

- 33 1. Body: Forged or cast brass.
- 34 2. Connections: Threaded.
- 35 3. Union: Provide union with four 1/4-inch body tappings with brass end connections. Union
- 36 seal shall be EPDM O-rings. Provide a pressure/temperature test plug.
- 37 4. Size: NPS 2 (DN 50) and smaller.
- 38 5. Minimum CWP Rating: 275 psig (1896 kPa).
- 39 6. Maximum Operating Temperature: 250 deg F (121 deg C).

40 D. Stainless Steel, Flexible Connectors:

- 41 1. Body: Flame retardant, flexible, stainless steel braided hose with EPDM core.
- 42 2. End Connections: Threaded to match equipment connected.
- 43 3. Performance: Capable of 3/4-inch (20-mm) misalignment.
- 44 4. CWP Rating: 150 psig (1035 kPa).
- 45 5. Maximum Operating Temperature: 250 deg F (121 deg C).

1 **2.3 AIR VENTS**

2 A. Manual Air Vents:

- 3 1. Body: Bronze.
- 4 2. Internal Parts: Nonferrous.
- 5 3. Operator: Screwdriver or thumbscrew.
- 6 4. Inlet Connection: NPS 1/2 (DN 15).
- 7 5. Discharge Connection: NPS 1/8 (DN 6).
- 8 6. CWP Rating: 150 psig (1035 kPa).
- 9 7. Maximum Operating Temperature: 225 deg F (107 deg C).

10 B. Automatic Air Vents:

- 11 1. Body: Bronze or cast iron.
- 12 2. Internal Parts: Nonferrous.
- 13 3. Operator: Noncorrosive metal float.
- 14 4. Inlet Connection: NPS 1/2 (DN 15).
- 15 5. Discharge Connection: NPS 1/4 (DN 8).
- 16 6. CWP Rating: 150 psig (1035 kPa).
- 17 7. Maximum Operating Temperature: 240 deg F (116 deg C).

18 **2.4 STRAINERS**

19 A. Y-Pattern Strainers:

- 20 1. Body: ASTM A126, Class B, cast iron with bolted cover and bottom drain connection.
- 21 2. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
- 22 3. Strainer Screen: Stainless steel, 20-mesh strainer, or perforated stainless steel basket.
- 23 4. CWP Rating: 125 psig (860 kPa).
- 24

25 **PART 3 - EXECUTION**

26 **3.1 EXAMINATION**

- 27 A. Examine all piping specialties for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.
- 28
- 29
- 30 B. Examine threads on all devices for form and cleanliness.
- 31 C. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.
- 32
- 33
- 34 D. Do not attempt to repair defective piping specialties; replace with new devices. Remove defective piping specialties from site.
- 35

1 **3.2 INSTALLATION OF VALVES**

- 2 A. Install calibrated-orifice balancing valve at each branch connection to return main.
- 3 B. Install calibrated-orifice, balancing valve in the return pipe of each heating or cooling terminal.

4 **3.3 HYDRONIC SPECIALTIES INSTALLATION**

- 5 A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required
6 for system air venting.
- 7 B. Install automatic air vents at high points of system piping in mechanical equipment rooms only.
 - 8 1. Provide air outlet drain line full size of air outlet to floor drain or to other point indicated on
9 Drawings.
- 10 C. Install manual vents at heat-transfer coils and elsewhere as required for air venting.
- 11 D. Install air purgers in pump suction.
- 12 E. Install air/dirt separators in pump suction. Install blowdown piping with gate or full-port ball valve
13 full size of separator outlet; extend full size to nearest floor drain.
- 14 F. Install bladder-type expansion tanks on the floor.
- 15 G. Vent and purge air from hydronic system, and ensure that tank is properly charged with air to suit
16 system Project requirements.

17 **3.4 BALANCING VALVE SCHEDULE**

- 18 A. Coil Connections, NPS 2 (DN 50) and smaller, shall be the following (as indicated on the
19 Drawings):
 - 20 1. Bronze, Calibrated-Orifice, Balancing Valves
 - 21 2. Automatic Flow-Control Valves
- 22 B. Coil Connections, NPS 2-1/2 (DN 65) and larger, shall be the following (as indicated on the
23 Drawings):
 - 24 1. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves
 - 25 2. Automatic Flow-Control Valves

26 **3.5 HYDRONIC COIL PACKAGE SCHEDULE**

- 27 A. Coil Connections, NPS 2 (DN 50) and Smaller, where indicated on the Drawings:
 - 28 1. Combination Strainer / Isolation Ball Valve: Supply side of coil.
 - 29 2. Isolation Union: Return side of coil, on inlet side of control valve.
 - 30 3. Combination Union / Isolation Ball Valve: Return side of coil, on leaving side of control
31 valve.
 - 32 4. Stainless Steel, Flexible Connectors: Supply and return sides of coil.

1 **END OF SECTION 23 21 16**

1 **SECTION 23 23 00 - REFRIGERANT PIPING**



3 **PART 1 - GENERAL**

4 **1.1 RELATED DOCUMENTS**

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

7 **1.2 SUMMARY**

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

12 **1.3 ACTION SUBMITTALS**

- 13 A. Shop Drawings:
- 14 1. Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes;
15 flow capacities; valve arrangements and locations; slopes of horizontal runs; oil traps;
16 double risers; wall and floor penetrations; and equipment connection details.
 - 17 2. Show piping size and piping layout, including oil traps, double risers, specialties, and pipe
18 and tube sizes to accommodate, as a minimum, equipment provided, elevation difference
19 between compressor and evaporator, and length of piping to ensure proper operation and
20 compliance with warranties of connected equipment.
 - 21 3. Show interface and spatial relationships between piping and equipment.

22 **1.4 CLOSEOUT SUBMITTALS**

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

25 **1.5 QUALITY ASSURANCE**

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

1 **1.6 PRODUCT STORAGE AND HANDLING**

- 2 A. Store piping with end caps in place to ensure that piping interior and exterior are clean when
3 installed.

4 **PART 2 - PRODUCTS**

5 **2.1 PERFORMANCE REQUIREMENTS**

- 6 A. Line Test Pressure for Refrigerant R-410A:
- 7 1. Suction Lines for Air-Conditioning Applications: 300 psig (2068 kPa).
8 2. Suction Lines for Heat-Pump Applications: 535 psig (3689 kPa).
9 3. Hot-Gas and Liquid Lines: 535 psig (3689 kPa).

10 **2.2 COPPER TUBE AND FITTINGS**

- 11 A. Copper Tube: ASTM B 88, Type K or L (ASTM B 88M, Type A or B).
12 B. Wrought-Copper Fittings: ASME B16.22.
13 C. Wrought-Copper Unions: ASME B16.22.
14 D. Solder Filler Metals: ASTM B 32. Use 95-5 tin antimony or alloy HB solder to join copper socket
15 fittings on copper pipe.

16 **2.3 VALVES AND SPECIALTIES**

- 17 A. Service Valves:
18 1. Body: Forged brass with brass cap including key end to remove core.
19 2. Core: Removable ball-type check valve with stainless-steel spring.
20 3. Seat: Polytetrafluoroethylene.
21 4. End Connections: Copper spring.
22 5. Working Pressure Rating: 500 psig (3450 kPa).
- 23 B. Safety Relief Valves: Comply with 2010 ASME Boiler and Pressure Vessel Code; listed and
24 labeled by an NRTL.
25 1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
26 2. Piston, Closing Spring, and Seat Insert: Stainless steel.
27 3. Seat: Polytetrafluoroethylene.
28 4. End Connections: Threaded.
29 5. Working Pressure Rating: 400 psig (2760 kPa).
30 6. Maximum Operating Temperature: 240 deg F (116 deg C).
- 31 C. Thermostatic Expansion Valves: Comply with AHRI 750.
32 1. Body, Bonnet, and Seal Cap: Forged brass or steel.
33 2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
34 3. Packing and Gaskets: Non-asbestos.
35 4. Capillary and Bulb: Copper tubing filled with refrigerant charge.
36 5. Suction Temperature: 40 deg F (4.4 deg C).
37 6. Superheat: Adjustable.

- 1 7. Reverse-flow option (for heat-pump applications).
- 2 8. End Connections: Socket, flare, or threaded union.
- 3 9. Working Pressure Rating: 700 psig (4820 kPa).

- 4 D. Moisture/Liquid Indicators:
- 5 1. Body: Forged brass.
- 6 2. Window: Replaceable, clear, fused glass window with indicating element protected by
- 7 filter screen.
- 8 3. Indicator: Color coded to show moisture content in parts per million (ppm).
- 9 4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
- 10 5. End Connections: Socket or flare.
- 11 6. Working Pressure Rating: 500 psig (3450 kPa).
- 12 7. Maximum Operating Temperature: 240 deg F (116 deg C).

- 13 E. Replaceable-Core Filter Dryers: Comply with AHRI 730.
- 14 1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and
- 15 neoprene gaskets.
- 16 2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
- 17 3. Desiccant Media: Activated alumina or charcoal.
- 18 4. Designed for reverse flow (for heat-pump applications).
- 19 5. End Connections: Socket.
- 20 6. Access Ports: NPS 1/4 (DN 8) connections at entering and leaving sides for pressure
- 21 differential measurement.
- 22 7. Working Pressure Rating: 500 psig (3450 kPa).
- 23 8. Maximum Operating Temperature: 240 deg F (116 deg C).

24 **2.4 REFRIGERANTS**

- 25 A. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

26 **PART 3 - EXECUTION**

27 **3.1 PIPING APPLICATIONS FOR REFRIGERANT R-410A**

- 28 A. Suction Lines NPS 4 (DN 100) and Smaller for Conventional Air-Conditioning Applications:
- 29 Copper, Type L (B), drawn-temper tubing and wrought-copper fittings with soldered joints.

- 30 B. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications: Copper, Type L (B),
- 31 drawn-temper tubing and wrought-copper fittings with Alloy HB soldered joints.

- 32 C. Safety-Relief-Valve Discharge Piping: Copper, Type L (B), drawn-temper tubing and wrought-
- 33 copper fittings with Alloy HB soldered joints.

34 **3.2 VALVE AND SPECIALTY APPLICATIONS**

- 35 A. Install service valves for gage taps at inlet and outlet of hot-gas bypass valves and strainers if
- 36 they are not an integral part of valves and strainers.

- 37 B. Install solenoid valves upstream from each expansion valve and hot-gas bypass valve. Install
- 38 solenoid valves in horizontal lines with coil at top.

- 1 C. Install thermostatic expansion valves as close as possible to distributors on evaporators.
- 2 1. Install valve so diaphragm case is warmer than bulb.
- 3 2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do
- 4 not mount bulb in a trap or at bottom of the line.
- 5 3. If external equalizer lines are required, make connection where it will reflect suction-line
- 6 pressure at bulb location.
- 7 D. Install safety relief valves where required by 2010 ASME Boiler and Pressure Vessel Code.
- 8 Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.
- 9 E. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or
- 10 at the inlet of the evaporator coil capillary tube.
- 11 F. Install filter dryers in liquid line between compressor and thermostatic expansion valve.
- 12 G. Install receivers sized to accommodate pump-down charge.
- 13 H. Install flexible connectors at compressors.

14 3.3 PIPING INSTALLATION

- 15 A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping
- 16 systems; indicated locations and arrangements were used to size pipe and calculate friction
- 17 loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless
- 18 deviations to layout are approved on Shop Drawings.
- 19 B. Install refrigerant piping according to ASHRAE 15.
- 20 C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms
- 21 and service areas.
- 22 D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right
- 23 angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated
- 24 otherwise.
- 25 E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- 26 F. Install piping adjacent to machines to allow service and maintenance.
- 27 G. Install piping free of sags and bends.
- 28 H. Install fittings for changes in direction and branch connections.
- 29 I. Select system components with pressure rating equal to or greater than system operating
- 30 pressure.
- 31 J. Install piping as short and direct as possible, with a minimum number of joints, elbows, and
- 32 fittings.
- 33 K. Install refrigerant piping in protective conduit where installed belowground.
- 34 L. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical
- 35 injury.

- 1 M. Slope refrigerant piping as follows:
- 2 1. Install horizontal hot-gas discharge piping with a uniform slope downward away from
3 compressor.
- 4 2. Install horizontal suction lines with a uniform slope downward to compressor.
- 5 3. Liquid lines may be installed level.
- 6 N. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve
7 stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply
8 heat near expansion-valve bulb.
- 9 O. Install piping with adequate clearance between pipe and adjacent walls and hangers or between
10 pipes for insulation installation.
- 11 P. Identify refrigerant piping and valves according to Section 23 05 53 "Identification for HVAC
12 Piping and Equipment."
- 13 Q. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for
14 sleeves specified in Section 23 05 17 "Sleeves and Sleeve Seals for HVAC Piping."
- 15 R. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with
16 requirements for escutcheons specified in Section 23 05 18 "Escutcheons for HVAC Piping."

17 **3.4 PIPE JOINT CONSTRUCTION**

- 18 A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- 19 B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before
20 assembly.
- 21 C. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."

22 **3.5 INSTALLATION OF HANGERS AND SUPPORTS**

- 23 A. Comply with Section 23 05 29 "Hangers and Supports for HVAC Piping and Equipment" for
24 hangers, supports, and anchor devices.
- 25 B. Install the following pipe attachments:
26 1. Copper-clad hangers and supports for hangers and supports in direct contact with copper
27 pipe.
- 28 C. Install hangers for copper tubing, with maximum horizontal spacing and minimum rod
29 diameters, to comply with MSS-58, locally enforced codes, and authorities having jurisdiction
30 requirements, whichever are most stringent.
- 31 D. Support horizontal piping within 12 inches (300 mm) of each fitting.
- 32 E. Support vertical runs of copper tubing to comply with MSS-58, locally enforced codes, and
33 authorities having jurisdiction requirements, whichever are most stringent.

1 **3.6 FIELD QUALITY CONTROL**

2 A. Perform the following tests and inspections:

- 3 1. Comply with ASME B31.5, Chapter VI.
- 4 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.
- 5 3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in "Performance Requirements" Article.
- 6 a. Fill system with nitrogen to the required test pressure.
- 7 b. System shall maintain test pressure at the manifold gage throughout duration of test.
- 8 c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
- 9 d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

10 B. Prepare test and inspection reports.

11 **3.7 SYSTEM CHARGING**

12 A. Charge system using the following procedures:

- 13 1. Install core in filter dryers after leak test but before evacuation.
- 14 2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers (67 Pa). If vacuum holds for 12 hours, system is ready for charging.
- 15 3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig (14 kPa).
- 16 4. Charge system with a new filter-dryer core in charging line.

17 **3.8 ADJUSTING**

18 A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.

19 B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

20 C. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:

- 21 1. Open shutoff valves in condenser water circuit.
- 22 2. Verify that compressor oil level is correct.
- 23 3. Open compressor suction and discharge valves.
- 24 4. Open refrigerant valves except bypass valves that are used for other purposes.
- 25 5. Check open compressor-motor alignment and verify lubrication for motors and bearings.

26 D. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

27 **END OF SECTION 23 23 00**

1 **SECTION 23 25 13 - WATER TREATMENT FOR CLOSED-LOOP HYDRONIC SYSTEMS**

2 **PART 1 - GENERAL**

3 **1.1 RELATED DOCUMENTS**

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

6 **1.2 SUMMARY**

- 7 A. Section includes the following water treatment for closed-loop hydronic systems:
8 1. Chemicals.

9 **1.3 DEFINITIONS**

- 10 A. RO: Reverse osmosis.
- 11 B. TDS: Total dissolved solids consist of salts and other materials that combine with water as a
12 solution.
- 13 C. TSS: Total suspended solids include both organic and inorganic solids that are suspended in
14 the water. These solids may include silt, plankton, and industrial wastes.

15 **1.4 ACTION SUBMITTALS**

- 16 A. Product Data: Include rated capacities, operating characteristics, and furnished specialties and
17 accessories for the following products:
18 1. Chemical-treatment test equipment.
19 2. Chemical material safety data sheets.

20 **1.5 INFORMATIONAL SUBMITTALS**

- 21 A. Water-Analysis Provider Qualifications: Verification of experience and capability of HVAC water-
22 treatment service provider.
- 23 B. Field quality-control reports.
- 24 C. Water-Treatment Program: Written sequence of operation on an annual basis for the application
25 equipment required to achieve water quality defined in "Performance Requirements" Article.
- 26 D. Water Analysis: Illustrate water quality available at Project site.

1 **1.6 QUALITY ASSURANCE**

- 2 A. HVAC Water-Treatment Service Provider Qualifications: An experienced HVAC water-treatment
 3 service provider, capable of analyzing water qualities, installing water-treatment equipment, and
 4 applying water treatment as specified in this Section.

5 **PART 2 - PRODUCTS**

6 **2.1 PERFORMANCE REQUIREMENTS**

- 7 A. Provide all hardware, chemicals, and other material necessary to maintain HVAC water quality
 8 in all systems, as indicated in this Specification. Water quality for hydronic systems shall
 9 minimize corrosion, scale buildup, and biological growth for optimum efficiency of hydronic
 10 equipment without creating a hazard to operating personnel or the environment.

- 11 B. Base HVAC water treatment on quality of water available at Project site, hydronic system
 12 equipment material characteristics and functional performance characteristics, operating
 13 personnel capabilities, and requirements and guidelines of authorities having jurisdiction.

- 14 C. Closed hydronic systems, including hot-water heating below 250 deg F (120 deg C), chilled
 15 water, heat recovery water, and process cooling water shall have the following water qualities:

- 16 1. pH: Maintain a value within 9.0 to 10.5.
 17 2. "P" Alkalinity: Maintain a value within 100 to 500 ppm.
 18 3. Boron: Maintain a value within 100 to 200 ppm.
 19 4. Chemical Oxygen Demand: Maintain a maximum value of 100 ppm.
 20 5. Soluble Copper: Maintain a maximum value of 0.20 ppm.
 21 6. TSS: Maintain a maximum value of 10 ppm.
 22 7. Ammonia: Maintain a maximum value of 20 ppm.
 23 8. Free Caustic Alkalinity: Maintain a maximum value of 20 ppm.
 24 9. Scale Control: Provide softened water for initial fill and makeup. Where softened water is
 25 not used, provide sufficient scale inhibitors to prevent formation of scale and maintain all
 26 scale-forming material in solution.
 27 10. Dispersants: Provide sufficient dispersants to prevent sedimentation of fine particulate
 28 matter.
 29 11. Microbiological Limits:
 30 a. Total Aerobic Plate Count: Maintain a maximum value of 1000 organisms/mL.
 31 b. Total Anaerobic Plate Count: Maintain a maximum value of 100 organisms/mL.
 32 c. Nitrate Reducers: Maintain a maximum value of 100 organisms/mL.
 33 d. Sulfate Reducers: Maintain a maximum value of zero organisms/mL.
 34 e. Iron Bacteria: Maintain a maximum value of zero organisms/mL.

35 **2.2 CHEMICALS**

- 36 A. Chemicals shall be as recommended by water-treatment system manufacturer, compatible with
 37 piping system components and connected equipment, and able to attain water quality specified
 38 in "Performance Requirements" Article.

1 **PART 3 - EXECUTION**

2 **3.1 WATER ANALYSIS**

- 3 A. Perform an analysis of supply water to determine quality of water available at Project site.

4 **3.2 INSTALLATION**

- 5 A. Install water-testing equipment on wall near water-chemical-application equipment.

6 **3.3 PIPING CONNECTIONS**

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

- 9 B. Where installing piping adjacent to equipment, allow space for service and maintenance.

- 10 C. Make piping connections between HVAC water-treatment equipment and dissimilar-metal piping
11 with dielectric fittings. Dielectric fittings are specified in Section 23 21 13 "Hydronic Piping."

- 12 D. Install shutoff valves on HVAC water-treatment equipment inlet and outlet. Metal general-duty
13 valves are specified in:

- 14 1. Section 230523.12 "Ball Valves for HVAC Piping".
15 2. Section 230523.13 "Butterfly Valves for HVAC Piping".

- 16 E. Comply with requirements in Section 22 11 19 "Domestic Water Piping Specialties" for backflow
17 preventers required in makeup-water connections to potable-water systems.

18 **3.4 FIELD QUALITY CONTROL**

- 19 A. Perform tests and inspections with the assistance of a factory-authorized service representative.

- 20 B. Tests and Inspections:

- 21 1. Inspect field-assembled components and equipment installation, including piping and
22 electrical connections.

- 23 2. Inspect piping and equipment to determine that systems and equipment have been
24 cleaned, flushed, and filled with water, and are fully operational before introducing
25 chemicals for water-treatment system.

- 26 3. Place HVAC water-treatment system into operation and calibrate controls during the
27 preliminary phase of hydronic systems' startup procedures.

- 28 4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test
29 results are achieved.

- 30 5. Test for leaks and defects. If testing is performed in segments, submit separate report for
31 each test, complete with diagram of portion of piping tested.

- 32 6. Leave uncovered and unconcealed new, altered, extended, and replaced water piping
33 until it has been tested and approved. Expose work that has been covered or concealed
34 before it has been tested and approved.

- 1 7. Cap and subject piping to static water pressure of 50 psig (345 kPa) above operating
- 2 pressure, without exceeding pressure rating of piping system materials. Isolate test
- 3 source and allow test pressure to stand for four hours. Leaks and loss in test pressure
- 4 constitute defects.
- 5 8. Repair leaks and defects with new materials, and retest piping until no leaks exist.

- 6 C. Equipment will be considered defective if it does not pass tests and inspections.

- 7 D. Prepare test and inspection reports.

- 8 E. At six-week intervals following Substantial Completion, perform separate water analyses on
- 9 hydraulic systems to show that automatic chemical-feed systems are maintaining water quality
- 10 within performance requirements specified in this Section. Submit written reports of water
- 11 analysis, advising Owner of changes necessary to adhere to "Performance Requirements"
- 12 Article.

- 13 F. Comply with ASTM D3370 and with the following standards:

- 14 1. Silica: ASTM D859.
- 15 2. Acidity and Alkalinity: ASTM D1067.
- 16 3. Iron: ASTM D1068.
- 17 4. Water Hardness: ASTM D1126.

18 **3.5 MAINTENANCE SERVICE**

- 19 A. Scope of Maintenance Service: Provide chemicals and service program to maintain water
- 20 conditions required above, to inhibit corrosion and scale formation for hydronic piping and
- 21 equipment. Services and chemicals shall be provided for a period of one year from date of
- 22 Substantial Completion and shall include the following:

- 23 1. Initial water analysis and HVAC water-treatment recommendations.
- 24 2. Startup assistance for Contractor to flush the systems, clean with detergents, and initially
- 25 fill systems with required chemical treatment prior to operation.
- 26 3. Periodic field service and consultation.
- 27 4. Customer report charts and log sheets.
- 28 5. Laboratory technical analysis.
- 29 6. Analyses and reports of all chemical items concerning safety and compliance with
- 30 government regulations.

31 **3.6 DEMONSTRATION**

- 32 A. Engage a factory-authorized service representative to train Owner's maintenance personnel to
- 33 adjust, operate, and maintain HVAC water-treatment systems and equipment.

34 **END OF SECTION 23 25 13**

1 **SECTION 23 29 23 - VARIABLE-FREQUENCY MOTOR CONTROLLERS**

2 **PART 1 - GENERAL**

3 **1.1 RELATED DOCUMENTS**

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

6 **1.2 SUMMARY**

- 7 A. Section includes separately enclosed, pre-assembled, combination VFCs, rated 600 V and less,
8 for speed control of three-phase, squirrel-cage induction motors.

- 9 B. Related Sections:

- 10 1. Section 26 24 19 "Motor-Control Centers" for VFCs installed in motor-control centers.

11 **1.3 DEFINITIONS**

- 12 A. BAS: Building automation system.
- 13 B. CE: Conformance Europeene (European Compliance).
- 14 C. CPT: Control power transformer.
- 15 D. EMI: Electromagnetic interference.
- 16 E. IGBT: Insulated-gate bipolar transistor.
- 17 F. LAN: Local area network.
- 18 G. LED: Light-emitting diode.
- 19 H. MCP: Motor-circuit protector.
- 20 I. NC: Normally closed.
- 21 J. NO: Normally open.
- 22 K. OCPD: Overcurrent protective device.
- 23 L. PCC: Point of common coupling.
- 24 M. PID: Control action, proportional plus integral plus derivative.
- 25 N. PWM: Pulse-width modulated.
- 26 O. RFI: Radio-frequency interference.

- 1 P. TDD: Total demand (harmonic current) distortion.
- 2 Q. THD(V): Total harmonic voltage demand.
- 3 R. VFC: Variable-frequency motor controller.

4 **1.4 ACTION SUBMITTALS**

- 5 A. Product Data: For each type and rating of VFC indicated. Include features, performance,
6 electrical ratings, operating characteristics, shipping and operating weights, and furnished
7 specialties and accessories.
- 8 B. LEED Submittals:
 - 9 1. Product Data for Credit EA 5: For continuous metering equipment for energy
10 consumption.
 - 11 C. Shop Drawings: For each VFC indicated. Include dimensioned plans, elevations, and sections;
12 and conduit entry locations and sizes, mounting arrangements, and details, including required
13 clearances and service space around equipment.
 - 14 1. Show tabulations of installed devices, equipment features, and ratings. Include the
15 following:
 - 16 a. Each installed unit's type and details.
 - 17 b. Factory-installed devices.
 - 18 c. Enclosure types and details.
 - 19 d. Nameplate legends.
 - 20 e. Short-circuit current (withstand) rating of enclosed unit.
 - 21 f. Features, characteristics, ratings, and factory settings of each VFC and installed
22 devices.
 - 23 g. Specified modifications.
 - 24 2. Schematic and Connection Wiring Diagrams: For power, signal, and control wiring.

25 **1.5 INFORMATIONAL SUBMITTALS**

- 26 A. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required
27 working clearances, and required area above and around VFCs. Show VFC layout and
28 relationships between electrical components and adjacent structural and mechanical elements.
29 Show support locations, type of support, and weight on each support. Indicate field
30 measurements.
- 31 B. Qualification Data: For qualified testing agency.
- 32 C. Product Certificates: For each VFC, from manufacturer.
- 33 D. Harmonic Analysis Study and Report: Comply with IEEE 399 and NETA Acceptance Testing
34 Specification; identify the effects of nonlinear loads and their associated harmonic contributions
35 on the voltages and currents throughout the electrical system. Analyze possible operating
36 scenarios, including recommendations for VFC input filtering to limit TDD and THD(V) at each
37 VFC to specified levels.

- 1 E. Source quality-control reports.
- 2 F. Field quality-control reports.
- 3 G. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have
4 been installed and arrange to demonstrate that switch settings for motor-running overload
5 protection suit actual motors to be protected.

6 **1.6 CLOSEOUT SUBMITTALS**

- 7 A. Operation and Maintenance Data: For VFCs to include in emergency, operation, and
8 maintenance manuals. In addition to items specified in Section 01 78 23 "Operation and
9 Maintenance Data," include the following:
 - 10 1. Manufacturer's written instructions for testing and adjusting thermal-magnetic circuit
11 breaker and MCP trip settings.
 - 12 2. Manufacturer's written instructions for setting field-adjustable overload relays.
 - 13 3. Manufacturer's written instructions for testing, adjusting, and reprogramming
14 microprocessor control modules.
 - 15 4. Manufacturer's written instructions for setting field-adjustable timers, controls, and status
16 and alarm points.

17 **1.7 MAINTENANCE MATERIAL SUBMITTALS**

- 18 A. Furnish extra materials described below that match products installed and that are packaged
19 with protective covering for storage and identified with labels describing contents.
 - 20 1. Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no
21 fewer than three of each size and type.
 - 22 2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type,
23 but no fewer than two of each size and type.
 - 24 3. Indicating Lights: Two of each type and color installed.
 - 25 4. Auxiliary Contacts: Furnish one spare(s) for each size and type of magnetic controller
26 installed.
 - 27 5. Power Contacts: Furnish three spares for each size and type of magnetic contactor
28 installed.

29 **1.8 QUALITY ASSURANCE**

- 30 A. Testing Agency Qualifications: Member company of NETA or an NRTL.
 - 31 1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site
32 testing.
- 33 B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70,
34 by a qualified testing agency, and marked for intended location and application.
- 35 C. Comply with NFPA 70.
- 36 D. IEEE Compliance: Fabricate and test VFC according to IEEE 344 to withstand seismic forces
37 defined in Section 26 05 48 "Vibration and Seismic Controls for Electrical Systems."

1 **1.9 DELIVERY, STORAGE, AND HANDLING**

- 2 A. Store in space that is enclosed, air conditioned and free of construction born debris and dust.
- 3 B. If stored in space that is not permanently enclosed and air conditioned, remove loose packing
4 and flammable materials from inside controllers and connect factory-installed space heaters to
5 temporary electrical service.

6 **1.10 PROJECT CONDITIONS**

- 7 A. Environmental Limitations: Rate equipment for continuous operation, capable of driving full load
8 without derating, under the following conditions unless otherwise indicated:
- 9 1. Ambient Temperature: Not less than 14 deg F (minus 10 deg C) and not exceeding 104
10 deg F (40 deg C).
- 11 2. Ambient Storage Temperature: Not less than minus 4 deg F (minus 20 deg C) and not
12 exceeding 140 deg F (60 deg C)
- 13 3. Humidity: Less than 95 percent (noncondensing).
- 14 4. Altitude: Not exceeding 3300 feet (1005 m).
- 15 B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for VFCs,
16 including clearances between VFCs, and adjacent surfaces and other items.

17 **1.11 COORDINATION**

- 18 A. Coordinate features of motors, load characteristics, installed units, and accessory devices to be
19 compatible with the following:
- 20 1. Torque, speed, and horsepower requirements of the load.
- 21 2. Ratings and characteristics of supply circuit and required control sequence.
- 22 3. Ambient and environmental conditions of installation location.
- 23 B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-
24 bolt inserts into bases.

25 **1.12 WARRANTY**

- 26 A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or
27 replace VFCs that fail in materials or workmanship within specified warranty period.
- 28 1. Warranty Period: Five years from date of Substantial Completion.

29 **PART 2 - PRODUCTS**

30 **2.1 MANUFACTURED UNITS**

- 31 A. Basis-of-Design Product: Subject to compliance with requirements, provide ABB; ACH 550 or
32 comparable product by one of the following:
- 33 1. Danfoss Inc.; Danfoss Drives Div.

- 1 2. Siemens Energy & Automation, Inc.
- 2 3. Square D; a brand of Schneider Electric.
- 3 4. Yaskawa Electric America, Inc; Drives Division.

- 4 B. General Requirements for VFCs: Comply with NEMA ICS 7, NEMA ICS 61800-2, and
- 5 UL 508C.

- 6 C. Application: Variable torque.

- 7 D. VFC Description: Variable-frequency power converter (rectifier, dc bus, and IGBT, PWM
- 8 inverter) factory packaged in an enclosure, with integral disconnecting means and overcurrent
- 9 and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide
- 10 self-protection, protection, and variable-speed control of one or more three-phase induction
- 11 motors by adjusting output voltage and frequency.

- 12 1. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1,
- 13 Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."
- 14 2. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL
- 15 acceptable to authorities having jurisdiction.

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

- 18 F. Output Rating: Three-phase; 10 to 60 Hz, with voltage proportional to frequency throughout
- 19 voltage range ; maximum voltage equals input voltage.

- 20 G. Unit Operating Requirements:

- 21 1. Input AC Voltage Tolerance: Plus 10 and minus 15 percent of VFC input voltage rating.
- 22 2. Input AC Voltage Unbalance: Not exceeding 5 percent.
- 23 3. Input Frequency Tolerance: Plus or minus 3 percent of VFC frequency rating.
- 24 4. Minimum Efficiency: 97 percent at 60 Hz, full load.
- 25 5. Minimum Displacement Primary-Side Power Factor: 98 percent under any load or
- 26 speed condition.
- 27 6. Minimum Short-Circuit Current (Withstand) Rating: 100 kA.
- 28 7. Ambient Temperature Rating: Not less than 14 deg F (minus 10 deg C) and not
- 29 exceeding 104 deg F (40 deg C).
- 30 8. Ambient Storage Temperature Rating: Not less than minus 4 deg F (minus 20 deg C)
- 31 and not exceeding 140 deg F (60 deg C)
- 32 9. Humidity Rating: Less than 95 percent (noncondensing).
- 33 10. Altitude Rating: Not exceeding 3300 feet (1005 m).
- 34 11. Vibration Withstand: Comply with IEC 60068-2-6.
- 35 12. Overload Capability: 1.1 times the base load current for 60 seconds; minimum of 1.8
- 36 times the base load current for three seconds.
- 37 13. Starting Torque: Minimum 100 percent of rated torque from 3 to 60 Hz.
- 38 14. Speed Regulation: Plus or minus 0.1 percent.
- 39 15. Output Carrier Frequency: Selectable; 0.5 to 15 kHz.
- 40 16. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.

- 41 H. Inverter Logic: Microprocessor based, 32 bit, isolated from all power circuits.

- 42 I. Isolated Control Interface: Allows VFCs to follow remote-control signal over a minimum 40:1
- 43 speed range.

- 44 1. Signal: Electrical.

- 1 J. Internal Adjustability Capabilities:
- 2 1. Minimum Speed: 5 to 25 percent of maximum rpm.
- 3 2. Maximum Speed: 80 to 100 percent of maximum rpm.
- 4 3. Acceleration: 0.1 to 6,000 seconds.
- 5 4. Deceleration: 0.1 to 6,000 seconds.
- 6 5. Current Limit: 30 to minimum of 150 percent of maximum rating.
- 7 K. Self-Protection and Reliability Features:
- 8 1. Input transient protection by means of surge suppressors to provide three-phase
- 9 protection against damage from supply voltage surges 10 percent or more above nominal
- 10 line voltage.
- 11 2. Loss of Input Signal Protection: Selectable response strategy, including speed default to
- 12 a percent of the most recent speed, a preset speed, or stop; with alarm.
- 13 3. Under- and overvoltage trips.
- 14 4. Inverter overcurrent trips.
- 15 5. VFC and Motor Overload/Over-temperature Protection: Microprocessor-based thermal
- 16 protection system for monitoring VFCs and motor thermal characteristics, and for
- 17 providing VFC over-temperature and motor overload alarm and trip; settings selectable
- 18 via the keypad; NRTL approved.
- 19 6. Critical frequency rejection, with three selectable, adjustable deadbands.
- 20 7. Instantaneous line-to-line and line-to-ground overcurrent trips.
- 21 8. Loss-of-phase protection.
- 22 9. Reverse-phase protection.
- 23 10. Short-circuit protection.
- 24 11. Motor over-temperature fault.
- 25 L. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an
- 26 interruption and before shutting down for manual reset or fault correction; adjustable delay time
- 27 between restart attempts.
- 28 M. Bidirectional Auto-speed Search: Capable of starting VFC into rotating loads spinning in either
- 29 direction and returning motor to set speed in proper direction, without causing damage to drive,
- 30 motor, or load.
- 31 N. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the
- 32 minimum torque to ensure high-starting torque and increased torque at slow speeds.
- 33 O. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on
- 34 output frequency for temperature protection of self-cooled, fan-ventilated motors at slow
- 35 speeds.
- 36 P. Integral Input Disconnecting Means and OCPD: NEMA AB 1, instantaneous-trip circuit breaker
- 37 with pad-lockable, door-mounted handle mechanism.
- 38 1. Disconnect Rating: Not less than 115 percent of NFPA 70 motor full-load current rating
- 39 or VFC input current rating, whichever is larger.
- 40 2. Auxiliary contacts "a" and "b" arranged to activate with circuit-breaker handle.
- 41 3. NC alarm contact that operates only when circuit breaker has tripped.

42 **2.2 CONTROLS AND INDICATION**

- 43 A. Status Lights: Door-mounted LED indicators displaying the following conditions:

- 1 1. Power on.
- 2 2. Run.
- 3 3. Overvoltage.
- 4 4. Line fault.
- 5 5. Overcurrent.
- 6 6. External fault.

- 7 B. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and
- 8 plain-English language digital display; allows complete programming, program copying,
- 9 operating, monitoring, and diagnostic capability.

- 10 1. Keypad: In addition to required programming and control keys, include keys for HAND,
- 11 OFF, and AUTO modes.
- 12 2. Security Access: Provide electronic security access to controls through identification and
- 13 password with at least three levels of access: View only; view and operate; and view,
- 14 operate, and service.

- 15 a. Control Authority: Supports at least four conditions: Off, local manual control at
- 16 VFC, local automatic control at VFC, and automatic control through a remote
- 17 source.

- 18 C. Historical Logging Information and Displays:

- 19 1. Real-time clock with current time and date.
- 20 2. Running log of total power versus time.
- 21 3. Total run time.
- 22 4. Fault log, maintaining last four faults with time and date stamp for each.

- 23 D. Indicating Devices: Digital display mounted flush in VFC door and connected to display VFC
- 24 parameters including, but not limited to:

- 25 1. Output frequency (Hz).
- 26 2. Motor speed (rpm).
- 27 3. Motor status (running, stop, fault).
- 28 4. Motor current (amperes).
- 29 5. Motor torque (percent).
- 30 6. Fault or alarming status (code).
- 31 7. PID feedback signal (percent).
- 32 8. DC-link voltage (V dc).
- 33 9. Set point frequency (Hz).
- 34 10. Motor output voltage (V ac).

- 35 E. Control Signal Interfaces:

- 36 1. Electric Input Signal Interface:

- 37 a. A minimum of two programmable analog inputs: 0- to 10-V dc or 4- to 20-mA dc
- 38 Operator-selectable "x"- to "y"-mA dc .
- 39 b. A minimum of six multifunction programmable digital inputs.

- 40 2. Remote Signal Inputs: Capability to accept any of the following speed-setting input
- 41 signals from the BAS or other control systems:

- 42 a. 0- to 10-V dc.
- 43 b. 4- to 20-mA dc.

- 1 c. Potentiometer using up/down digital inputs.
- 2 3. Output Signal Interface: A minimum of one programmable analog output signal(s) (0- to
- 3 10-V dc or 4- to 20-mA dc operator-selectable "x"- to "y"-mA dc), which can be
- 4 configured for any of the following:
- 5 a. Output frequency (Hz).
- 6 b. Output current (load).
- 7 c. DC-link voltage (V dc).
- 8 d. Motor torque (percent).
- 9 e. Motor speed (rpm).
- 10 f. Set point frequency (Hz).
- 11 4. Remote Indication Interface: A minimum of two programmable dry-circuit relay outputs
- 12 (120-V ac, 1 A) for remote indication of the following:
- 13 a. Motor running.
- 14 b. Set point speed reached.
- 15 c. Fault and warning indication (over-temperature or overcurrent).
- 16 d. PID high- or low-speed limits reached.
- 17 F. PID Control Interface: Provides closed-loop set point, differential feedback control in response
- 18 to dual feedback signals. Allows for closed-loop control of fans and pumps for pressure, flow, or
- 19 temperature regulation.
- 20 1. Number of Loops: One .
- 21 G. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control,
- 22 and display VFC status and alarms and energy usage. Allows VFC to be used with an external
- 23 system within a multi-drop LAN configuration; settings retained within VFC's nonvolatile
- 24 memory.
- 25 1. Network Communications Ports: Ethernet and RS-422/485 .
- 26 2. Embedded BAS Protocols for Network Communications: ASHRAE 135 BACnet, ;
- 27 protocols accessible via the communications ports.

28 **2.3 LINE CONDITIONING AND FILTERING**

- 29 A. Input Line Conditioning: 3% DC Bus Reactor.

30 **2.4 EMI/RFI Filtering: CE marked; certify compliance with IEC 61800-3 for Category C2**

- 32 **2.4A. BYPASS SYSTEMS** Safely transfers motor between power converter output and bypass circuit,
- 33 manually, automatically, or both. Selector switches set modes and indicator lights indicate
- 34 mode selected. Unit is capable of stable operation (starting, stopping, and running) with motor
- 35 completely disconnected from power converter.
- 36 B. Bypass Mode: Field-selectable automatic or manual, allows local and remote transfer between
- 37 power converter and bypass contactor and retransfer, either via manual operator interface or
- 38 automatic control system feedback.

- 1 C. Bypass Controller: Three-contactor-style bypass allows motor operation via the power
 2 converter or the bypass controller; with input isolating switch and barrier arranged to isolate the
 3 power converter input and output and permit safe testing and troubleshooting of the power
 4 converter, both energized and de-energized, while motor is operating in bypass mode.
- 5 1. Bypass Contactor: Load-break, NEMA-rated contactor.
 6 2. Input and Output Isolating Contactors: Non-load-break, NEMA-rated contactors.
 7 3. Isolating Switch: Non-load-break switch arranged to isolate power converter and permit
 8 safe troubleshooting and testing of the power converter, both energized and de-
 9 energized, while motor is operating in bypass mode; pad-lockable, door-mounted handle
 10 mechanism.
- 11 D. Bypass Contactor Configuration: Reduced-voltage (autotransformer) type.
- 12 1. NORMAL/BYPASS selector switch.
 13 2. HAND/OFF/AUTO selector switch.
 14 3. NORMAL/TEST Selector Switch: Allows testing and adjusting of VFC while the motor is
 15 running in the bypass mode.
 16 4. Contactor Coils: Pressure-encapsulated type with coil transient suppressors.
- 17 a. Operating Voltage: Depending on contactor NEMA size and line-voltage rating,
 18 manufacturer's standard matching control power or line voltage.
 19 b. Power Contacts: Totally enclosed, double break, and silver-cadmium oxide;
 20 assembled to allow inspection and replacement without disturbing line or load
 21 wiring.
- 22 5. Control Circuits: 120 -V ac; obtained from integral CPT, with primary and secondary
 23 fuses , with CPT of sufficient capacity to operate all integral devices and remotely
 24 located pilot, indicating, and control devices.
- 25 a. CPT Spare Capacity: 100 VA.
- 26 6. Overload Relays: NEMA ICS 2.
- 27 a. Solid-State Overload Relays:
- 28 1) Switch or dial selectable for motor-running overload protection.
 29 2) Sensors in each phase.
 30 3) Class 10/20 selectable tripping characteristic selected to protect motor
 31 against voltage and current unbalance and single phasing.
 32 4) Class II ground-fault protection, with start and run delays to prevent
 33 nuisance trip on starting.
 34 5) Analog communication module.
- 35 b. NC isolated overload alarm contact.
 36 c. External overload reset push button.

37 2.5 OPTIONAL FEATURES

- 38 A. Sleep Function: Senses a minimal deviation of a feedback signal and stops the motor. On an
 39 increase in speed-command signal deviation, VFC resumes normal operation.
- 40 B. Communication Port: RS-232 port, USB 2.0 port, or equivalent connection capable of
 41 connecting a printer and a notebook computer.

1 **2.6 ENCLOSURES**

- 2 A. VFC Enclosures: NEMA 250, to comply with environmental conditions at installed location.
- 3 1. Dry and Clean Indoor Locations: Type 1 .
- 4 2. Outdoor Locations: Type 3R .
- 5 3. Other Wet or Damp Indoor Locations: Type 4 .
- 6 4. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids:
- 7 Type 12.
- 8 B. Plenum Rating: UL 1995; NRTL certification label on enclosure, clearly identifying VFC as
- 9 "Plenum Rated."

10 **2.7 ACCESSORIES**

- 11 A. General Requirements for Control-Circuit and Pilot Devices: NEMA ICS 5; factory installed in
- 12 VFC enclosure cover unless otherwise indicated.
- 13 1. Push Buttons, Pilot Lights, and Selector Switches: Standard-duty, type.
- 14 a. Push Buttons: Covered types; momentary.
- 15 b. Pilot Lights: LED types; ; push to test.
- 16 c. Selector Switches: Rotary type.
- 17 B. Phase-Failure, Phase-Reversal, and Under-voltage and Overvoltage Relays: Solid-state
- 18 sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable
- 19 under-voltage, overvoltage, and time-delay settings.
- 20 1. Current Transformers: Continuous current rating, basic impulse insulating level (BIL)
- 21 rating, burden, and accuracy class suitable for connected circuitry. Comply with
- 22 IEEE C57.13.
- 23 C. Breather and drain assemblies, to maintain interior pressure and release condensation in
- 24 NEMA 250, Type 4X enclosures installed outdoors or in unconditioned interior spaces subject to
- 25 humidity and temperature swings.
- 26 D. Space heaters, with NC auxiliary contacts, to mitigate condensation in NEMA 250, Type 4X
- 27 enclosures installed outdoors or in unconditioned interior spaces subject to humidity and
- 28 temperature swings.
- 29 E. Cooling Fan and Exhaust System: For NEMA 250, Type 1 ; UL 508 component recognized:
- 30 Supply fan, with stainless steel intake and exhaust grills and filters; 120 -V ac; obtained from
- 31 integral CPT .
- 32 F. Sun shields installed on fronts, sides, and tops of enclosures installed outdoors and subject to
- 33 direct and extended sun exposure.

34 **2.8 SOURCE QUALITY CONTROL**

- 35 A. Testing: Test and inspect VFCs according to requirements in NEMA ICS 61800-2 .
- 36 1. Test each VFC while connected to a motor that is comparable to that for which the VFC
- 37 is rated.

- 1 2. Verification of Performance: Rate VFCs according to operation of functions and features
- 2 specified.
- 3 B. VFCs will be considered defective if they do not pass tests and inspections.
- 4 C. Prepare test and inspection reports.

5 **PART 3 - EXECUTION**

6 **3.1 EXAMINATION**

- 7 A. Examine areas, surfaces, and substrates to receive VFCs, with Installer present, for compliance
- 8 with requirements for installation tolerances, and other conditions affecting performance.
- 9 B. Examine VFC before installation. Reject VFCs that are wet, moisture damaged, or mold
- 10 damaged.
- 11 C. Examine roughing-in for conduit systems to verify actual locations of conduit connections before
- 12 VFC installation.
- 13 D. Proceed with installation only after unsatisfactory conditions have been corrected.

14 **3.2 HARMONIC ANALYSIS STUDY**

- 15 A. Perform a harmonic analysis study to identify the effects of nonlinear loads and their associated
- 16 harmonic contributions on the voltages and currents throughout the electrical system. Analyze
- 17 possible operating scenarios, including recommendations for VFC input filtering to limit TDD
- 18 and THD(V) at each VFC to specified levels.
- 19 B. Prepare a harmonic analysis study and report complying with IEEE 399 and NETA Acceptance
- 20 Testing Specification.

21 **3.3 INSTALLATION**

- 22 A. Coordinate layout and installation of VFCs with other construction including conduit, piping,
- 23 equipment, and adjacent surfaces. Maintain required workspace clearances and required
- 24 clearances for equipment access doors and panels.
- 25 B. Wall-Mounting Controllers: Install VFCs on walls with tops at uniform height and with
- 26 disconnect operating handles not higher than 79 inches (2000 mm) above finished floor unless
- 27 otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel
- 28 channels bolted to wall. For controllers not on walls, provide freestanding racks complying with
- 29 Section 26 05 29 "Hangers and Supports for Electrical Systems."
- 30 C. Floor-Mounting Controllers: Install VFCs on 4-inch (100-mm) nominal thickness concrete base.
- 31 Comply with requirements for concrete base specified in Division 03.
- 32 1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise
- 33 indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of
- 34 concrete base.

- 1 2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete
- 2 base and anchor into structural concrete floor.
- 3 3. Place and secure anchorage devices. Use setting drawings, templates, diagrams,
- 4 instructions, and directions furnished with items to be embedded.
- 5 4. Install anchor bolts to elevations required for proper attachment to supported equipment.

- 6 D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and
- 7 temporary blocking of moving parts from enclosures and components.

- 8 E. Install fuses in control circuits if not factory installed. Comply with requirements in
- 9 Section 26 28 13 "Fuses."

- 10 F. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven
- 11 equipment.

- 12 G. Comply with NECA 1.

13 **3.4 IDENTIFICATION**

- 14 A. Identify VFCs, components, and control wiring. Comply with requirements for identification
- 15 specified in Section 230553 "Identification for HVAC Systems."

- 16 1. Identify field-installed conductors, interconnecting wiring, and components; provide
- 17 warning signs.
- 18 2. Label each VFC with engraved nameplate.
- 19 3. Label each enclosure-mounted control and pilot device.

- 20 B. Operating Instructions: Frame printed operating instructions for VFCs, including control
- 21 sequences and emergency procedures. Fabricate frame of finished metal, and cover
- 22 instructions with clear acrylic plastic. Mount on front of VFC units.

23 **3.5 CONTROL WIRING INSTALLATION**

- 24 A. Install wiring between VFCs and remote devices and facility's central-control system. Comply
- 25 with requirements in Section 26 05 23 "Control-Voltage Electrical Power Cables."

- 26 B. Bundle, train, and support wiring in enclosures.

- 27 C. Connect selector switches and other automatic control devices where applicable.

- 28 1. Connect selector switches to bypass only those manual- and automatic control devices
- 29 that have no safety functions when switches are in manual-control position.
- 30 2. Connect selector switches with control circuit in both manual and automatic positions for
- 31 safety-type control devices such as low- and high-pressure cutouts, high-temperature
- 32 cutouts, and motor overload protectors.

33 **3.6 FIELD QUALITY CONTROL**

- 34 A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

- 35 B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect,
- 36 test, and adjust components, assemblies, and equipment installations, including connections.

- 1 C. Perform tests and inspections.
- 2 1. Manufacturer's Field Service: Engage a factory-authorized service representative to
- 3 inspect components, assemblies, and equipment installations, including connections, and
- 4 to assist in testing.
- 5 D. Acceptance Testing Preparation:
- 6 1. Test insulation resistance for each VFC element, bus, component, connecting supply,
- 7 feeder, and control circuit.
- 8 2. Test continuity of each circuit.
- 9 E. Tests and Inspections:
- 10 1. Inspect VFC, wiring, components, connections, and equipment installation. Test and
- 11 adjust controllers, components, and equipment.
- 12 2. Test insulation resistance for each VFC element, component, connecting motor supply,
- 13 feeder, and control circuits.
- 14 3. Test continuity of each circuit.
- 15 4. Verify that voltages at VFC locations are within 10 percent of motor nameplate rated
- 16 voltages. If outside this range for any motor, notify Engineer before starting the
- 17 motor(s).
- 18 5. Test each motor for proper phase rotation.
- 19 6. Correct malfunctioning units on-site, where possible, and retest to demonstrate
- 20 compliance; otherwise, replace with new units and retest.
- 21 7. Test and adjust controls, remote monitoring, and safeties. Replace damaged and
- 22 malfunctioning controls and equipment.
- 23 F. VFCs will be considered defective if they do not pass tests and inspections.
- 24 G. Prepare test and inspection reports, including a certified report that identifies the VFC and
- 25 describes scanning results. Include notation of deficiencies detected, remedial action taken,
- 26 and observations made after remedial action.

27 **3.7 STARTUP SERVICE**

- 28 A. Engage a factory-authorized service representative to perform startup service.
- 29 1. Complete installation and startup checks according to manufacturer's written instructions.
- 30 2. Document all internal configurations in a report and submit to Engineer.

31 **3.8 ADJUSTING**

- 32 A. Program microprocessors for required operational sequences, status indications, alarms, event
- 33 recording, and display features. Clear events memory after final acceptance testing and prior to
- 34 Substantial Completion.
- 35 B. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay
- 36 pickup and trip ranges.
- 37 C. Adjust the trip settings of MCPs and thermal-magnetic circuit breakers with adjustable,
- 38 instantaneous trip elements. Initially adjust to six times the motor nameplate full-load amperes

1 and attempt to start motors several times, allowing for motor cool-down between starts. If
2 tripping occurs on motor inrush, adjust settings in increments until motors start without tripping.
3 Do not exceed eight times the motor full-load amperes (or 11 times for NEMA Premium Efficient
4 motors if required). Where these maximum settings do not allow starting of a motor, notify
5 Engineer before increasing settings.

6 D. Set the taps on reduced-voltage autotransformer controllers.

7 E. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573 "Overcurrent
8 Protective Device Coordination Study."

9 F. Set field-adjustable pressure switches.

10 **3.9 PROTECTION**

11 A. Replace VFCs whose interiors have been exposed to water or other liquids prior to Substantial
12 Completion.

13 **3.10 DEMONSTRATION**

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

16 **END OF SECTION 23 29 23**

1 **SECTION 23 31 13.11 - METAL DUCTS FOR GENERAL HVAC**

2 **PART 1 - GENERAL**

3 **1.1 RELATED DOCUMENTS**

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

6 **1.2 SUMMARY**

- 7 A. Section includes duct services for supply, return, outdoor air, and general exhaust
8 (ASHRAE 62.1, Class 1 and 2):

- 9 1. Single-wall rectangular ducts and fittings.
10 2. Double-wall rectangular ducts and fittings.
11 3. Single-wall round and flat-oval ducts and fittings.
12 4. Double-wall round and flat-oval ducts and fittings.
13 5. Sheet metal materials.
14 6. Duct liner.
15 7. Sealants and gaskets.
16 8. Hangers and supports.

17 **1.3 ACTION SUBMITTALS**

- 18 A. Product Data: For each type of the following products:

- 19 1. Liners and adhesives.
20 2. Sealants and gaskets.

- 21 B. Delegated-Design Submittal:

- 22 1. Sheet metal thicknesses.
23 2. Joint and seam construction and sealing.
24 3. Reinforcement details and spacing.
25 4. Materials, fabrication, assembly, and spacing of hangers and supports.

26 **1.4 INFORMATIONAL SUBMITTALS**

- 27 A. Coordination Drawings: Plans or BIM model, drawn to scale, on which the following items are
28 shown and coordinated with each other, using input from installers of the items involved:

- 29 1. Duct installation in congested spaces, indicating coordination with general construction,
30 building components, and other building services. Indicate proposed changes to duct
31 layout.
32 2. Suspended ceiling components.
33 3. Structural members to which duct will be attached.
34 4. Size and location of initial access modules for acoustical tile.
35 5. Penetrations of smoke barriers and fire-rated construction.

- 1 6. Items penetrating finished ceiling including the following:
- 2 a. Luminaires (Lighting fixtures).
- 3 b. Air outlets and inlets.
- 4 c. Speakers.
- 5 d. Sprinklers.
- 6 e. Access panels.
- 7 f. Perimeter moldings.
- 8 g. Fire alarm devices.
- 9 h. Lighting control devices.

10 **PART 2 - PRODUCTS**

11 **2.1 PERFORMANCE REQUIREMENTS**

- 12 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 with performance requirements and design criteria indicated in "Duct Schedule" Article.
- 13
- 14
- 15
- 16 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".
- 17
- 18
- 19 C. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in
- 20 ASHRAE 62.1.
- 21 D. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and
- 22 Equipment," and Section 7 - "Construction and System Startup."
- 23 E. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 -
- 24 "HVAC System Construction and Insulation."
- 25 F. Duct Dimensions: Unless otherwise indicated, all duct dimensions indicated on Drawings are
- 26 inside clear dimensions and do not include insulation or duct wall thickness.

27 **2.2 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS**

- 28 A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction
- 29 Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise
- 30 indicated.
- 31 1. Construct ducts of galvanized sheet steel unless otherwise indicated.
- 32 2. For ducts exposed to weather, comply with requirements per "Ductwork Exposed to
- 33 Weather" Article.
- 34 B. Transverse Joints: Fabricate joints in accordance with SMACNA's "HVAC Duct Construction
- 35 Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-
- 36 pressure class, applicable sealing requirements, materials involved, duct-support intervals, and
- 37 other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

- 1 1. For ducts with longest side less than 36 inches (914 mm), select joint types in
2 accordance with Figure 2-1.
- 3 2. For ducts with longest side 36 inches (914 mm) or greater, use flange joint connector
4 Type T-22, T-24, T-24A, T-25a, or T-25b. Factory-fabricated flanged duct connection
5 system may be used if submitted and approved by engineer of record.

- 6 C. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC
7 Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal
8 Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-
9 support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards -
10 Metal and Flexible." All longitudinal seams shall be Pittsburgh lock seams unless otherwise
11 specified for specific application.

- 12 D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types
13 and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and
14 Flexible," Ch. 4, "Fittings and Other Construction," for static-pressure class, applicable sealing
15 requirements, materials involved, duct-support intervals, and other provisions in SMACNA's
16 "HVAC Duct Construction Standards - Metal and Flexible."

17 **2.3 SINGLE-WALL ROUND AND FLAT-OVAL DUCTS AND FITTINGS**

- 18 A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction
19 Standards - Metal and Flexible," Ch. 3, "Round, Oval, and Flexible Duct," based on indicated
20 static-pressure class unless otherwise indicated.

- 21 1. Construct ducts of galvanized sheet steel unless otherwise indicated.
- 22 2. For ducts exposed to weather, comply with requirements per "Ductwork Exposed to
23 Weather" Article.

- 24 3. Basis-of-Design Product: Subject to compliance with requirements, provide SEMCO,
25 LLC; SEMCO Single-Wall Round Duct & Fittings or a comparable product by one of the
26 following:
 - 27 a. Crown Products Company, Inc.
 - 28 b. McGill AirFlow LLC.
 - 29 c. Sheet Metal Connectors, Inc.

- 30 B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the
31 round sides connecting the flat portions of the duct (minor dimension).

- 32 C. Transverse Joints: Select joint types and fabricate in accordance with SMACNA's "HVAC Duct
33 Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for
34 static-pressure class, applicable sealing requirements, materials involved, duct-support
35 intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and
36 Flexible."

- 37 1. Transverse Joints in Ducts Larger Than 60 (1524) Inches (mm) in Diameter: Flanged.

- 38 D. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC
39 Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal
40 Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-
41 support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards -
42 Metal and Flexible."

- 1 1. Fabricate round ducts larger than 90 inches (2286 mm) in diameter with butt-welded
- 2 longitudinal seams.
- 3 2. Fabricate flat-oval ducts larger than 72 inches (1830 mm) in width (major dimension) with
- 4 butt-welded longitudinal seams.

- 5 E. Tees and Laterals: Select types and fabricate in accordance with SMACNA's "HVAC Duct
- 6 Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and
- 7 Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials
- 8 involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction
- 9 Standards - Metal and Flexible."

10 **2.4 SHEET METAL MATERIALS**

- 11 A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards -
- 12 Metal and Flexible" for acceptable materials, material thicknesses, and duct construction
- 13 methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks,
- 14 roller marks, stains, discolorations, and other imperfections.

- 15 B. Galvanized Sheet Steel: Comply with ASTM A653/A653M.

- 16 1. Galvanized Coating Designation: G90 (Z275).
- 17 2. Finishes for Surfaces Exposed to View: Mill phosphatized.

- 18 C. Stainless-Steel Sheets: Comply with ASTM A480/A480M, Type 304 or 316, as indicated in
- 19 "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B,
- 20 No. 2D, No. 3, or No. 4 as indicated in "Duct Schedule" Article.

- 21 D. Reinforcement Shapes and Plates: ASTM A36/A36M, steel plates, shapes, and bars; black and
- 22 galvanized.

- 23 1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum
- 24 ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

- 25 E. Tie Rods: Galvanized steel, 1/4-inch- (6-mm-) minimum diameter for lengths 36 inches (900
- 26 mm) or less; 3/8-inch- (10-mm-) minimum diameter for lengths longer than 36 inches (900 mm).

27 **2.5 DUCT LINER**

- 28 A. Flexible Elastomeric Duct Liner: Preformed, cellular, closed-cell, sheet materials complying with
- 29 ASTM C534/C534M, Type II, Grade 1; and with NFPA 90A or NFPA 90B.
- 30 1. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum
- 31 smoke-developed index of 50 when tested in accordance with UL 723; certified by an
- 32 NRTL.
- 33 2. Liner Adhesive: As recommended by insulation manufacturer and complying with
- 34 NFPA 90A or NFPA 90B.

- 35 a. Adhesive shall have a VOC content of 80 g/L or less.
- 36 b. Adhesive shall comply with the testing and product requirements of the California
- 37 Department of Public Health's "Standard Method for the Testing and Evaluation of
- 38 Volatile Organic Chemical Emissions from Indoor Sources Using Environmental
- 39 Chambers."

- 40 B. Insulation Pins and Washers:

1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch (38-mm) galvanized carbon-steel washer.
 2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick galvanized steel; with beveled edge sized as required to hold insulation securely in place, but not less than 1-1/2 inches (38 mm) in diameter.
- C. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 7-11, "Flexible Duct Liner Installation."
1. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
 2. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
 3. Butt transverse joints without gaps, and coat joint with adhesive.
 4. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
 5. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.
 6. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm (12.7 m/s) or greater.
 7. Secure liner with mechanical fasteners 4 inches (100 mm) from corners and at intervals not exceeding 12 inches (300 mm) transversely; at 3 inches (75 mm) from transverse joints and at intervals not exceeding 18 inches (450 mm) longitudinally.
 8. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:
 - a. Fan discharges.
 - b. Intervals of lined duct preceding unlined duct.
 - c. Upstream edges of transverse joints in ducts where air velocities are higher than 2500 fpm (12.7 m/s) or where indicated.
 9. Secure insulation between perforated sheet metal inner duct of same thickness as specified for outer shell. Use mechanical fasteners that maintain inner duct at uniform distance from outer shell without compressing insulation.
 - a. Sheet Metal Inner Duct Perforations: 3/32-inch (2.4-mm) diameter, with an overall open area of 23 percent.
 10. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

2.6 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 in accordance with UL 723; certified by an NRTL.
- B. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.
3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10 inch wg (2500 Pa), positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

C. Solvent-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Base: Synthetic rubber resin.
3. Solvent: Toluene and heptane.
4. Solids Content: Minimum 60 percent.
5. Shore A Hardness: Minimum 60.
6. Water resistant.
7. Mold and mildew resistant.
8. Sealant shall have a VOC content of 420 g/L or less.
9. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
10. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive or negative.
11. Service: Indoor or outdoor.
12. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. Flanged Joint Sealant: Comply with ASTM C920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.
6. Sealant shall have a VOC content of 420 g/L or less.
7. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using 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 (0.14 L/s per sq. m at 250 Pa) and shall be rated for 10-inch wg (2500-Pa) static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

1 **2.7 HANGERS AND SUPPORTS**

- 2 A. Hanger Rods for Noncorrosive Environments: Galvanized-steel rods and nuts.
- 3 B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods
4 with threads painted with zinc-chromate primer after installation.
- 5 C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and
6 Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2,
7 "Minimum Hanger Sizes for Round Duct."
- 8 D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A603.
- 9 E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A492.
- 10 F. Steel Cable End Connections: Galvanized-steel assemblies with brackets, swivel, and bolts
11 designed for duct hanger service; with an automatic-locking and clamping device.
- 12 G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible
13 with duct materials.
- 14 H. Trapeze and Riser Supports:
- 15 1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.

16 **PART 3 - EXECUTION**

17 **3.1 DUCT INSTALLATION**

- 18 A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct
19 system. Indicated duct locations, configurations, and arrangements were used to size ducts and
20 calculate friction loss for air-handling equipment sizing and for other design considerations.
21 Install duct systems as indicated unless deviations to layout are approved on Shop Drawings
22 and coordination drawings.
- 23 B. Install ducts in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and
24 Flexible" unless otherwise indicated.
- 25 C. Install ducts in maximum practical lengths with fewest possible joints.
- 26 D. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for
27 branch connections.
- 28 E. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and
29 perpendicular to building lines.
- 30 F. Install ducts close to walls, overhead construction, columns, and other structural and permanent
31 enclosure elements of building.
- 32 G. Install ducts with a clearance of 1 inch (25 mm), plus allowance for insulation thickness.
- 33 H. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and
34 enclosures.

- 1 I. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed
2 to view, cover the opening between the partition and duct or duct insulation with sheet metal
3 flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2
4 inches (38 mm).
- 5 J. Install fire, combination fire/smoke, and smoke dampers where indicated on Drawings and as
6 required by code, and by local authorities having jurisdiction. Comply with requirements in
7 Section 23 33 00 "Air Duct Accessories" for fire and smoke dampers and specific installation
8 requirements of the damper UL listing.
- 9 K. Install heating coils, cooling coils, air filters, dampers, and all other duct-mounted accessories in
10 air ducts where indicated on Drawings.
- 11 L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials
12 both before and after installation.
- 13 M. Elbows: Use long-radius elbows wherever they fit.
- 14 1. Fabricate 90-degree rectangular mitered elbows to include turning vanes.
15 2. Fabricate 90-degree round elbows with a minimum of three segments for 12 inches (300
16 mm) and smaller and a minimum of five segments for 14 inches (350 mm) and larger.
- 17 N. Branch Connections: Use lateral or conical branch connections.

18 3.2 INSTALLATION OF EXPOSED DUCTWORK

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

29 3.3 DUCTWORK EXPOSED TO WEATHER

- 30 A. All external joints are to have secure watertight mechanical connections. Seal all openings to
31 provide weatherproof construction.
- 32 B. Construct ductwork to resist external loads of wind, snow, ice, and other effects of weather.
33 Provide necessary supporting structures.
- 34 C. Single Wall:
- 35 1. Ductwork shall be galvanized steel.

- 1 a. If duct outer surface is uninsulated, protect outer surface with suitable paint.
- 2 2. Where ducts have external insulation, provide weatherproof aluminum jacket. See
- 3 Section 23 07 13 "Duct Insulation."

4 **3.4 DUCT SEALING**

- 5 A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct
- 6 Schedule" Article in accordance with SMACNA's "HVAC Duct Construction Standards - Metal
- 7 and Flexible."
- 8 B. Seal ducts to Seal Class A in accordance with SMACNA's "HVAC Duct Construction Standards
- 9 - Metal and Flexible":

10 **3.5 HANGER AND SUPPORT INSTALLATION**

- 11 A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5,
- 12 "Hangers and Supports."
- 13 B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners
- 14 appropriate for construction materials to which hangers are being attached.
- 15 1. Where practical, install concrete inserts before placing concrete.
- 16 2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
- 17 3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for
- 18 slabs more than 4 inches (100 mm) thick.
- 19 4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for
- 20 slabs less than 4 inches (100 mm) thick.
- 21 5. Do not use powder-actuated concrete fasteners for seismic restraints.
- 22 C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and
- 23 Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2,
- 24 "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and
- 25 supports within 24 inches (610 mm) of each elbow and within 48 inches (1220 mm) of each
- 26 branch intersection.
- 27 D. Hangers Exposed to View: Threaded rod and angle or channel supports.
- 28 E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds,
- 29 bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16
- 30 feet (5 m).
- 31 F. Install upper attachments to structures. Select and size upper attachments with pull-out,
- 32 tension, and shear capacities appropriate for supported loads and building materials where
- 33 used.

34 **3.6 CONNECTIONS**

- 35 A. Make connections to equipment with flexible connectors complying with Section 23 33 00 "Air
- 36 Duct Accessories."

1 B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch,
 2 outlet and inlet, and terminal unit connections.

3 **3.7 PAINTING**

4 A. Paint interior of metal ducts that are visible through registers and grilles and that do not have
 5 duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer.

6 **3.8 FIELD QUALITY CONTROL**

7 A. Perform tests and inspections.

8 B. Leakage Tests:

- 9 1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for
 10 each test.
- 11 2. Test the following systems:

12 a. Ducts with a Pressure Class of 3-Inch wg (750 Pa) or Greater: Test representative
 13 duct sections, selected by Engineer from sections installed, totaling no less than
 14 25 percent of total installed duct area for each designated pressure class.

15 3. Disassemble, reassemble, and seal segments of systems to accommodate leakage
 16 testing and for compliance with test requirements.

17 4. Testing of each duct section is to be performed with access doors, coils, filters, dampers,
 18 and other duct-mounted devices in place as designed. No devices are to be removed or
 19 blanked off so as to reduce or prevent additional leakage.

20 5. Test for leaks before applying external insulation.

21 6. Conduct tests at static pressures equal to maximum design pressure of system or section
 22 being tested. If static-pressure classes are not indicated, test system at maximum system
 23 design pressure. Do not pressurize systems above maximum design operating pressure.

24 7. Give seven days' advance notice for testing.

25 C. Duct System Cleanliness Tests:

26 1. Visually inspect duct system to ensure that no visible contaminants are present.

27 2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness in
 28 accordance with "Description of Method 3 - NADCA Vacuum Test" in NADCA ACR,
 29 "Assessment, Cleaning and Restoration of HVAC Systems."

30 a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media
 31 shall not exceed 0.75 mg/100 sq. cm.

32 D. Duct system will be considered defective if it does not pass tests and inspections.

33 E. Prepare test and inspection reports.

34 **3.9 STARTUP**

35 A. Air Balance: Comply with requirements in Section 23 05 93 "Testing, Adjusting, and Balancing
 36 for HVAC."

1 **3.10 DUCT SCHEDULE**

2 A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:

3 1. Fabricate all ducts to achieve SMACNA pressure class, seal class, and leakage class as
4 indicated below.

5 B. Supply Ducts:

6 1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:

7 a. Pressure Class: Positive 2- (500)inch wg (Pa).

8 2. Ducts Connected to Air-Handling Units:

9 a. Pressure Class: Positive 3- (750)inch wg (Pa).

10 3. Ducts Connected to Equipment Not Listed Above:

11 a. Pressure Class: Positive 2- (500)inch wg (Pa).

12 C. Return Ducts:

13 1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:

14 a. Pressure Class: Positive or negative 2- (500)inch wg (Pa).

15 2. Ducts Connected to Air-Handling Units:

16 a. Pressure Class: Positive or negative 2- (500)inch wg (Pa).

17 3. Ducts Connected to Equipment Not Listed above:

18 a. Pressure Class: Positive or negative 2- (500)inch wg (Pa).

19 D. Exhaust Ducts:

20 1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:

21 a. Pressure Class: Negative 2- (500)inch wg (Pa).

22 2. Ducts Connected to Air-Handling Units:

23 a. Pressure Class: Positive or negative 3- (750)inch wg (Pa).

24 3. Ducts Connected to Equipment Not Listed above:

25 a. Pressure Class: Positive or negative 2- (500)inch wg (Pa).

26 E. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:

27 1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:

28 a. Pressure Class: Positive or negative 2- (500)inch wg (Pa).

- 1 2. Ducts Connected to Air-Handling Units:
- 2 a. Pressure Class: Positive or negative 2- (500)inch wg (Pa).
- 3 3. Ducts Connected to Equipment Not Listed Above:
- 4 a. Pressure Class: Positive or negative 2- (500)inch wg (Pa).
- 5 F. Intermediate Reinforcement:
- 6 1. Galvanized-Steel Ducts: Galvanized steel or carbon steel coated with zinc-chromate
- 7 primer.
- 8 2. Stainless-Steel Ducts:
- 9 a. Exposed to Airstream: Match duct material.
- 10 b. Not Exposed to Airstream: Match duct material.
- 11 G. Liner:
- 12 1. Supply-Air Ducts: Flexible elastomeric, 1 (25) inch(es) (mm) thick.
- 13 2. Return-Air Ducts: Flexible elastomeric, 1 (25) inch(es) (mm) thick.
- 14 3. Exhaust-Air Ducts: Flexible elastomeric ,1 (25) inch(es) (mm) thick.
- 15 4. Supply Fan Plenums: Flexible elastomeric,1 (25) inch(es) (mm) thick.
- 16 5. Return- and Exhaust-Fan Plenums: Flexible elastomeric,2 (51) inches (mm) thick.
- 17 6. Transfer Ducts: Flexible elastomeric,1 (25) inch(es) (mm) thick.
- 18 H. Elbow Configuration:
- 19 1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal
- 20 and Flexible," Figure 4-2, "Rectangular Elbows."
- 21 a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
- 22 b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
- 23 c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct
- 24 Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane
- 25 Runners," and Figure 4-4, "Vane Support in Elbows."
- 26 1) Mitered elbows are not permitted in Noise Critical Spaces.
- 27 2. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and
- 28 Flexible," Figure 3-4, "Round Duct Elbows."
- 29 a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's
- 30 "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered
- 31 Elbows." Elbows with less than 90-degree change of direction have proportionately
- 32 fewer segments.
- 33 b. Round Elbows, 12 (305) Inches (mm) and Smaller in Diameter: Stamped or
- 34 pleated.
- 35 c. Round Elbows, 14 (356) Inches (mm) and Larger in Diameter: Welded.
- 36 I. Branch Configuration:

- 1 1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal
2 and Flexible," Figure 4-6, "Branch Connection."
- 3 a. Rectangular Main to Rectangular Branch: 45-degree entry.
4 b. Rectangular Main to Round Branch: 45-degree entry.
- 5 2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards -
6 Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical
7 Tees." Saddle taps are permitted in existing duct.
- 8 a. Velocity 1000 fpm (5 m/s) or Lower: Conical tap.
9 b. Velocity 1000 to 1500 fpm (5 to 7.6 m/s): Conical tap.
10 c. Velocity 1500 fpm (7.6 m/s) or Higher: 45-degree lateral.

11 **END OF SECTION 23 31 13.11**

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1 **SECTION 23 31 13.12 - METAL DUCTS FOR COMMERCIAL KITCHEN EXHAUST**

2 **PART 1 - GENERAL**

3 **1.1 RELATED DOCUMENTS**

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

6 **1.2 SUMMARY**

- 7 A. Section includes duct services for exhausting Type 1 commercial kitchen grease hoods and
8 commercial dishwashers:

- 9 1. Single-wall rectangular ducts and fittings.
10 2. Single-wall round and flat-oval ducts and fittings.
11 3. Sheet metal materials.
12 4. Hangers and supports.

13 **1.3 DEFINITIONS**

- 14 A. OSHPD: Office of Statewide Health Planning and Development (State of California).

15 **1.4 ACTION SUBMITTALS**

- 16 A. Delegated-Design Submittal:
17 1. Sheet metal thicknesses.
18 2. Joint and seam construction and sealing.
19 3. Reinforcement details and spacing.
20 4. Materials, fabrication, assembly, and spacing of hangers and supports.

21 **1.5 INFORMATIONAL SUBMITTALS**

- 22 A. Coordination Drawings: Plans or BIM model, drawn to scale, on which the following items are
23 shown and coordinated with each other, using input from installers of the items involved:

- 24 1. Duct installation in congested spaces, indicating coordination with general construction,
25 building components, and other building services. Indicate proposed changes to duct
26 layout.
27 2. Suspended ceiling components.
28 3. Structural members to which duct will be attached.
29 4. Size and location of initial access modules for acoustical tile.
30 5. Penetrations of smoke barriers and fire-rated construction.
31 6. Items penetrating finished ceiling including the following:
32 a. Luminaires (Lighting fixtures).
33 b. Air outlets and inlets.

- 1 c. Speakers.
- 2 d. Sprinklers.
- 3 e. Access panels.
- 4 f. Perimeter moldings.
- 5 g. Fire alarm devices.
- 6 h. Lighting control devices.

7 **PART 2 - PRODUCTS**

8 **2.1 PERFORMANCE REQUIREMENTS**

- 9 A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint
10 construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC
11 Duct Construction Standards - Metal and Flexible" and with performance requirements and
12 design criteria indicated in "Duct Schedule" Article.
- 13 B. Structural Performance: Duct hangers and supports shall withstand the effects of gravity loads
14 and stresses within limits and under conditions described in SMACNA's "HVAC Duct
15 Construction Standards - Metal and Flexible".
- 16 C. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in
17 ASHRAE 62.1.
- 18 D. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and
19 Equipment," and Section 7 - "Construction and System Startup."
- 20 E. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 -
21 "HVAC System Construction and Insulation."
- 22 F. Duct Dimensions: Unless otherwise indicated, all duct dimensions indicated on Drawings are
23 inside clear dimensions and do not include insulation or duct wall thickness.

24 **2.2 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS**

- 25 A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction
26 Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise
27 indicated.
- 28 1. Construct ducts of galvanized sheet steel unless otherwise indicated.
- 29 2. For ducts exposed to weather, comply with requirements per "Ductwork Exposed to
30 Weather" Article.
- 31 B. Transverse Joints: Fabricate joints in accordance with SMACNA's "HVAC Duct Construction
32 Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-
33 pressure class, applicable sealing requirements, materials involved, duct-support intervals, and
34 other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- 35 1. For ducts with longest side less than 36 inches (914 mm), select joint types in
36 accordance with Figure 2-1.
- 37 2. For ducts with longest side 36 inches (914 mm) or greater, use flange joint connector
38 Type T-22, T-24, T-24A, T-25a, or T-25b. Factory-fabricated flanged duct connection
39 system may be used if submitted and approved by engineer of record.

- 1 3. Where specified for specific applications, all joints shall be welded.
- 2 C. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC
3 Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal
4 Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-
5 support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards -
6 Metal and Flexible." All longitudinal seams shall be Pittsburgh lock seams unless otherwise
7 specified for specific application.
- 8 1. Where specified for specific applications, all joints shall be welded.
- 9 D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types
10 and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and
11 Flexible," Ch. 4, "Fittings and Other Construction," for static-pressure class, applicable sealing
12 requirements, materials involved, duct-support intervals, and other provisions in SMACNA's
13 "HVAC Duct Construction Standards - Metal and Flexible."
- 14 **2.3 SINGLE-WALL ROUND AND FLAT-OVAL DUCTS AND FITTINGS**
- 15 A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction
16 Standards - Metal and Flexible," Ch. 3, "Round, Oval, and Flexible Duct," based on indicated
17 static-pressure class unless otherwise indicated.
- 18 1. Construct ducts of galvanized sheet steel unless otherwise indicated.
- 19 2. For ducts exposed to weather, comply with requirements per "Ductwork Exposed to
20 Weather" Article.
- 21 3. Basis-of-Design Product: Subject to compliance with requirements, provide SEMCO,
22 LLC; SEMCO Single-Wall Round Duct & Fittings or a comparable product by one of the
23 following:
- 24 a. Crown Products Company, Inc.
- 25 b. McGill AirFlow LLC.
- 26 c. Sheet Metal Connectors, Inc.
- 27 B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the
28 round sides connecting the flat portions of the duct (minor dimension).
- 29 C. Transverse Joints: Select joint types and fabricate in accordance with SMACNA's "HVAC Duct
30 Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for
31 static-pressure class, applicable sealing requirements, materials involved, duct-support
32 intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and
33 Flexible."
- 34 1. Transverse Joints in Ducts Larger Than 60 (1524) Inches (mm) in Diameter: Flanged.
- 35 D. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC
36 Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal
37 Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-
38 support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards -
39 Metal and Flexible."
- 40 1. Fabricate round ducts larger than 90 inches (2286 mm) in diameter with butt-welded
41 longitudinal seams.

1 2. Fabricate flat-oval ducts larger than 72 inches (1830 mm) in width (major dimension) with
2 butt-welded longitudinal seams.

3 E. Tees and Laterals: Select types and fabricate in accordance with SMACNA's "HVAC Duct
4 Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and
5 Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials
6 involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction
7 Standards - Metal and Flexible."

8 **2.4 SHEET METAL MATERIALS**

9 A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards -
10 Metal and Flexible" for acceptable materials, material thicknesses, and duct construction
11 methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks,
12 roller marks, stains, discolorations, and other imperfections.

13 B. Stainless-Steel Sheets: Comply with ASTM A480/A480M, Type 304 or 316, as indicated in
14 "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B,
15 No. 2D, No. 3, or No. 4 as indicated in "Duct Schedule" Article.

16 C. Reinforcement Shapes and Plates: ASTM A36/A36M, steel plates, shapes, and bars; black and
17 galvanized.

18 1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum
19 ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

20 D. Tie Rods: Galvanized steel, 1/4-inch- (6-mm-) minimum diameter for lengths 36 inches (900
21 mm) or less; 3/8-inch- (10-mm-) minimum diameter for lengths longer than 36 inches (900 mm).

22 **2.5 HANGERS AND SUPPORTS**

23 A. Hanger Rods for Noncorrosive Environments: Galvanized-steel rods and nuts.

24 B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods
25 with threads painted with zinc-chromate primer after installation.

26 C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and
27 Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2,
28 "Minimum Hanger Sizes for Round Duct."

29 D. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A492.

30 E. Steel Cable End Connections: Galvanized-steel assemblies with brackets, swivel, and bolts
31 designed for duct hanger service; with an automatic-locking and clamping device.

32 F. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible
33 with duct materials.

34 G. Trapeze and Riser Supports:
35 1. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.

1 **PART 3 - EXECUTION**

2 **3.1 DUCT INSTALLATION**

- 3 A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct
 4 system. Indicated duct locations, configurations, and arrangements were used to size ducts and
 5 calculate friction loss for air-handling equipment sizing and for other design considerations.
 6 Install duct systems as indicated unless deviations to layout are approved on Shop Drawings
 7 and coordination drawings.
- 8 B. Install ducts in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and
 9 Flexible" unless otherwise indicated.
- 10 C. Install ducts in maximum practical lengths with fewest possible joints.
- 11 D. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for
 12 branch connections.
- 13 E. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and
 14 perpendicular to building lines.
- 15 F. Install ducts close to walls, overhead construction, columns, and other structural and permanent
 16 enclosure elements of building.
- 17 G. Install ducts with a clearance of 1 inch (25 mm), plus allowance for insulation thickness.
- 18 H. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and
 19 enclosures.
- 20 I. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed
 21 to view, cover the opening between the partition and duct or duct insulation with sheet metal
 22 flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2
 23 inches (38 mm).
- 24 J. Install fire, combination fire/smoke, and smoke dampers where indicated on Drawings and as
 25 required by code, and by local authorities having jurisdiction. Comply with requirements in
 26 Section 23 33 00 "Air Duct Accessories" for fire and smoke dampers and specific installation
 27 requirements of the damper UL listing.
- 28 K. Install heating coils, cooling coils, air filters, dampers, and all other duct-mounted accessories in
 29 air ducts where indicated on Drawings.
- 30 L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials
 31 both before and after installation.
- 32 M. Elbows: Use long-radius elbows wherever they fit.
- 33 1. Fabricate 90-degree rectangular mitered elbows to include turning vanes.
 34 2. Fabricate 90-degree round elbows with a minimum of three segments for 12 inches (300
 35 mm) and smaller and a minimum of five segments for 14 inches (350 mm) and larger.
- 36 N. Branch Connections: Use lateral or conical branch connections.

1 **3.2 INSTALLATION OF EXPOSED DUCTWORK**

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

12 **3.3 ADDITIONAL INSTALLATION REQUIREMENTS FOR TYPE 1 COMMERCIAL KITCHEN**
13 **GREASE HOOD EXHAUST DUCT**

- 14 A. Install ducts in accordance with NFPA 96, "Ventilation Control and Fire Protection of
15 Commercial Cooking Operation"; SMACNA's "HVAC Duct Construction Standards - Metal and
16 Flexible"; and SMACNA's "Kitchen Ventilation Systems and Food Service Equipment
17 Fabrication and Installation Guidelines" unless otherwise indicated.
- 18 B. Install all ducts without dips and traps that may hold grease, and sloped a minimum of 2 percent
19 to drain grease back to the hood.
- 20 C. All ducts exposed to view shall be constructed of stainless steel as per "Duct Schedule" Article.
21 All ducts concealed from view shall be stainless steel as per "Duct Schedule" Article.
- 22 D. All joints and seams shall be welded and shall be telescoping, bell, or flange joint as per
23 NFPA 96.
- 24 E. Minimum Duct Thickness: No. 16 Ga (1.52mm)
- 25 F. Install fire-rated access panel assemblies at each change in direction and at maximum intervals
26 of 12 (3.7) feet (m) in horizontal ducts, and at every floor for vertical ducts, or as indicated on
27 Drawings.
- 28 G. Do not penetrate fire-rated assemblies except as allowed by applicable building codes and
29 authorities having jurisdiction.

30 **3.4 ADDITIONAL INSTALLATION REQUIREMENTS FOR EXHAUST DUCTS SERVING**
31 **COMMERCIAL DISHWASHERS AND OTHER HIGH-HUMIDITY LOCATIONS**

- 32 A. Install dishwasher exhaust ducts and other exhaust ducts from wet, high-humidity locations
33 without dips and traps that may hold water. Slope ducts a minimum of 2 percent back to
34 dishwasher or toward drain.
- 35 B. Provide a drain pocket at each low point and at the base of each riser with a 1-inch (25-
36 mm)trapped copper drain from each drain pocket to open site floor drain.

- 1 C. Minimize number of transverse seams.
- 2 D. Do not locate longitudinal seams on bottom of duct.
- 3 E. Minimum Duct Thickness: No. 16 Ga. (1.52mm)

4 **3.5 DUCTWORK EXPOSED TO WEATHER**

- 5 A. All external joints are to be welded. Seal all openings to provide weatherproof construction.
- 6 B. Construct ductwork to resist external loads of wind, snow, ice, and other effects of weather.
7 Provide necessary supporting structures.
- 8 C. Single Wall:
 - 9 1. Ductwork shall be Type 316 stainless steel
 - 10 2. Where ducts have external insulation, provide weatherproof aluminum jacket. See
11 Section 23 07 13 "Duct Insulation."

12 **3.6 DUCT SEALING**

- 13 A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct
14 Schedule" Article in accordance with SMACNA's "HVAC Duct Construction Standards - Metal
15 and Flexible."
- 16 B. Seal ducts to Seal Class A in accordance with SMACNA's "HVAC Duct Construction Standards
17 - Metal and Flexible":

18 **3.7 HANGER AND SUPPORT INSTALLATION**

- 19 A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5,
20 "Hangers and Supports."
- 21 B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners
22 appropriate for construction materials to which hangers are being attached.
 - 23 1. Where practical, install concrete inserts before placing concrete.
 - 24 2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
 - 25 3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for
26 slabs more than 4 inches (100 mm) thick.
 - 27 4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for
28 slabs less than 4 inches (100 mm) thick.
 - 29 5. Do not use powder-actuated concrete fasteners for seismic restraints.
- 30 C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and
31 Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2,
32 "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and
33 supports within 24 inches (610 mm) of each elbow and within 48 inches (1220 mm) of each
34 branch intersection.
- 35 D. Hangers Exposed to View: Threaded rod and angle or channel supports.

1 E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds,
 2 bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16
 3 feet (5 m).

4 F. Install upper attachments to structures. Select and size upper attachments with pull-out,
 5 tension, and shear capacities appropriate for supported loads and building materials where
 6 used.

7 **3.8 CONNECTIONS**

8 A. Make connections to equipment with flexible connectors complying with Section 23 33 00 "Air
 9 Duct Accessories."

10 B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch,
 11 outlet and inlet, and terminal unit connections.

12 **3.9 PAINTING**

13 A. Paint interior of metal ducts that are visible through registers and grilles and that do not have
 14 duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer.

15 **3.10 FIELD QUALITY CONTROL**

16 A. Perform tests and inspections.

17 B. Leakage Tests:

18 1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for
 19 each test.

20 2. Test the following systems:

21 a. Ducts with a Pressure Class of 3-Inch wg (750 Pa) or Greater: Test representative
 22 duct sections, selected by Engineer from sections installed, totaling no less than
 23 100 percent of total installed duct area for each designated pressure class.

24 3. Disassemble, reassemble, and seal segments of systems to accommodate leakage
 25 testing and for compliance with test requirements.

26 4. Testing of each duct section is to be performed with access doors, coils, filters, dampers,
 27 and other duct-mounted devices in place as designed. No devices are to be removed or
 28 blanked off so as to reduce or prevent additional leakage.

29 5. Test for leaks before applying external insulation.

30 6. Conduct tests at static pressures equal to maximum design pressure of system or section
 31 being tested. If static-pressure classes are not indicated, test system at maximum system
 32 design pressure. Do not pressurize systems above maximum design operating pressure.

33 7. Light test grease duct system in addition to above prescribed pressure test for engineer
 34 and AHJ.

35 8. Give seven days' advance notice for testing.

36 C. Duct System Cleanliness Tests:

37 1. Visually inspect duct system to ensure that no visible contaminants are present.

- 1 2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness in
- 2 accordance with "Description of Method 3 - NADCA Vacuum Test" in NADCA ACR,
- 3 "Assessment, Cleaning and Restoration of HVAC Systems."
- 4 a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media
- 5 shall not exceed 0.75 mg/100 sq. cm.
- 6 D. Duct system will be considered defective if it does not pass tests and inspections.
- 7 E. Prepare test and inspection reports.

8 **3.11 STARTUP**

- 9 A. Air Balance: Comply with requirements in Section 23 05 93 "Testing, Adjusting, and Balancing
- 10 for HVAC."

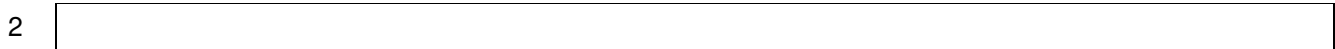
11 **3.12 DUCT SCHEDULE**

- 12 A. Fabricate ducts as follows:
- 13 1. Fabricate all ducts to achieve SMACNA pressure class, seal class, and leakage class as
- 14 indicated below.
- 15 B. Exhaust Ducts:
- 16 1. Ducts Connected to Commercial Kitchen Hoods: Comply with NFPA 96.
- 17 a. Exposed to View: Type 304, stainless-steel sheet, No. 4 finish.
- 18 b. Concealed: Type 304, stainless-steel sheet, No. 2D finish.
- 19 c. Minimum Duct Thickness: No. 16 Ga. (1.52mm)
- 20 d. Complete welded system.
- 21 e. Pressure Class: Positive or negative 4- (1000)inch wg (Pa).
- 22 f. Airtight/watertight.
- 23 2. Ducts Connected to Dishwashers, Dishwasher Hoods, and Other High-Humidity
- 24 Locations:
- 25 a. Type 304, stainless-steel sheet.
- 26 b. Exposed to View: No. 4 finish.
- 27 c. Concealed: No. 2D finish.
- 28 d. Minimum Duct Thickness: No. 16 Ga. (1.52mm)
- 29 e. Welded longitudinal seams; welded or flanged transverse joints with watertight
- 30 EPDM gaskets.
- 31 f. Pressure Class: Positive or negative 3- (750)inch wg (Pa).
- 32 g. Airtight/watertight.
- 33 C. Intermediate Reinforcement:
- 34 1. Stainless-Steel Ducts:
- 35 a. Exposed to Airstream: Match duct material.
- 36 b. Not Exposed to Airstream: Match duct material.

- 1 D. Elbow Configuration:
- 2 1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal
3 and Flexible," Figure 4-2, "Rectangular Elbows."
- 4 a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
- 5 b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
- 6 c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct
7 Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane
8 Runners," and Figure 4-4, "Vane Support in Elbows."
- 9 2. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and
10 Flexible," Figure 3-4, "Round Duct Elbows."
- 11 a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's
12 "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered
13 Elbows." Elbows with less than 90-degree change of direction have proportionately
14 fewer segments.
- 15 b. Round Elbows, 12 (305) Inches (mm) and Smaller in Diameter: Stamped or
16 pleated.
- 17 c. Round Elbows, 14 (356) Inches (mm) and Larger in Diameter: Welded.
- 18 E. Branch Configuration:
- 19 1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal
20 and Flexible," Figure 4-6, "Branch Connection."
- 21 a. Rectangular Main to Rectangular Branch: 45-degree entry.
- 22 b. Rectangular Main to Round Branch: 45-degree entry.
- 23 2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards -
24 Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical
25 Tees." Saddle taps are permitted in existing duct.
- 26 a. Velocity 1000 fpm (5 m/s) or Lower: Conical tap.
- 27 b. Velocity 1000 to 1500 fpm (5 to 7.6 m/s): Conical tap.
- 28 c. Velocity 1500 fpm (7.6 m/s) or Higher: 45-degree lateral.

29 **END OF SECTION 23 31 13.12**

1 **SECTION 23 33 00 - AIR DUCT ACCESSORIES**



3 **PART 1 - GENERAL**

4 **1.1 RELATED DOCUMENTS**

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

7 **1.2 SUMMARY**

8 A. Section Includes:

- 9 1. Backdraft and pressure relief dampers.
- 10 2. Manual volume dampers.
- 11 3. Control dampers.
- 12 4. Fire dampers.
- 13 5. Flange connectors.
- 14 6. Duct silencers.
- 15 7. Turning vanes.
- 16 8. Remote powered, manual balancing dampers.
- 17 9. Remote damper operators.
- 18 10. Duct-mounted access doors.
- 19 11. Flexible connectors.
- 20 12. Duct accessory hardware.

21 **1.3 ACTION SUBMITTALS**

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

- 23 1. For duct silencers, include pressure drop and dynamic insertion loss data. Include
24 breakout noise calculations for high transmission loss casings.

25 **1.4 INFORMATIONAL SUBMITTALS**

26 A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted
27 access panels and access doors required for access to duct accessories are shown and
28 coordinated with each other, using input from Installers of the items involved.

29 **1.5 CLOSEOUT SUBMITTALS**

30 A. Operation and Maintenance Data: For air duct accessories to include in operation and
31 maintenance manuals.

1 **PART 2 - PRODUCTS**

2 **2.1 ASSEMBLY DESCRIPTION**

- 3 A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with
4 NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."
- 5 B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for
6 acceptable materials, material thicknesses, and duct construction methods unless otherwise
7 indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains,
8 discolorations, and other imperfections.

9 **2.2 MATERIALS**

- 10 A. Galvanized Sheet Steel: Comply with ASTM A653/A653M.
- 11 1. Galvanized Coating Designation: G90 (Z275).
12 2. Exposed-Surface Finish: Mill phosphatized.
- 13 B. Stainless-Steel Sheets: Comply with ASTM A480/A480M, Type 304, and having a No. 2D finish
14 for concealed ducts and No. 2B finish for exposed ducts.
- 15 C. Aluminum Sheets: Comply with ASTM B209 (ASTM B209M), Alloy 3003, Temper H14; with mill
16 finish for concealed ducts and standard, 1-side bright finish for exposed ducts.
- 17 D. Extruded Aluminum: Comply with ASTM B221 (ASTM B221M), Alloy 6063, Temper T6.
- 18 E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on
19 galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.
- 20 F. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm)
21 or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

22 **2.3 BACKDRAFT AND PRESSURE RELIEF DAMPERS**

- 23 A. Basis-of-Design Product: Subject to compliance with requirements, provide Ruskin Company;
24 CBD4 or a comparable product by one of the following:
- 25 1. Greenheck Fan Corporation.
26 2. Nailor Industries Inc.
- 27 B. Description: Gravity balanced with adjustable counterweights.
- 28 C. Maximum Air Velocity: 2000 fpm (10 m/s).
- 29 D. Maximum System Pressure: 3-inch wg (0.8 kPa).
- 30 E. Frame: Hat-shaped, 0.063-inch- (1.6-mm-) thick extruded aluminum, with welded corners or
31 mechanically attached.
- 32 F. Blades: Multiple single-piece blades, end pivoted, maximum 6-inch (150-mm) width, 0.063-inch-
33 (1.6-mm-) thick extruded aluminum with sealed edges.

- 1 G. Blade Action: Parallel.
- 2 H. Blade Seals: Extruded vinyl, mechanically locked.
- 3 I. Blade Axles:
 - 4 1. Material: Nonmetallic.
 - 5 2. Diameter: 0.50 inch (13 mm).
- 6 J. Tie Bars and Brackets: Aluminum.
- 7 K. Return Spring: Adjustable tension.
- 8 L. Bearings: Steel ball.
- 9 M. Accessories:
 - 10 1. Adjustment device to permit setting for varying differential static pressure between 0.01-
 - 11 inch wg (0.003 kPa) and 0.05-inch wg (0.013 kPa).
 - 12 2. Counterweights and spring-assist kits for vertical airflow installations.
 - 13 3. 90-degree stops.

14 **2.4 MANUAL VOLUME DAMPERS**

- 15 A. Standard, Steel, Manual Volume Dampers:
 - 16 1. Basis-of-Design Product: Subject to compliance with requirements, provide Ruskin
 - 17 Company; MD35 (rectangular) and MDRS25 (round) or a comparable product by one of
 - 18 the following:
 - 19 a. Greenheck Fan Corporation.
 - 20 b. Nailor Industries Inc.
 - 21 2. Standard leakage rating, with linkage outside airstream.
 - 22 3. Suitable for horizontal or vertical applications.
 - 23 4. Frames:
 - 24 a. Frame: Hat-shaped, 0.064-inch- (1.2-mm-) thick, galvanized sheet steel.
 - 25 b. Mitered and welded corners.
 - 26 c. Flanges for attaching to walls and flangeless frames for installing in ducts.
 - 27 5. Blades:
 - 28 a. Multiple or single blade.
 - 29 b. Opposed-blade design.
 - 30 c. Stiffen damper blades for stability.
 - 31 d. Galvanized-steel, 0.064 inch (1.62 mm) thick.
 - 32 6. Blade Axles: Galvanized steel.
 - 33 7. Bearings:
 - 34 a. Molded synthetic.
 - 35 b. Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have
 - 36 axles full length of damper blades and bearings at both ends of operating shaft.

- 1 8. Tie Bars and Brackets: Galvanized steel.
- 2 B. Jackshaft:
- 3 1. Size: 1-inch (25-mm) diameter.
- 4 2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on
- 5 supports at each mullion and at each end of multiple-damper assemblies.
- 6 3. Length and Number of Mountings: As required to connect linkage of each damper in
- 7 multiple-damper assembly.
- 8 C. Damper Hardware:
- 9 1. Zinc-plated, die-cast core with dial and handle made of 3/32-inch- (2.4-mm-) thick zinc-
- 10 plated steel, and a 3/4-inch (19-mm) hexagon locking nut.
- 11 2. Include center hole to suit damper operating-rod size.
- 12 3. Include elevated platform for insulated duct mounting.
- 13 **2.5 CONTROL DAMPERS**
- 14 A. Basis-of-Design Product: Subject to compliance with requirements, provide Ruskin Company;
- 15 CD60 or a comparable product by one of the following:
- 16 1. Greenheck Fan Corporation.
- 17 2. Nailor Industries Inc.
- 18 B. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal
- 19 for both air performance and air leakage.
- 20 C. Frames:
- 21 1. Hat shaped.
- 22 2. 0.064-inch- (1.2-mm-) thick, galvanized sheet steel.
- 23 3. Mitered and welded corners.
- 24 D. Blades:
- 25 1. Multiple airfoil-shaped blades with maximum blade width of 6 inches (152 mm).
- 26 2. Opposed-blade design.
- 27 3. Galvanized-steel.
- 28 4. 0.0747-inch- (1.9-mm-) thick dual skin.
- 29 5. Blade Edging: Closed-cell neoprene.
- 30 6. Blade Edging: Inflatable seal blade edging, or replaceable rubber seals.
- 31 E. Blade Axles: 1/2-inch- (13-mm-) diameter; galvanized steel; blade-linkage hardware of zinc-
- 32 plated steel and brass; ends sealed against blade bearings.
- 33 1. Operating Temperature Range: From minus 40 to plus 200 deg F (minus 40 to plus 93
- 34 deg C).
- 35 F. Bearings:
- 36 1. Oil-impregnated stainless-steel sleeve.
- 37 2. Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have axles full
- 38 length of damper blades and bearings at both ends of operating shaft.

- 1 3. Thrust bearings at each end of every blade.
- 2 G. Damper Operators: Comply with requirements in Section 250923.12 "Control Damper
- 3 Accessories."

4 **2.6 FIRE DAMPERS**

- 5 A. Basis-of-Design Product: Subject to compliance with requirements, provide Ruskin Company;
- 6 IBD or a comparable product by one of the following:

- 7 1. Greenheck Fan Corporation.
- 8 2. Nailor Industries Inc.

- 9 B. Type: Static; rated and labeled according to UL 555 by an NRTL.

- 10 C. Fire Rating: 1-1/2 hours.

- 11 D. Frame: Curtain type with blades outside airstream except when located behind grille where
- 12 blades may be inside airstream; fabricated with roll-formed galvanized steel; with mitered and
- 13 interlocking corners; gauge in accordance with UL listing.

- 14 E. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel; gauge in accordance with
- 15 UL listing.

- 16 F. Mounting Orientation: Vertical or horizontal as indicated.

- 17 G. Blades: Roll-formed, interlocking, galvanized sheet steel; gauge in accordance with UL listing.

- 18 H. Horizontal Dampers: Include blade lock and stainless-steel closure spring.

- 19 I. Heat-Responsive Device: Replaceable, 165 deg F (74 deg C) rated, fusible links.

20 **2.7 FLANGE CONNECTORS**

- 21 A. Description: Add-on or roll-formed, factory-fabricated, slide-on transverse flange connectors,
- 22 gaskets, and components.

- 23 B. Material: Galvanized steel.

- 24 C. Gauge and Shape: Match connecting ductwork.

25 **2.8 DUCT SILENCERS**

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

- 28 1. Industrial Noise Control, Inc.
- 29 2. McGill AirFlow LLC.
- 30 3. Price Noise Control.
- 31 4. Vibro-Acoustics.

- 32 B. General Requirements:

- 1 1. Factory fabricated.
- 2 2. Fire-Performance Characteristics: Adhesives, sealants, packing materials, and accessory
- 3 materials shall have flame-spread index not exceeding 25 and smoke-developed index
- 4 not exceeding 50 when tested according to ASTM E84.
- 5 3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with
- 6 requirements in ASHRAE 62.1.

- 7 C. Rectangular Silencer Outer Casing: ASTM A653/A653M, G90 (Z275), galvanized sheet steel,
- 8 0.034 inch (0.85 mm) thick.

- 9 D. Round Silencer Outer Casing: ASTM A653/A653M, G90 (Z275), galvanized sheet steel.

- 10 1. Sheet Metal Thickness for Units up to 24 Inches (600 mm) in Diameter: 0.034 inch (0.85
- 11 mm) thick.
- 12 2. Sheet Metal Thickness for Units 26 through 40 Inches (660 through 1000 mm) in
- 13 Diameter: 0.040 inch (1.02 mm) thick.
- 14 3. Sheet Metal Thickness for Units 42 through 52 Inches (1060 through 1300 mm) in
- 15 Diameter: 0.05 inch (1.3 mm) thick.
- 16 4. Sheet Metal Thickness for Units 54 through 60 Inches (1370 through 1500 mm) in
- 17 Diameter: 0.064 inch (1.62 mm) thick.

- 18 E. Inner Casing and Baffles: ASTM A653/A653M, G90 (Z275) galvanized sheet metal, 0.034 inch
- 19 (0.85 mm) thick, and with 1/8-inch- (3-mm-) diameter perforations.

- 20 F. Special Construction:
- 21 1. High transmission loss to achieve STC 45.

- 22 G. Connection Sizes: Match connecting ductwork unless otherwise indicated.

- 23 H. Principal Sound-Absorbing Mechanism:
- 24 1. Controlled impedance membranes and broadly tuned resonators without absorptive
- 25 media.
- 26 2. Dissipative type with fill material.
- 27 a. Fill Material: Inert and vermin-proof fibrous material, packed under not less than 5
- 28 percent compression.

- 29 3. Lining: None.

- 30 I. Fabricate silencers to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to
- 31 system pressure variations. Do not use mechanical fasteners for unit assemblies.

- 32 1. Joints: Flanged connections.
- 33 2. Suspended Units: Factory-installed suspension hooks or lugs attached to frame in
- 34 quantities and spaced to prevent deflection or distortion.
- 35 3. Reinforcement: Cross or trapeze angles for rigid suspension.

- 36 J. Accessories:
- 37 1. Factory-installed end caps to prevent contamination during shipping.

- 38 K. Capacities and Characteristics:
- 39 1. Maximum Pressure Drop: [] 0.20-inch wg (0.05 kPa).

1 **2.9 TURNING VANES**

- 2 A. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support
 3 with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
- 4 1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated
 5 faces and fibrous-glass fill.
- 6 B. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal
 7 and Flexible"; Figures 4-3, "Vaness and Vane Runners," and 4-4, "Vane Support in Elbows."
- 8 C. Vane Construction: Single wall for ducts up to 48 inches (1200 mm) wide and double wall for
 9 larger dimensions.

10 **2.10 REMOTE POWERED, MANUAL BALANCING DAMPER**

- 11 A. Basis-of-Design Product: Subject to compliance with requirements, provide Ruskin ZPD15 (for
 12 square and rectangular ducts) and Ruskin ZPD25 (for round ducts) or comparable product by
 13 one of the following:
- 14 1. Greenheck Fan Corporation.
- 15 B. Description: Remote powered, manual balancing damper.
- 16 1. Standard leakage rating, with linkage outside airstream.
 17 2. Suitable up to pressures of 2-inch water column and velocities up to 2,000 fpm.
 18 3. Suitable for temperatures up to 120 degrees Fahrenheit.
 19 4. Suitable for horizontal or vertical applications.
- 20 C. Frames:
- 21 1. Frame: Hat-shaped, 0.034-inch thick, galvanized sheet steel.
 22 2. Mitered and welded corners.
 23 3. Flanges for attaching to walls and flangeless frames for installing in ducts.
- 24 D. Blades:
- 25 1. Multiple or single blade.
 26 2. Opposed-blade design.
 27 3. Stiffen damper blades for stability.
 28 4. Galvanized -steel, 0.037 inch thick.
- 29 E. Blade Axles: Galvanized steel.
- 30 F. Bearings: Molded synthetic.
- 31 G. Actuator:
- 32 1. 9-volt DC operated damper motor, powered by a remote 9-volt battery operated
 33 controller. Damper shall fail-in-place upon loss of power.
 34 2. Factory wired and tested, plenum rated, RJ11 cable terminating at the RJ11 damper
 35 motor on one end and RJ11 connector located in a wall or ceiling box on the other end.
 36 Provide sufficient length to extend from damper motor to wall box.

- 1 H. Controller (furnish one hand-held, remote damper positioned):
- 2 1. Portable, hand-held, 9-volt DC power supply and damper positioner, providing a pulse
- 3 signal to electronic zone pulse dampers.
- 4 2. DPDT switch (open-off-closed).
- 5 3. 6-foot long RJ11 cable with male connector.
- 6 I. Wall-Box Mounting: Recessed 1 or 2 gang.
- 7 J. Cover Plate; Stainless steel. 1 to 12 ports.
- 8 K. Tie Bars and Brackets: Galvanized steel.

9 **2.11 DUCT-MOUNTED ACCESS DOORS**

- 10 A. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct
- 11 Construction Standards - Metal and Flexible"; Figures 7-2 (7-2M), "Duct Access Doors and
- 12 Panels," and 7-3, "Access Doors - Round Duct."
- 13 1. Door:
- 14 a. Double wall, rectangular.
- 15 b. Galvanized sheet metal with insulation fill and thickness as indicated for duct
- 16 pressure class.
- 17 c. Hinges and Latches: 1-by-1-inch (25-by-25-mm) butt or piano hinge and cam
- 18 latches.
- 19 d. Fabricate doors airtight and suitable for duct pressure class.
- 20 2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
- 21 3. Number of Hinges and Locks:
- 22 a. Access Doors Less Than 12 Inches (300 mm) Square: No hinges and two sash
- 23 locks.
- 24 b. Access Doors up to 18 Inches (460 mm) Square: Two hinges and two sash locks.
- 25 c. Access Doors up to 24 by 48 Inches (600 by 1200 mm): Three hinges and two
- 26 compression latches with outside and inside handles.
- 27 d. Access Doors Larger Than 24 by 48 Inches (600 by 1200 mm): Four hinges and
- 28 two compression latches with outside and inside handles.

29 **2.12 DUCT ACCESS PANEL ASSEMBLIES**

- 30 A. Labeled according to UL 1978 by an NRTL.
- 31 B. Panel and Frame: Minimum thickness 0.0428-inch (1.1-mm) stainless steel.
- 32 C. Fasteners: Stainless steel. Panel fasteners shall not penetrate duct wall.
- 33 D. Gasket: Comply with NFPA 96; grease-tight, high-temperature ceramic fiber, rated for minimum
- 34 2000 deg F (1093 deg C).
- 35 E. Minimum Pressure Rating: 10-inch wg (2500 Pa), positive or negative.

1 **2.13 FLEXIBLE CONNECTORS**

- 2 A. Materials: Flame-retardant or noncombustible fabrics.
- 3 B. Coatings and Adhesives: Comply with UL 181, Class 1.
- 4 C. Metal-Edged Connectors: Factory fabricated with a fabric strip 5-3/4 inches (146 mm) wide
5 attached to two strips of 2-3/4-inch- (70-mm-) wide, 0.028-inch- (0.7-mm-) thick, galvanized
6 sheet steel or 0.032-inch- (0.8-mm-) thick aluminum sheets. Provide metal compatible with
7 connected ducts.
- 8 D. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
- 9 1. Minimum Weight: 26 oz./sq. yd. (880 g/sq. m).
10 2. Tensile Strength: 480 lbf/inch (84 N/mm) in the warp and 360 lbf/inch (63 N/mm) in the
11 filling.
12 3. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).
- 13 E. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof,
14 synthetic rubber resistant to UV rays and ozone.
- 15 1. Minimum Weight: 24 oz./sq. yd. (810 g/sq. m).
16 2. Tensile Strength: 530 lbf/inch (93 N/mm) in the warp and 440 lbf/inch (77 N/mm) in the
17 filling.
18 3. Service Temperature: Minus 50 to plus 250 deg F (Minus 45 to plus 121 deg C).
- 19 F. High-Temperature System, Flexible Connectors: Glass fabric coated with silicone rubber.
- 20 1. Minimum Weight: 16 oz./sq. yd. (542 g/sq. m).
21 2. Tensile Strength: 285 lbf/inch (50 N/mm) in the warp and 185 lbf/inch (32 N/mm) in the
22 filling.
23 3. Service Temperature: Minus 67 to plus 500 deg F (Minus 55 to plus 260 deg C).

24 **PART 3 - EXECUTION**

25 **3.1 COORDINATION OF WORK WITH OTHER TRADES**

- 26 A. Control Dampers:
- 27 1. Damper furnished and installed by Division 23.
28 2. Damper actuator furnished and installed by Division 25.

29 **3.2 INSTALLATION**

- 30 A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction
31 Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct
32 Construction Standards," for fibrous-glass ducts.
- 33 B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories
34 in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts,
35 and aluminum accessories in aluminum ducts.

- 1 C. Install backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to
2 exhaust fan unless otherwise indicated.
- 3 D. Install volume dampers at points on supply, return, and exhaust systems where branches
4 extend from larger ducts. Where dampers are installed in ducts having duct liner, install
5 dampers with hat channels of same depth as liner, and terminate liner with nosing at hat
6 channel.
- 7 1. Install steel volume dampers in steel ducts.
8 2. Install aluminum volume dampers in aluminum ducts.
- 9 E. Set dampers to fully open position before testing, adjusting, and balancing.
- 10 F. Install test holes at fan inlets and outlets and elsewhere as indicated.
- 11 G. Install fire and smoke dampers according to UL listing.
- 12 H. Connect ducts to duct silencers rigidly.
- 13 I. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining
14 accessories and equipment at the following locations:
- 15 1. On both sides of duct coils.
16 2. Upstream and downstream from duct filters.
17 3. At outdoor-air intakes and mixed-air plenums.
18 4. At drain pans and seals.
19 5. Downstream from manual volume dampers, control dampers, backdraft dampers, and
20 equipment.
21 6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links.
22 Access doors for access to fire or smoke dampers having fusible links shall be pressure
23 relief access doors and shall be outward operation for access doors installed upstream
24 from dampers and inward operation for access doors installed downstream from
25 dampers.
26 7. Upstream or downstream from duct silencers.
27 8. Downstream of air terminal units with reheat coils.
28 9. Control devices requiring inspection.
29 10. Elsewhere as indicated.
- 30 J. Install access doors with swing against duct static pressure.
- 31 K. Access Door Sizes:
- 32 1. One-Hand or Inspection Access: 8 by 5 inches (200 by 125 mm).
33 2. Two-Hand Access: 12 by 6 inches (300 by 150 mm).
34 3. Head and Hand Access: 18 by 10 inches (460 by 250 mm).
35 4. Head and Shoulders Access: 21 by 14 inches (530 by 355 mm).
36 5. Body Access: 25 by 14 inches (635 by 355 mm).
37 6. Body plus Ladder Access: 25 by 17 inches (635 by 430 mm).
- 38 L. Label access doors according to Section 23 05 53 "Identification for HVAC Piping and
39 Equipment" to indicate the purpose of access door.
- 40 M. Install flexible connectors to connect ducts to equipment.

- 1 N. For fans developing static pressures of 5-inch wg (1250 Pa) and more, cover flexible connectors
2 with loaded vinyl sheet held in place with metal straps.

3 **3.3 FLEXIBLE CONNECTOR SCHEDULE**

- 4 A. Indoor equipment, non-corrosive environment with airstream not in excess of 200 deg F (93
5 deg C): Indoor system, flexible connector fabric.

- 6 B. Outdoor equipment, non-corrosive environment with airstream not in excess of 200 deg F (93
7 deg C): Outdoor system, flexible connector fabric.

- 8 C. Indoor and outdoor equipment with airstream in excess of 200 deg F (93 deg C): High-
9 Temperature System, Flexible Connectors. Systems to include but not limited to the following:

- 10 1. Smoke exhaust fans.
11 2. Kitchen grease and heat removal hood exhaust fans.

12 **3.4 FIELD QUALITY CONTROL**

- 13 A. Tests and Inspections:

- 14 1. Operate dampers to verify full range of movement.
15 2. Inspect locations of access doors and verify that purpose of access door can be
16 performed.
17 3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of
18 movement and verify that proper heat-response device is installed.
19 4. Inspect turning vanes for proper and secure installation.
20 5. Operate remote damper operators to verify full range of movement of operator and
21 damper.

22 **END OF SECTION 23 33 00**

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1 **SECTION 23 33 46 - FLEXIBLE DUCTS**

2 **PART 1 - GENERAL**

3 **1.1 RELATED DOCUMENTS**

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

6 **1.2 SUMMARY**

- 7 A. Section Includes:
8 1. Insulated flexible ducts.

9 **1.3 ACTION SUBMITTALS**

- 10 A. Product Data: For each type of product.

11 **PART 2 - PRODUCTS**

12 **2.1 ASSEMBLY DESCRIPTION**

- 13 A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with
14 NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

15 B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for
16 acceptable materials, material thicknesses, and duct construction methods unless otherwise
17 indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains,
18 discolorations, and other imperfections.

19 C. Comply with the Air Diffusion Council's "ADC Flexible Air Duct Test Code FD 72-R1."

20 D. Comply with ASTM E96/E96M, "Test Methods for Water Vapor Transmission of Materials."

21 **2.2 INSULATED FLEXIBLE DUCTS**

- 22 A. Products: Subject to compliance with requirements, provide one of the following:

23 1. Flexmaster U.S.A., Inc; 1M.
24 2. JP Lamborn Co.; AMR.
25 3. Thermaflex; a Flex-Tek Group company; M-KE.
26 4. Atco; UPC 036.

27 B. Insulated, Flexible Duct: UL 181, Class 1, two-ply vinyl film or polyethylene fabric supported by
28 helically wound, spring-steel wire; fibrous-glass insulation; aluminized vapor-barrier film.

29 1. Pressure Rating: 10-inch wg (2500 Pa) positive and 1.0-inch wg (250 Pa) negative.

- 1 2. Maximum Air Velocity: 4000 fpm (20 m/s).
- 2 3. Temperature Range: Minus 10 to plus 160 deg F (Minus 23 to plus 71 deg C).
- 3 4. Insulation R-Value: R6.

4 **2.3 FLEXIBLE DUCT CONNECTORS**

- 5 A. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear
- 6 action in sizes 3 through 18 inches (75 through 460 mm), to suit duct size.

7 **PART 3 - EXECUTION**

8 **3.1 INSTALLATION**

- 9 A. Install flexible ducts according to applicable details in SMACNA's "HVAC Duct Construction
- 10 Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct
- 11 Construction Standards," for fibrous-glass ducts.
- 12 B. Install in indoor applications only. Flexible ductwork should not be exposed to UV lighting.
- 13 C. Connect terminal units to supply ducts with maximum 24-inch (600-mm) lengths of flexible duct.
- 14 Do not use flexible ducts to change directions.
- 15 D. Connect diffusers to ducts with maximum 60-inch (1500-mm) lengths of flexible duct clamped or
- 16 strapped in place.
- 17 E. Connect flexible ducts to metal ducts with draw bands.
- 18 F. Installation:
 - 19 1. Install ducts fully extended.
 - 20 2. Do not bend ducts across sharp corners.
 - 21 3. Bends of flexible ducting shall not exceed a minimum of one duct diameter.
 - 22 4. Avoid contact with metal fixtures, water lines, pipes, or conduits.
 - 23 5. Install flexible ducts in a direct line, without sags, twists, or turns.
- 24 G. Supporting Flexible Ducts:
 - 25 1. Suspend flexible ducts with bands 1-1/2 inches (38 mm) wide or wider and spaced a
 - 26 maximum of 48 inches (1200 mm) apart. Maximum centerline sag between supports shall
 - 27 not exceed 1/2 inch (13 mm) per 12 inches (300 mm).
 - 28 2. Install extra supports at bends placed approximately one duct diameter from center line
 - 29 of the bend.
 - 30 3. Ducts may rest on ceiling joists or truss supports. Spacing between supports shall not
 - 31 exceed the maximum spacing per manufacturer's written installation instructions.
 - 32 4. Vertically installed ducts shall be stabilized by support straps at a maximum of 72 inches
 - 33 (1800 mm) o.c.

34 **END OF SECTION 23 33 46**

1 **SECTION 23 34 16.11 - SQUARE IN-LINE CENTRIFUGAL FANS**

2 **PART 1 - GENERAL**

3 **1.1 RELATED DOCUMENTS**

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

6 **1.2 SUMMARY**

- 7 A. Section Includes:
8 1. Square in-line centrifugal fans.

9 **1.3 ACTION SUBMITTALS**

- 10 A. Product Data: For each type of product.
- 11 1. Construction details, material descriptions, dimensions of individual components and
12 profiles, and finishes for fans.
- 13 2. Rated capacities, operating characteristics, and furnished specialties and accessories.
- 14 3. Certified fan performance curves with system operating conditions indicated.
- 15 4. Certified fan sound-power ratings.
- 16 5. Motor ratings and electrical characteristics, plus motor and electrical accessories.
- 17 6. Material thickness and finishes, including color charts.
- 18 7. Dampers, including housings, linkages, and operators.
- 19 B. Shop Drawings:
- 20 1. Include plans, elevations, sections, and attachment details.
- 21 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required
22 clearances, method of field assembly, components, and location and size of each field
23 connection.
- 24 3. Include diagrams for power, signal, and control wiring.

25 **1.4 INFORMATIONAL SUBMITTALS**

- 26 A. Coordination Drawings: Fan room layout and relationships between components and adjacent
27 structural and mechanical elements, drawn to scale, and coordinated with each other, using
28 input from installers of the items involved.

29 **1.5 CLOSEOUT SUBMITTALS**

- 30 A. Operation and Maintenance Data: For centrifugal fans to include in normal operation,
31 emergency operation, and maintenance manuals with replacement parts listing.

1 **1.6 MAINTENANCE MATERIAL SUBMITTALS**

- 2 A. Furnish extra materials, from the same product run, that match products installed and that are
 3 packaged with protective covering for storage and identified with labels describing contents.
- 4 1. Belts: One set(s) for each belt-driven unit.

5 **PART 2 - PRODUCTS**

6 **2.1 SQUARE IN-LINE CENTRIFUGAL FANS**

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

- 9 1. Carnes Company.
 10 2. Greenheck Fan Corporation.
 11 3. Loren Cook Company.
 12 4. PennBarry.

13 B. Description: Square in-line centrifugal fans.

14 C. Housing:

- 15 1. Housing Material: Reinforced galvanized steel .
 16 2. Housing Coating: None.
 17 3. Housing Construction: Side panels shall be easily removable for service. Include inlet and
 18 outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.

19 D. Direct-Drive Units: Motor mounted in airstream, factory wired to disconnect switch located on
 20 outside of fan housing.

21 E. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosures
 22 around belts within fan housing, and lubricating tubes from fan bearings extended to outside of
 23 fan housing.

24 F. Fan Wheels: Aluminum airfoil blades welded to aluminum hub.

25 G. Motor Enclosure: Totally enclosed, fan cooled.

26 H. Accessories:

- 27 1. Access for Inspection, Cleaning, and Maintenance: Comply with requirements in
 28 ASHRAE 62.1.
 29 2. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50
 30 percent.
 31 3. Companion Flanges: For inlet and outlet duct connections.
 32 4. Fan Guards: 1/2- by 1-inch (13- by 25-mm) mesh of galvanized steel in removable frame.
 33 Provide guard for inlet or outlet for units not connected to ductwork.
 34 5. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.
 35 6. Side Discharge: Flange connector and attachment hardware to provide right-angle
 36 discharge on side of unit.
 37 7. Insulated Housing: Fiberglass duct liner for the interior of unit to provide a reduction in
 38 noise.

1 **2.2 MOTORS**

- 2 A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements
3 for motors specified in Section 23 05 13 "Common Motor Requirements for HVAC Equipment."
- 4 B. Where variable-frequency drives are indicated or scheduled, provide fan motor compatible with
5 variable-frequency drive.

6 **2.3 SOURCE QUALITY CONTROL**

- 7 A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70,
8 by an NRTL, and marked for intended location and application.
- 9 B. AMCA Compliance: Fans shall comply with AMCA 11 and bear the AMCA-Certified Ratings
10 Seal.
- 11 C. Fan Sound Ratings: Comply with AMCA 311 and label fans with the AMCA-Certified Ratings
12 Seal. Sound ratings shall comply with AMCA 301. The fans shall be tested according to
13 AMCA 300.
- 14 D. Fan Performance Ratings: Comply with AMCA 211 and label fans with AMCA-Certified Rating
15 Seal. The fans shall be tested for air performance - flow rate, fan pressure, power, fan
16 efficiency, air density, speed of rotation, and fan efficiency - according to
17 AMCA 210/ASHRAE 51.
- 18 E. Operating Limits: Classify fans according to AMCA 99.

19 **PART 3 - EXECUTION**

20 **3.1 INSTALLATION OF CENTRIFUGAL HVAC FANS**

- 21 A. Install centrifugal fans level and plumb.
- 22 B. Disassemble and reassemble units, as required for moving to the final location, according to
23 manufacturer's written instructions.
- 24 C. Lift and support units with manufacturer's designated lifting or supporting points.
- 25 D. Equipment Mounting:
26 1. Support duct-mounted and other hanging centrifugal fans directly from the building
27 structure, using suitable hanging systems as specified in Section 23 05 29 "Hangers and
28 Supports for HVAC Piping and Equipment."
29 2. Comply with requirements for vibration isolation devices specified in Section 23 05 48.13
30 "Vibration Controls for HVAC."
- 31 E. Install units with clearances for service and maintenance.
- 32 F. Label fans according to requirements specified in Section 23 05 53 "Identification for HVAC
33 Piping and Equipment."

- 1 9. Verify that manual and automatic volume control and fire and smoke dampers in
2 connected ductwork systems are in fully open position.
3 10. See Section 23 05 93 "Testing, Adjusting, and Balancing For HVAC" for testing,
4 adjusting, and balancing procedures.
5 11. Remove and replace malfunctioning units and retest as specified above.
- 6 C. Test and adjust controls and safeties. Controls and equipment will be considered defective if
7 they do not pass tests and inspections.
- 8 D. Prepare test and inspection reports.

9 **3.6 ADJUSTING**

- 10 A. Adjust damper linkages for proper damper operation.
- 11 B. Adjust belt tension.
- 12 C. Comply with requirements in Section 23 05 93 "Testing, Adjusting, and Balancing for HVAC" for
13 testing, adjusting, and balancing procedures.
- 14 D. Replace fan and motor pulleys as required to achieve design airflow.
- 15 E. Lubricate bearings.

16 **3.7 DEMONSTRATION**

- 17 A. Train Owner's maintenance personnel to adjust, operate, and maintain centrifugal fans.

18 **END OF SECTION 23 34 16.11**

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1 **SECTION 23 34 23.13 - CENTRIFUGAL ROOF VENTILATORS**

2 **PART 1 - GENERAL**

3 **1.1 RELATED DOCUMENTS**

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

6 **1.2 SUMMARY**

- 7 A. Section Includes:
8 1. Centrifugal ventilators - roof upblast.

9 **1.3 ACTION SUBMITTALS**

- 10 A. Product Data: For each type of product.
- 11 1. Construction details, material descriptions, dimensions of individual components and
12 profiles, and finishes for fans.
13 2. Rated capacities, operating characteristics, and furnished specialties and accessories.
14 3. Certified fan performance curves with system operating conditions indicated.
15 4. Certified fan sound-power ratings.
16 5. Motor ratings and electrical characteristics, plus motor and electrical accessories.
17 6. Material thickness and finishes, including color charts.
18 7. Dampers, including housings, linkages, and operators.
19 8. Prefabricated roof curbs.
20 9. Fan speed controllers.

21 **1.4 INFORMATIONAL SUBMITTALS**

- 22 A. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, or BIM model,
23 drawn to scale, showing the items described in this Section and coordinated with all building
24 trades.

25 **1.5 CLOSEOUT SUBMITTALS**

- 26 A. Operation and Maintenance Data: For HVAC power ventilators to include in normal and
27 emergency operation, and maintenance manuals.

28 **1.6 MAINTENANCE MATERIAL SUBMITTALS**

- 29 A. Furnish extra materials, from the same product run, that match products installed and that are
30 packaged with protective covering for storage and identified with labels describing contents.
- 31 1. Belts: One set(s) for each belt-driven unit.

1 **PART 2 - PRODUCTS**

2 **2.1 CENTRIFUGAL VENTILATORS - ROOF UPBLAST**

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

- 5 1. Carnes Company.
- 6 2. Greenheck Fan Corporation.
- 7 3. Loren Cook Company.
- 8 4. PennBarry.

9 B. Housing: Removable spun-aluminum dome top and outlet baffle; square, one-piece aluminum
10 base with venturi inlet cone.

- 11 1. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward,
12 with rain and snow drains.
- 13 2. Grease-Laden Air Exhaust Applications: Provide grease collector.]

14 C. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.

15 D. Belt Drives:

- 16 1. Resiliently mounted to housing.
- 17 2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
- 18 3. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings;
19 minimum ABMA9, L(10) of 100,000 hours.
- 20 4. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at
21 factory.
- 22 5. Motor Pulleys: Adjustable pitch for use with motors through 5 hp. Select pulley so pitch
23 adjustment is at the middle of adjustment range at fan design conditions. Provide fixed
24 pitch for use with motors larger than 5 hp.
- 25 6. Fan and motor isolated from exhaust airstream.

26 E. Accessories:

- 27 1. Variable-Frequency Motor Controller: Solid-state control to reduce speed from 100 to less
28 than 50 percent.
- 29 2. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan
30 housing, factory wired through an internal aluminum conduit.
- 31 3. Bird Screens: Removable, 1/2-inch (13-mm) mesh, aluminum or brass wire.
- 32 4. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base;
33 factory set to close when fan stops.
- 34 5. Spark-resistant, all-aluminum wheel construction.
- 35 6. Restaurant Kitchen Exhaust: UL 762 listed for grease-laden air exhaust.
- 36 7. Extended Lubrication Lines.

37 F. Prefabricated Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch- (40-mm-)
38 thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch (40-mm) wood nailer.
39 Size as required to suit roof opening and fan base.

- 40 1. Configuration: Built-in raised cant and mounting flange.
- 41 2. Overall Height: 12 inches (300 mm).
- 42 3. Sound Curb: Curb with sound-absorbing insulation.

- 1 4. Hinged sub-base to provide access to damper or as cleanout for grease applications.
- 2 5. Pitch Mounting: Manufacture curb for roof slope.
- 3 6. Metal Liner: Galvanized steel.

4 G. Prefabricated Kitchen Exhaust Roof Curbs: Galvanized steel; mitered and welded corners;
 5 ventilation openings on all sides to ventilate curb interstitial space. Size as required to suit roof
 6 opening and fan base.

- 7 1. Configuration: Built-in raised cant and mounting flange manufactured to accommodate
- 8 roof slope.
- 9 2. Overall Height: 12 inches (300 mm).
- 10 3. Hinged sub-base to provide access to damper or as cleanout for grease applications.
- 11 4. Pitch Mounting: Manufacture curb for roof slope.
- 12 5. Vented Curb: For kitchen exhaust; 12-inch- (300-mm-) high galvanized steel; unlined,
- 13 with louvered vents in vertical sides.
- 14 6. NFPA 96 code requirements for commercial cooking operations.
- 15 7. Kitchen Hood Exhaust: UL 762 listed for grease-laden air.

16 **2.2 MOTORS**

- 17 A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements
- 18 for motors specified in Section 23 05 13 "Common Motor Requirements for HVAC Equipment."
- 19 1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will
- 20 not require motor to operate in service factor range above 1.0.

21 **2.3 SOURCE QUALITY CONTROL**

- 22 A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70,
- 23 by an NRTL, and marked for intended location and application.
- 24 B. AMCA Certification: Fans shall comply with AMCA 11 and bear the AMCA-Certified Ratings
- 25 Seal.
- 26 C. Fan Sound Ratings: Comply with AMCA 311, and label fans with the AMCA-Certified Ratings
- 27 Seal. Sound ratings shall comply with AMCA 301. The fans shall be tested according to
- 28 AMCA 300.
- 29 D. Fan Performance Ratings: Comply with AMCA 211 and label fans with AMCA-Certified Rating
- 30 Seal. The fans shall be tested for air performance - flow rate, fan pressure, power, fan
- 31 efficiency, air density, speed of rotation, and fan efficiency - according to
- 32 AMCA 210/ASHRAE 51.
- 33 E. Operating Limits: Classify according to AMCA 99.
- 34 F. UL Standards: Power ventilators shall comply with UL 705. Power ventilators for use for
- 35 restaurant kitchen exhaust shall also comply with UL 762.

1 **PART 3 - EXECUTION**

2 **3.1 INSTALLATION OF HVAC POWER VENTILATORS**

- 3 A. Install power ventilators level and plumb.
- 4 B. Secure roof-mounted fans to roof curbs with zinc-plated hardware. See Division 07 for
5 installation of roof curbs.
- 6 C. Install units with clearances for service and maintenance.
- 7 D. Label units according to requirements specified in Section 23 05 53 "Identification for HVAC
8 Piping and Equipment."

9 **3.2 DUCTWORK CONNECTIONS**

- 10 A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct
11 connections with flexible connectors. Flexible connectors are specified in Section 23 33 00 "Air
12 Duct Accessories."

13 **3.3 ELECTRICAL CONNECTIONS**

- 14 A. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and
15 Cables."
- 16 B. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical
17 Systems."
- 18 C. Install electrical devices furnished by manufacturer, but not factory mounted, according to
19 NFPA 70 and NECA 1.
 - 20 1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in
21 Section 26 05 53 "Identification for Electrical Systems."
 - 22 2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background
23 and engraved white letters at least 1/2 inch (13 mm) high.

24 **3.4 CONTROL CONNECTIONS**

- 25 A. Install control and electrical power wiring to field-mounted control devices.
- 26 B. Connect control wiring according to Section 250523 "Control-Voltage Electrical Power Cables."

27 **3.5 FIELD QUALITY CONTROL**

- 28 A. Perform tests and inspections.
- 29 B. Tests and Inspections:
 - 30 1. Verify that shipping, blocking, and bracing are removed.

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

- 18 C. Test and adjust controls and safeties. Controls and equipment will be considered defective if
- 19 they do not pass tests and inspections.

- 20 D. Prepare test and inspection reports.

21 **3.6 ADJUSTING**

- 22 A. Adjust damper linkages for proper damper operation.
- 23 B. Adjust belt tension.
- 24 C. Comply with requirements in Section 23 05 93 "Testing, Adjusting, and Balancing for HVAC" for
- 25 testing, adjusting, and balancing procedures.
- 26 D. Replace fan and motor pulleys as required to achieve design airflow.
- 27 E. Lubricate bearings.

28 **3.7 DEMONSTRATION**

- 29 A. Train Owner's maintenance personnel to adjust, operate, and maintain centrifugal fans.

30 **END OF SECTION 23 34 23.13**

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1 **SECTION 23 36 00 - AIR TERMINAL UNITS**

2 **PART 1 - GENERAL**

3 **1.1 RELATED DOCUMENTS**

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

6 **1.2 SUMMARY**

- 7 A. Section Includes:
8 1. Shutoff, single-duct air terminal units.
9 2. Casing liner.

10 **1.3 ACTION SUBMITTALS**

- 11 A. Product Data: For each type of air terminal unit.
- 12 1. Include construction details, material descriptions, dimensions of individual components
13 and profiles, and finishes for air terminal units.
14 2. Include rated capacities, operating characteristics, electrical characteristics, and
15 furnished specialties and accessories.
- 16 B. Shop Drawings: For air terminal units.
- 17 1. Include plans, elevations, sections, and mounting details.
18 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required
19 clearances, method of field assembly, components, and location and size of each field
20 connection.
21 3. Include diagrams for power, signal, and control wiring.
22 4. Hangers and supports, including methods for duct and building attachment and vibration
23 isolation.

24 **1.4 INFORMATIONAL SUBMITTALS**

- 25 A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are
26 shown and coordinated with each other, using input from installers of the items involved:
- 27 1. Ceiling suspension assembly members.
28 2. Size and location of initial access modules for acoustic tile.
29 3. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers,
30 access panels, and special moldings.

31 **1.5 CLOSEOUT SUBMITTALS**

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

1 **1.6 MAINTENANCE MATERIAL SUBMITTALS**

2 A. Furnish extra materials that match products installed and that are packaged with protective
3 covering for storage and identified with labels describing contents.

4 1. Fan-Powered-Unit Filters: Furnish one spare filter(s) for each filter installed.

5 **PART 2 - PRODUCTS**

6 **2.1 SYSTEM DESCRIPTION**

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

9 B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and
10 Equipment" and Section 7 - "Construction and System Start-up."

11 C. ASHRAE Compliance: Applicable requirements in ASHRAE/IES 90.1, "Section 6 - Heating,
12 Ventilating, and Air Conditioning."

13 **2.2 SHUTOFF, SINGLE-DUCT AIR TERMINAL UNITS**

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

- 16 1. Carrier Corporation; a unit of United Technologies Corp.
- 17 2. ENVIRO-TEC; by Johnson Controls, Inc.
- 18 3. METALAIRE, Inc.
- 19 4. Price Industries.
- 20 5. Titus.

21 B. Configuration: Volume-damper assembly inside unit casing with control components inside a
22 protective metal shroud.

23 C. Casing: 0.034-inch- (0.85-mm-) thick galvanized steel, single wall.

- 24 1. Casing Liner: Comply with requirements in "Casing Liner" Article for flexible elastomeric
25 duct liner.
- 26 2. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
- 27 3. Air Outlet: S-slip and drive connections.
- 28 4. Access: Removable panels for access to parts requiring service, adjustment, or
29 maintenance; with airtight gasket.
- 30 5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with
31 requirements in ASHRAE 62.1.

32 D. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.

33 1. Maximum Damper Leakage: AHRI 880 rated, 2 percent of nominal airflow at 3-inch wg
34 (750-Pa) inlet static pressure.

35 E. Velocity Sensors: Multi-point, multi-axis flow ring or cross sensor in air inlet. Single point or flow
36 bar sensors are not acceptable. Sensor shall be capable of maintaining airflow to within plus or

- 1 minus 5 percent of rated unit airflow setpoint with 1.5 duct diameters straight duct upstream
 2 from the unit.
- 3 F. Hydronic Heating Coils: Minimum of two rows. Copper tube, with mechanically bonded
 4 aluminum fins spaced no closer than 0.1 inch (2.5 mm), and rated for a minimum working
 5 pressure of 200 psig (1380 kPa) and a maximum entering-water temperature of 220 deg F (104
 6 deg C). Include manual air vent and drain valve.
- 7 G. Factory-Mounted and -Wired Controls: Electrical components mounted in control box with
 8 removable cover. Incorporate single-point electrical connection to power source.
- 9 1. Wiring Terminations: Fan and controls to terminal strip. Terminal lugs to match quantities,
 10 sizes, and materials of branch-circuit conductors. Enclose terminal lugs in terminal box
 11 that is sized according to NFPA 70.
 - 12 2. Disconnect Switch: Factory-mounted, fuse type.
 - 13 3. Damper actuator, differential pressure transmitter, transformer, and microprocessor-
 14 based application specific controller shall be provided by the Division 25 contractor to the
 15 air terminal unit manufacturer for factory installation prior to shipment to the project.
- 16 H. Control Panel Enclosure: NEMA 250, Type 1, with access panel sealed from airflow and
 17 mounted on side of unit.
- 18 I. Control devices shall be compatible with temperature controls system specified in Division 25.

19 **2.3 CASING LINER**

- 20 A. Casing Liner: Flexible elastomeric duct liner fabricated of preformed, cellular, closed-cell, sheet
 21 materials complying with ASTM C534, Type II, Grade 1; and with NFPA 90A or NFPA 90B.
- 22 1. Minimum Thickness: 1/2 inch (13 mm).
 - 23 2. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum
 24 smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
 - 25 3. Liner Adhesive: As recommended by insulation manufacturer and complying with
 26 NFPA 90A or NFPA 90B.
- 27 a. Adhesive shall have a VOC content of 80 g/L or less.

28 **2.4 SOURCE QUALITY CONTROL**

- 29 A. Factory Tests: Test assembled air terminal units according to AHRI 880.
- 30 1. Label each air terminal unit with plan number, nominal airflow, maximum and minimum
 31 factory-set airflows, coil type, and AHRI certification seal.

32 **PART 3 - EXECUTION**

33 **3.1 HANGER AND SUPPORT INSTALLATION**

- 34 A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 5,
 35 "Hangers and Supports" and with Section 23 05 29 "Hangers and Supports for HVAC Piping
 36 and Equipment."

- 1 B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners
2 appropriate for construction materials to which hangers are being attached.
- 3 1. Where practical, install concrete inserts before placing concrete.
- 4 2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
- 5 3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes and
6 for slabs more than 4 inches (100 mm) thick.
- 7 4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes and
8 for slabs less than 4 inches (100 mm) thick.
- 9 C. Hangers Exposed to View: Threaded rod and angle or channel supports.
- 10 D. Install upper attachments to structures. Select and size upper attachments with pull-out,
11 tension, and shear capacities appropriate for supported loads and building materials where
12 used.

13 **3.2 TERMINAL UNIT INSTALLATION**

- 14 A. Install air terminal units according to NFPA 90A, "Standard for the Installation of Air
15 Conditioning and Ventilating Systems."
- 16 B. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and
17 maintenance.

18 **3.3 CONNECTIONS**

- 19 A. Where installing piping adjacent to air terminal unit, allow space for service and maintenance.
- 20 B. Hot-Water Piping: Comply with requirements in Section 23 21 13 "Hydronic Piping" and
21 Section 23 21 16 Hydronic Piping Specialties," and connect heating coils to supply with shutoff
22 valve, strainer, control valve, and union or flange; and to return with balancing valve and union
23 or flange.
- 24 C. Comply with requirements in Section 233113.11 "Metal Ducts for General HVAC", for
25 connecting ducts to air terminal units.

26 **3.4 IDENTIFICATION**

- 27 A. Label each air terminal unit with plan number, nominal airflow, and maximum and minimum
28 factory-set airflows. Comply with requirements in Section 23 05 53 "Identification for HVAC
29 Piping and Equipment" for equipment labels and warning signs and labels.

30 **3.5 FIELD QUALITY CONTROL**

- 31 A. Perform the following tests and inspections:
- 32 1. After installing air terminal units and after electrical circuitry has been energized, test for
33 compliance with requirements.
- 34 2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until
35 no leaks exist.

- 1 3. Operational Test: After electrical circuitry has been energized, start units to confirm
- 2 proper motor rotation and unit operation.
- 3 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and
- 4 equipment.

5 B. Air terminal unit will be considered defective if it does not pass tests and inspections.

6 C. Prepare test and inspection reports.

7 **3.6 STARTUP SERVICE**

8 A. Perform startup service.

- 9 1. Complete installation and startup checks according to manufacturer's written instructions.
- 10 2. Verify that inlet duct connections are as recommended by air terminal unit manufacturer
- 11 to achieve proper performance.
- 12 3. Verify that controls and control enclosure are accessible.
- 13 4. Verify that control connections are complete.
- 14 5. Verify that nameplate and identification tag are visible.
- 15 6. Verify that controls respond to inputs as specified.

16 **3.7 DEMONSTRATION**

17 A. Train Owner's maintenance personnel to adjust, operate, and maintain air terminal units.

18 **END OF SECTION 23 36 00**

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1 **SECTION 23 37 13.13 - AIR DIFFUSERS**

2 **PART 1 - GENERAL**

3 **1.1 RELATED DOCUMENTS**

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

6 **1.2 SUMMARY**

- 7 A. Section Includes:
- 8 1. Rectangular and square ceiling diffusers.
 - 9 2. Linear slot diffusers.
 - 10 3. Ceiling-integral continuous slot diffusers.
- 11 B. Related Requirements:
- 12 1. Section 23 33 00 "Air Duct Accessories" for fire and smoke dampers and volume-control
13 dampers not integral to diffusers.
 - 14 2. Section 23 37 13.23 "Registers and Grilles" for adjustable-bar register and grilles, fixed-
15 face registers and grilles, and linear bar grilles.

16 **1.3 ACTION SUBMITTALS**

- 17 A. Product Data: For each type of product.
- 18 1. Data Sheet: Indicate materials of construction, finish, and mounting details; and
19 performance data including throw and drop, static-pressure drop, and noise ratings.
 - 20 2. Diffuser Schedule: Indicate drawing designation, room location, quantity, model number,
21 size, and accessories furnished.

22 **1.4 INFORMATIONAL SUBMITTALS**

- 23 A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are
24 shown and coordinated with each other, using input from installers of the items involved:
- 25 1. Ceiling suspension assembly members.
 - 26 2. Method of attaching hangers to building structure.
 - 27 3. Size and location of initial access modules for acoustical tile.
 - 28 4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers,
29 access panels, and special moldings.
 - 30 5. Duct access panels.
- 31 B. Source quality-control reports.

1 **PART 2 - PRODUCTS**

2 **2.1 RECTANGULAR AND SQUARE CEILING DIFFUSERS**

3 A. Basis-of-Design Product: Subject to compliance with requirements, provide Price Industries;
4 SPD or a comparable product by one of the following:

- 5 1. Carnes Company.
- 6 2. METALAIRE, Inc.
- 7 3. Nailor Industries Inc.
- 8 4. Titus.
- 9 5. Tuttle & Bailey.

10 B. Devices shall be specifically designed for variable-air-volume flows.

11 C. Material: Aluminum.

12 D. Finish: Baked enamel, white.

13 E. Face Size: 24 by 24 inches (600 by 600 mm).

14 F. Face Style: Plaque.

15 G. Pattern: Adjustable.

16 H. Dampers: Radial opposed blade.

17 I. Insulation: Factory applied, foil faced, R-6 insulation formed to fit contour of diffuser back,
18 continuously glued and sealed around perimeter of outer cone to form vapor seal.

19 J. Accessories:

- 20 1. Equalizing grid.
- 21 2. Plaster ring.
- 22 3. Safety chain.
- 23 4. Wire guard.
- 24 5. Sectorizing baffles.
- 25 6. Operating rod extension.

26 **2.2 LINEAR SLOT DIFFUSERS**

27 A. Basis-of-Design Product: Subject to compliance with requirements, provide Price Industries;
28 TBD3 (supply), Price TBR (return) or a comparable product by one of the following:

- 29 1. Carnes Company.
- 30 2. METALAIRE, Inc.
- 31 3. Nailor Industries Inc.
- 32 4. Titus.
- 33 5. Tuttle & Bailey.

34 B. Devices shall be specifically designed for variable-air-volume flows.

35 C. Material - Shell: Aluminum, insulated.

- 1 D. Material - Pattern Controller and Tees: Aluminum.
- 2 E. Finish - Face and Shell: Baked enamel, black.
- 3 F. Finish - Pattern Controller: Baked enamel, black.
- 4 G. Finish - Tees: Baked enamel, white.
- 5 H. Slot Width: As indicated on plans.
- 6 I. Number of Slots: As indicated on plans .
- 7 J. Insulation: Factory applied, foil faced, R-6 insulation formed to fit contour of diffuser back,
8 continuously glued and sealed around perimeter of outer cone to form vapor seal.

9 **2.3 CEILING-INTEGRAL CONTINUOUS DIFFUSERS**

- 10 A. Basis-of-Design Product: Subject to compliance with requirements, provide Price Industries; AS
11 or JS or a comparable product by one of the following:
 - 12 1. Carnes Company.
 - 13 2. METALAIRE, Inc.
 - 14 3. Nailor Industries Inc.
 - 15 4. Titus.
 - 16 5. Tuttle & Bailey.
- 17 B. Slot Width: As indicated on plans.
- 18 C. Straight and curved sections as required to accommodate layout.
- 19 D. Mitered tees and corners.
- 20 E. Material: Aluminum, extruded, heavy wall.
- 21 F. Finishes:
 - 22 1. Exterior: Standard white.
 - 23 2. Interior: Standard black.
- 24 G. Throw: High.
- 25 H. Plenum: Insulated.
- 26 I. Other Features:
 - 27 1. Painted interior.
 - 28 2. Blank-offs.
 - 29 3. Insulated light shield on return slots.

30 **2.4 SOURCE QUALITY CONTROL**

- 31 A. Verification of Performance: Rate diffusers according to ASHRAE 70, "Method of Testing for
32 Rating the Performance of Air Outlets and Inlets."

1 **PART 3 - EXECUTION**

2 **3.1 EXAMINATION**

- 3 A. Examine areas where diffusers are installed for compliance with requirements for installation
4 tolerances and other conditions affecting performance of equipment.
- 5 B. Proceed with installation only after unsatisfactory conditions have been corrected.

6 **3.2 INSTALLATION**

- 7 A. Install diffusers level and plumb.
- 8 B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings,
9 and accessories. Air outlet and inlet locations have been indicated to achieve design
10 requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final
11 locations where indicated, as much as practical. For units installed in lay-in ceiling panels,
12 locate units in the center of panel. Where architectural features or other items conflict with
13 installation, notify Architect for a determination of final location.
- 14 C. Install diffusers with airtight connections to ducts and to allow service and maintenance of
15 dampers, air extractors, and fire dampers.

16 **3.3 ADJUSTING**

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

19 **END OF SECTION 23 37 13.13**

1 **SECTION 23 37 13.23 - REGISTERS AND GRILLES**

2 **PART 1 - GENERAL**

3 **1.1 RELATED DOCUMENTS**

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

6 **1.2 SUMMARY**

- 7 A. Section Includes:

- 8 1. Adjustable blade face registers and grilles.
9 2. Fixed face registers and grilles.

- 10 B. Related Requirements:

- 11 1. Section 23 33 00 "Air Duct Accessories" for fire volume-control dampers not integral to
12 registers and grilles.
13 2. Section 23 37 13.13 "Air Diffusers" for various types of air diffusers.

14 **1.3 ACTION SUBMITTALS**

- 15 A. Product Data: For each type of product.

- 16 1. Data Sheet: Indicate materials of construction, finish, and mounting details; and
17 performance data including throw and drop, static-pressure drop, and noise ratings.
18 2. Register and Grille Schedule: Indicate drawing designation, room location, quantity,
19 model number, size, and accessories furnished.

20 **1.4 INFORMATIONAL SUBMITTALS**

- 21 A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are
22 shown and coordinated with each other, using input from installers of the items involved:

- 23 1. Ceiling suspension assembly members.
24 2. Method of attaching hangers to building structure.
25 3. Size and location of initial access modules for acoustical tile.
26 4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers,
27 access panels, and special moldings.
28 5. Duct access panels.

1 **PART 2 - PRODUCTS**

2 **2.1 REGISTERS**

3 A. Adjustable Blade Face Register:

4 1. Basis-of-Design Product: Subject to compliance with requirements, provide Price
5 Industries; 630 or a comparable product by one of the following:

- 6 a. Carnes Company.
- 7 b. METALAIRE, Inc.
- 8 c. Nailor Industries Inc.
- 9 d. Titus.
- 10 e. Tuttle & Bailey.

- 11 2. Material: Aluminum.
- 12 3. Finish: Baked enamel, white.
- 13 4. Face Blade Arrangement: Vertical spaced 3/4 inch (19 mm) apart.
- 14 5. Core Construction: Removable.
- 15 6. Rear-Blade Arrangement: Horizontal spaced 3/4 inch (19 mm) apart.
- 16 7. Frame: 1 inch (25 mm) wide.
- 17 8. Mounting: Countersunk screw.
- 18 9. Damper Type: Adjustable, aluminum, opposed blade.

19 B. Fixed Face Register:

20 1. Basis-of-Design Product: Subject to compliance with requirements, provide Price
21 Industries; 630 (no filter) and 630FF (with filter) or a comparable product by one of the
22 following:

- 23 a. Carnes Company.
- 24 b. METALAIRE, Inc.
- 25 c. Nailor Industries Inc.
- 26 d. Titus.
- 27 e. Tuttle & Bailey.

- 28 2. Material: Aluminum.
- 29 3. Finish: Baked enamel, white.
- 30 4. Face Blade Arrangement: Vertical spaced 3/4 inch (19 mm) apart.
- 31 5. Core Construction: Removable.
- 32 6. Frame: 1 inch (25 mm) wide.
- 33 7. Mounting: Countersunk screw.
- 34 8. Damper Type: Adjustable, aluminum, opposed blade.

35 **2.2 GRILLES**

36 A. Adjustable Blade Face Grille:

37 1. Basis-of-Design Product: Subject to compliance with requirements, provide Price
38 Industries; 630 or a comparable product by one of the following:

- 39 a. Carnes Company.
- 40 b. METALAIRE, Inc.
- 41 c. Nailor Industries Inc.

- 1 d. Titus.
 2 e. Tuttle & Bailey.
- 3 2. Material: Aluminum.
 4 3. Finish: Baked enamel, white.
 5 4. Face Blade Arrangement: Vertical spaced 3/4 inch (19 mm) apart.
 6 5. Core Construction: Removable.
 7 6. Rear-Blade Arrangement: Horizontal spaced 3/4 inch (19 mm) apart.
 8 7. Frame: 1 inch (25 mm) wide.
 9 8. Mounting: Countersunk screw.
- 10 B. Fixed Face Grille:
- 11 1. Basis-of-Design Product: Subject to compliance with requirements, provide Price
 12 Industries; 630 (no filter) and 630FF (with filter) or a comparable product by one of the
 13 following:
- 14 a. Carnes Company.
 15 b. METALAIRE, Inc.
 16 c. Nailor Industries Inc.
 17 d. Titus.
 18 e. Tuttle & Bailey.
- 19 2. Material: Aluminum.
 20 3. Finish: Baked enamel, white.
 21 4. Face Blade Arrangement: Horizontal; spaced 3/4 inch (19 mm) apart.
 22 5. Core Construction: Removable.
 23 6. Frame: 1 inch (25 mm) wide.
 24 7. Mounting: Countersunk screw or Lay in, as required by ceiling type.
- 25 C. Linear Bar Grilles
- 26 1. Basis-of-Design Product: Subject to compliance with requirements, provide Price
 27 Industries; LBP or a comparable product by one of the following:
- 28 a. Carnes Company.
 29 b. METALAIRE, Inc.
 30 c. Nailor Industries Inc.
 31 d. Titus.
 32 e. Tuttle & Bailey.
- 33 2. Material: Aluminum.
 34 3. Finish: Baked enamel, white.
 35 4. Face Blade Arrangement: Horizontal; spaced 1/2 inch (13 mm) apart.
 36 5. Core Construction: Removable.
 37 6. Distribution plenum.
- 38 a. Internal insulation.
 39 b. Inlet damper.
- 40 7. Frame: 1 inch (25 mm) wide.
 41 8. Mounting: Countersunk screw.
 42 9. Damper Type: Adjustable opposed blade NRTL listed, opposed blade, spring closing,
 43 and with fusible link for 160 deg F (71 deg C).

1 **2.3 SOURCE QUALITY CONTROL**

- 2 A. Verification of Performance: Rate registers and grilles according to ASHRAE 70, "Method of
3 Testing for Rating the Performance of Air Outlets and Inlets."

4 **PART 3 - EXECUTION**

5 **3.1 EXAMINATION**

- 6 A. Examine areas where registers and grilles are installed for compliance with requirements for
7 installation tolerances and other conditions affecting performance of equipment.

- 8 B. Proceed with installation only after unsatisfactory conditions have been corrected.

9 **3.2 INSTALLATION**

- 10 A. Install registers and grilles level and plumb.

- 11 B. Outlets and Inlets Locations: Drawings indicate general arrangement of ducts, fittings, and
12 accessories. Air outlet and inlet locations have been indicated to achieve design requirements
13 for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations
14 where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in
15 the center of panel. Where architectural features or other items conflict with installation, notify
16 Architect for a determination of final location.

- 17 C. Install registers and grilles with airtight connections to ducts and to allow service and
18 maintenance of dampers, air extractors, and fire dampers.

19 **3.3 ADJUSTING**

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

22 **END OF SECTION 23 37 13.23**

1 **SECTION 23 41 00 - PARTICULATE AIR FILTRATION**

2 **PART 1 - GENERAL**

3 **1.1 RELATED DOCUMENTS**

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

6 **1.2 SUMMARY**

- 7 A. Section Includes:
8 1. Pleated panel filters.
9 2. Filter gauges.

10 **1.3 DEFINITIONS**

- 11 A. HIPS: High-impact polystyrene.

12 **1.4 ACTION SUBMITTALS**

- 13 A. Product Data: For each type of product. Include dimensions; operating characteristics; required
14 clearances and access; rated flow capacity, including initial and final pressure drop at rated
15 airflow; efficiency and test method; fire classification; furnished specialties; and accessories for
16 each model indicated.

17 **1.5 CLOSEOUT SUBMITTALS**

- 18 A. Operation and Maintenance Data: For each type of filter and rack to include in emergency,
19 operation, and maintenance manuals.

20 **1.6 MAINTENANCE MATERIAL SUBMITTALS**

- 21 A. Furnish extra materials that match products installed and that are packaged with protective
22 covering for storage and identified with labels describing contents.

23 1. Provide one complete set(s) of filters for each filter bank. If system includes prefilters,
24 provide only prefilters.

25 **1.7 QUALITY ASSURANCE**

- 26 A. Testing Agency Qualifications: An NRTL.

1 **1.8 DELIVERY, STORAGE, AND HANDLING**

- 2 A. Deliver and store products in a clean, dry place.
- 3 B. Comply with manufacturer's written rigging and installation instructions for unloading and
4 moving to final installed location.
- 5 C. Handle products carefully to prevent damage, breaking, denting, and scoring. Do not install
6 damaged products.
- 7 D. Protect products from weather, dirt, dust, water, construction debris, and physical damage.
- 8 1. Retain factory-applied coverings on equipment to protect finishes during construction and
9 remove just prior to operating unit.
- 10 2. Cover unit openings before installation to prevent dirt and dust from entering inside of
11 units. If required to remove coverings during unit installation, reapply coverings over
12 openings after unit installation and remove just prior to operating unit.
- 13 3. Replace installed products damaged during construction.

14 **PART 2 - PRODUCTS**

15 **2.1 PERFORMANCE REQUIREMENTS**

- 16 A. ASHRAE Compliance:
 - 17 1. Comply with applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality";
 - 18 Section 5 - "Systems and Equipment"; and Section 7 - "Construction and Startup."
 - 19 2. Comply with ASHRAE 52.2 for MERV for methods of testing and rating air-filter units.
- 20 B. Comply with NFPA 90A and NFPA 90B.
- 21 C. Comply with UL 900.
- 22 D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70,
23 by a qualified testing agency, and marked for intended location and application.

24 **2.2 PLEATED PANEL FILTERS**

- 25 A. Description: Factory-fabricated, self-supported, extended-surface, pleated, panel-type,
26 disposable air filters with holding frames.
 - 27 1. Basis-of-Design Product: Subject to compliance with requirements, provide Camfil Farr;
28 AP-Thirteen or comparable product by one of the following:
 - 29 a. AAF International.
 - 30 b. Airguard.
 - 31 c. Flanders-Precisionaire.
 - 32 d. Purafil, Inc.
- 33 B. Source Limitations: Obtain from single source from single manufacturer.
- 34 C. Capacities and Characteristics:

- 1 1. Depth: 1 inch (25 mm), 2 inches (50 mm), or 4 inches (100 mm) nominal, as indicated in
- 2 Equipment Schedules.
- 3 2. Maximum or Rated Face Velocity: 625 fpm (3.2 m/s).
- 4 3. Initial Resistance: 0.25-inch wg (62 Pa) at 350 fpm (1.8 m/s).
- 5 4. Recommended Final Resistance: 1.0 inches wg (249 Pa).
- 6 5. Minimum Efficiency Reporting Value: MERV 13, with "Composite Average Particle Size
- 7 Efficiency, Percent in Size Range, Micrometers" according to ASHRAE 52.2.

8 D. Media: Interlaced glass or synthetic fibers coated with nonflammable adhesive.

- 9 1. Separators shall be bonded to the media to maintain pleat configuration.
- 10 2. Welded-wire grid shall be on downstream side to maintain pleat.
- 11 3. Media shall be bonded to frame to prevent air bypass.
- 12 4. Support members on upstream and downstream sides to maintain pleat spacing.

13 E. Filter-Media Frame: Cardboard frame with perforated metal retainer sealed or bonded to the

14 media.

15 2.3 FILTER GAUGES

16 A. Diaphragm-type gauge with dial and pointer in metal case, vent valves, black figures on white

17 background, and front recalibration adjustment.

18 1. Basis-of-Design Product: Subject to compliance with requirements, provide Dwyer

19 Instruments, Inc; Series 2000 or comparable product by one of the following:

20 a. Airguard.

21 B. Source Limitations: Obtain from single source from single manufacturer.

- 22 1. Diameter: 4-1/2 inches (115 mm).
- 23 2. Scale Range for Filter Media Having a Recommended Final Resistance of 1.0- to 2.0-
- 24 Inch wg (250 to 500 Pa) or Less: 0- to 2.0-inch wg (0 to 500 Pa).

25 C. Accessories: Static-pressure tips, tubing, gauge connections, and mounting bracket.

26 PART 3 - EXECUTION

27 3.1 EXAMINATION

28 A. Examine ducts, air-handling units, and conditions for compliance with requirements for

29 installation tolerances and other conditions affecting performance of the Work.

30 B. Proceed with installation only after unsatisfactory conditions have been corrected.

31 3.2 INSTALLATION OF FILTERS

32 A. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding

33 frames to substrate.

34 B. Install filters in position to prevent passage of unfiltered air.

- 1 C. Install filter gauge for each filter bank.
- 2 D. Do not operate fan system until filters (temporary or permanent) are in place. Replace
3 temporary filters used during construction and testing with new, clean filters.
- 4 E. Coordinate filter installations with duct and air-handling-unit installations.
- 5 **3.3 INSTALLATION OF FILTER GAUGES**
- 6 A. Install filter gauge for each filter bank.
- 7 B. Install filter-gauge, static-pressure taps upstream and downstream from filters. Install filter
8 gauges on filter banks with separate static-pressure taps upstream and downstream from filters.
9 Mount filter gauges on outside of filter housing or filter plenum in an accessible position. Adjust
10 and level inclined gauges.
- 11 **3.4 CLEANING**
- 12 A. After completing system installation and testing, adjusting, and balancing of air-handling and air-
13 distribution systems, clean filter housings and install new filter media.
- 14 **END OF SECTION 23 41 00**

1 **SECTION 23 73 13.16 - INDOOR, SEMI-CUSTOM AIR-HANDLING UNITS**

2 **PART 1 - GENERAL**

3 **1.1 RELATED DOCUMENTS**

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

6 **1.2 SUMMARY**

- 7 A. Section includes insulated, double-wall-casing, indoor, semi-custom air-handling units that are
8 factory assembled using multiple section components, including the following:

- 9 1. Casings.
10 2. Fans, drives, and motors.
11 3. Coils.
12 4. Air filtration.
13 5. Dampers.
14 6. Air-to-air energy recovery.

15 **1.3 ACTION SUBMITTALS**

- 16 A. Product Data: For each air-handling unit.

- 17 1. Include construction details, material descriptions, dimensions of individual components
18 and profiles, and finishes.
19 2. Include rated capacities, operating characteristics, electrical characteristics, and
20 furnished specialties and accessories.
21 3. Include unit dimensions and weight.
22 4. Include cabinet material, metal thickness, finishes, insulation, and accessories.
23 5. Fans:
24 a. Include certified fan-performance curves with system operating conditions
25 indicated.
26 b. Include certified fan-sound power ratings for discharge, radiated, and return
27 positions by octave band.
28 c. Include fan construction and accessories.
29 d. Include motor ratings, electrical characteristics, and motor accessories.
30 6. Include certified coil-performance ratings with system operating conditions indicated.
31 7. Include psychrometric chart for each cooling coil with both design and final operating
32 points.
33 8. Include calculations for required base rail heights to satisfy condensate trapping
34 requirements of cooling coil.
35 9. Include filters with performance characteristics.
36 10. Include dampers, including housings, linkages, and operators.
37 11. Include installation instructions.

- 1 B. Shop Drawings: For each type and configuration of indoor, semi-custom air handling unit.
- 2 1. Include plans, elevations, sections, and mounting details.
- 3 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required
- 4 clearances, method of field assembly, components, and location and size of each field
- 5 connection.
- 6 3. Detail fabrication and assembly of indoor, semi-custom air-handling units, as well as
- 7 procedures and diagrams.
- 8 4. Include diagrams for power, signal, and control wiring.
- 9 **1.4 INFORMATIONAL SUBMITTALS**
- 10 A. Coordination Drawings: Floor plans and other details, or BIM model, drawn to scale, showing
- 11 the items described in this Section, and coordinated with all building trades.
- 12 B. Startup service reports.
- 13 **1.5 CLOSEOUT SUBMITTALS**
- 14 A. Operation and Maintenance Data: For air-handling units to include in emergency, operation, and
- 15 maintenance manuals.
- 16 **1.6 MAINTENANCE MATERIAL SUBMITTALS**
- 17 A. Furnish extra materials that match products installed and that are packaged with protective
- 18 covering for storage and identified with labels describing contents.
- 19 1. Filters: One set(s) for each air-handling unit.
- 20 2. Gaskets: One set(s) for each access door.
- 21 3. Fan Belts: One set(s) for each air-handling unit fan.
- 22 **1.7 WARRANTY**
- 23 A. Warranty: Manufacturer agrees to repair or replace components of indoor, semi-custom air-
- 24 handling units that fail in materials or workmanship within specified warranty period.
- 25 1. Warranty Period for Entire Unit: Manufacturer's standard but not less than one year(s)
- 26 from date of Substantial Completion.
- 27 2. Warranty Period for Heat Wheels: Not less than five years from date of Substantial
- 28 Completion.
- 29 **1.8 COORDINATION**
- 30 A. Provide air handling unit(s) that will not exceed the allocated space shown on the drawings,
- 31 including required clearances for service and future overhaul or for removal of unit components.
- 32 All structural, piping, wiring, and ductwork alterations of unit(s) which are dimensionally different
- 33 than those specified shall be the responsibility of the Contractor at no additional cost to the
- 34 Owner.

- 1 B. Provide knockdown capable air handling unit(s), if required, to accommodate any installation
2 limitations. The knockdown and re-assembly of the air handling unit(s) shall be performed by
3 personnel approved by the equipment manufacturer, such as not to void the equipment
4 warranty. The equipment warranty shall not be voided by the knockdown and re-assembly
5 process of the air handling unit(s).
- 6 C. Coordinate factory-applied coating of heat transfer coils. Verify with the coating manufacturer
7 whether coatings required must be applied and cured in factory-certified application shop. If
8 required, provide coils to factory-certified application shop for application. Following application,
9 provide coils back to air handling unit manufacturer to install in air handling unit.

10 **PART 2 - PRODUCTS**

11 **2.1 PERFORMANCE REQUIREMENTS**

- 12 A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70,
13 by a qualified testing agency, and marked for intended location and application.
- 14 B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-
15 handling units and components.
- 16 C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems
17 and Equipment" and Section 7 - "Construction and Startup."
- 18 D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 -
19 "Heating, Ventilating, and Air-Conditioning."
- 20 E. Structural Performance: Casing panels shall be self-supporting and capable of withstanding the
21 greater of positive/negative 6-inch wg (1500 Pa) or 125 percent of internal static pressure,
22 without exceeding a midpoint deflection of 0.0042 inch/inch (0.0042 mm/mm) of panel span.
- 23 F. Casing Leakage Performance: ASHRAE 111, Class 6 leakage or better at plus or minus 6 inch
24 wg (1500 Pa).
- 25 G. Acoustical Performance: Unit shall be tested by accredited independent laboratory for sound
26 transmission per ASTM E90-85 and E413-73 and sound absorption per ASTM C423-84A and
27 E795-83. Sound power levels (dB) for the unit shall not exceed specified levels. The
28 manufacturer shall provide necessary sound treatment to meet these levels if required.
- 29 H. Condensation: During first year guarantee period, if condensation forms on any section of air
30 handler when unit is operating at design conditions, contractor shall replace or repair unit to
31 correct the situation. Repairs shall not impair unit or component accessibility and future repair
32 ability and inherent access for maintenance. All repairs shall be subject to Engineer's approval.

33 **2.2 CAPACITIES AND CHARACTERISTICS**

- 34 A. Supply Fan:
 - 35 1. Type: SWSI, airfoil unhooded centrifugal fan.
 - 36 2. Class II: AMCA 99-2408.
 - 37 3. Drive: Direct.

- 1 B. Preheat Coil:
- 2 1. Maximum Air-Side, Static-Pressure Drop: 0.25 inches wg (62 Pa).
- 3 2. Maximum Water Pressure Drop: 5 feet of head (14.9 kPa).
- 4 C. Heating Coil:
- 5 1. Maximum Air-Side, Static-Pressure Drop: 0.25 inches wg (62 Pa).
- 6 2. Maximum Water Pressure Drop: 5 feet of head (14.9 kPa).
- 7 D. Cooling Coil:
- 8 1. Maximum Face Velocity: 500 fpm (152 m/s).
- 9 2. Maximum Air-Side, Static-Pressure Drop: 1.0 inches wg (259 Pa).
- 10 3. Maximum Water Pressure Drop: 10 feet of head (29.8 kPa).

11 2.3 MANUFACTURERS

- 12 A. Manufacturers: Subject to compliance with requirements, provide products by one of the
- 13 following:
- 14 1. Daikin Applied.
- 15 2. Trane.
- 16 3. YORK; a Johnson Controls company.

17 2.4 UNIT CASINGS

- 18 A. Frame: Modular and providing overall structural integrity without reliance on casing panels for
- 19 structural support.
- 20 B. Base Rail:
- 21 1. Material: Galvanized steel or Welded structural steel.
- 22 2. Height: 8 inches (200 mm) full perimeter.
- 23 3. Include integral lifting lugs.
- 24 4. Include welded or bolted cross members as required for lateral stability.
- 25 C. Casing Joints: Hermetically sealed at each corner and around entire perimeter.
- 26 D. Double-Wall Construction:
- 27 1. Outside Casing Wall:
- 28 a. Material, G90 Galvanized Steel: Minimum 18 gauge (1.3 mm) thick.
- 29 b. Factory Finish: Provide manufacturer's standard finish.
- 30 2. Inside Casing Wall:
- 31 a. Material, G90 Galvanized Steel: Solid or Perforated, minimum 18 gauge (1.3 mm)
- 32 thick.
- 33 b. Antimicrobial Coating: Applied during the manufacturing process. EPA approved.
- 34 E. Floor Plate:
- 35 1. Material, G90 Galvanized Steel: minimum 16 gauge (1.6 mm) thick.
- 36 2. Antimicrobial Coating: Applied during the manufacturing process. EPA approved.
- 37 F. Casing Insulation:
- 38 1. Materials: Injected polyurethane foam insulation.
- 39 2. Casing Panel R-Value: Minimum R-13.

- 1 3. Insulation Thickness: 2 inches (50 mm).
 2 4. Thermal Break: Provide continuity of insulation with no through-casing metal in casing
 3 walls, floors, or roofs of air-handling unit.
- 4 G. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in
 5 ASHRAE 62.1.
- 6 H. Static-Pressure Classifications:
- 7 1. For Unit Sections Upstream of Fans: Minus 6-inch wg (1500 Pa).
 8 2. For Unit Sections Downstream and Including Fans: 8-inch wg (2000 Pa) .
- 9 I. Doors and Windows:
- 10 1. Doors:
- 11 a. Fabrication: Formed and reinforced, double-wall and insulated panels of same
 12 materials and thicknesses as casing.
 13 b. Hinges: A minimum of two ball-bearing hinges or stainless-steel piano hinge and
 14 two wedge-lever latches, operable from inside and outside. Arrange doors to be
 15 opened against airflow. Provide safety latch retainers on doors so that doors do
 16 not open uncontrollably.
 17 c. Gasket: Neoprene, applied around entire perimeters of panel frames.
 18 d. Size: Large enough to allow for unobstructed access for inspection and
 19 maintenance of air-handling unit's internal components. At least 24 inches (600
 20 mm) wide by full height of unit casing up to a maximum height of 72 inches (1800
 21 mm).
 22 2. Windows:
- 23 a. Construction: Fabricate windows in access panels and doors of double-glazed,
 24 safety glass with an airspace between panes and sealed with interior and exterior
 25 rubber seals.
 26 b. Size: Minimum 6 inches (150 mm), square or round.
- 27 3. Locations and Applications:
- 28 a. Fan Section: Doors, with windows.
 29 b. Access Section: Doors.
 30 c. Access Sections Immediately Upstream and Downstream of Coil Sections: Doors.
 31 d. Damper Section: Doors.
 32 e. Filter Section: Doors large enough to allow periodic removal and installation of
 33 filters.
 34 f. Mixing Section: Doors.
- 35 4. Service Lights: 100-watt LED vaporproof luminaire with individual switched junction box
 36 located outside, adjacent to each access door and panel.
- 37 a. Locations: Each section accessed with door or panel.
- 38 5. Convenience Outlets: One 20-A duplex GFCI receptacle per location with junction box
 39 located on outside casing wall.
- 40 a. Locations: Fan section.
- 41 J. Condensate Drain Pans:

1. Construction:
 - a. Double-wall, stainless-steel sheet with space between walls filled with foam insulation and moisture-tight seal.
2. Drain Connection:
 - a. Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on both ends of pan.
 - b. Minimum Connection Size: NPS 2 (DN 50).
3. Slope: Minimum 0.125-in./ft. (10-mm/mm) slope, to comply with ASHRAE 62.1, in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and from humidifiers and to direct water toward drain connection.
4. Length: Extend drain pan downstream from leaving face for distance to comply with ASHRAE 62.1.
5. Width: Entire width of water producing device.
6. Depth: A minimum of 2 inches (50 mm) deep.
7. Formed sections.
8. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.

19 2.5 FAN, DRIVE, AND MOTOR SECTION

- A. Fan and Drive Assemblies: Statically and dynamically balanced on all three planes and at all bearing points 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. Performance: Select at a maximum total static pressure of 90% of the fan's peak static pressure capability at the specified fan / motor speed.
 2. Shafts: With field-adjustable alignment.
 - a. Turned, ground, and polished hot-rolled steel with keyway.
 3. Shaft Bearings:
 - a. Grease-Lubricated Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing with grease lines extended to outside unit and an L-50 rated life of 200,000.
 4. 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.
 5. Housings, Plenum Fans: Steel frame and panel; fabricated without fan scroll and volute housing. Provide inlet screens for Type SWSI fans.
 6. Plenum Fan Arrays: Steel or aluminum frame with inlet cone and structural framing around each fan built into an array of multiple fans. Provide backdraft dampers at each fan to prevent short circuiting of flow if one fan is not operating.

- 1 a. Each motor shall be wired to a control panel with integral disconnect, individual
 2 motor protection, and control terminals or separate variable frequency drive, as
 3 indicated on the Drawings.
- 4 b.
- 5 7. Airfoil, Centrifugal Fan Wheels (Plenum Fan Wheels): Smooth-curved inlet flange,
 6 backplate, and hollow die-formed airfoil-shaped blades continuously welded at tip flange
 7 and backplate; steel hub riveted to backplate and fastened to shaft with setscrews.
- 8 8. Mounting: For internal vibration isolation. Factory-mount fans with manufacturer's
 9 standard restrained spring vibration isolation mounting devices having a minimum static
 10 deflection of 2 inches (50 mm).
- 11 9. Shaft Lubrication Lines: Extended to a location outside the casing.
- 12 10. Flexible Connector: Factory fabricated with a fabric strip minimum 5-3/4 inches (146 mm)
 13 wide, attached to two strips of minimum 2-3/4-inch- (70-mm-) wide by 0.028-inch- (0.7-
 14 mm-) thick, galvanized-steel sheet or 0.032-inch- (0.8-mm-) thick, aluminum sheets.
- 15 a. Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics,
 16 coatings, and adhesives shall comply with UL 181, Class 1.
- 17 1) Fabric Minimum Weight: 26 oz./sq. yd. (880 g/sq. m).
 18 2) Fabric Minimum Tensile Strength: 480 lbf/inch (84 N/mm) in the warp and
 19 360 lbf/inch (63 N/mm) in the filling.
 20 3) Fabric Minimum Service Temperature Range: Minus 40 to plus 200 deg F
 21 (Minus 40 to plus 93 deg C).
- 22 C. Drive, Direct: Factory-mounted, direct drive.
- 23 D. Drive, Belt: Factory-mounted, V-belt drive, with adjustable alignment and belt tensioning, and
 24 with 1.5 service factor based on fan motor.
- 25 1. Pulleys: Cast iron or cast steel with split, tapered bushing, dynamically balanced at the
 26 factory.
 27 2. Belts: Oil resistant, non-sparking and nonstatic; in matched sets for multiple-belt drives.
- 28 E. Motors:
- 29 1. Comply with NEMA designation, temperature rating, service factor, enclosure type, and
 30 efficiency requirements for motors specified in Section 23 05 13 "Common Motor
 31 Requirements for HVAC Equipment."
 32 2. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will
 33 not require motor to operate in service factor range above 1.0.
 34 3. Enclosure Type: Totally enclosed, fan cooled.
 35 4. Motor Pulleys: Adjustable pitch for use with 7-1/2 hp motors and smaller; fixed pitch for
 36 use with motors larger than 7-1/2 hp. Select pulley size so pitch adjustment is at the
 37 middle of adjustment range at fan design conditions.
 38 5. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical
 39 devices and connections specified in electrical Sections.
 40 6. Mount unit-mounted disconnect switches on exterior of unit.
 41 7. Electrically commutated motors: Provide hand-off-auto (H-O-A) single point switch on
 42 control panel.
- 43 F. Variable-Frequency Motor Controller: Comply with Section 232923 "Variable-Frequency Motor
 44 Controllers."

1 **2.6 COIL SECTION**

2 A. General Requirements for Coil Section:

- 3 1. Comply with AHRI 410.
- 4 2. Fabricate coil section to allow removal and replacement of coil for maintenance and to
- 5 allow in-place access for service and maintenance of coil(s).
- 6 3. Coils shall not act as structural component of unit and shall be removable through side
- 7 and/or top panels of unit without the need to remove and disassemble the entire section
- 8 from the unit.
- 9 4. Enclose coil headers and return bends completely within unit casing.
- 10 5. Coil connections shall be factory sealed with grommets on interior and exterior and
- 11 gasket sleeve between outer wall and liner to minimize air leakage and condensation
- 12 inside panel assembly. If not factory packaged, contractor shall supply all coil connection
- 13 grommets and sleeves.
- 14 6. Vent and drain fittings shall be furnished on coil connections exterior to the air handler.

15 B. Preheat Coils:

- 16 1. Electrical Coils, Controls, and Accessories: Comply with UL 1995.
 - 17 a. Casing Assembly: Slip-in type with galvanized-steel frame.
 - 18 b. Open Heating Elements: Resistance wire of 80 percent nickel and 20 percent
 - 19 chromium supported and insulated by floating ceramic bushings recessed into
 - 20 casing openings, fastened to supporting brackets, and mounted in galvanized-steel
 - 21 frame.
 - 22 c. Overtemperature Protection: Disk-type, automatically resetting, thermal-cutout,
 - 23 safety device; serviceable through terminal box without removing heater from coil
 - 24 section.
 - 25 d. Secondary Protection: Load-carrying, manually resetting or manually replaceable,
 - 26 thermal cutouts; factory wired in series with each heater stage.
 - 27 e. Control Panel: Unit mounted with disconnecting means and overcurrent protection.
 - 28 1) Magnetic contactor.
 - 29 2) Solid-state, stepless pulse controller.
 - 30 3) Step controller.
 - 31 4) Time-delay relay.
 - 32 5) Airflow proving switch.

33 2. Hot-Water Coils: Self-draining.

- 34 a. Piping Connections: Threaded, same end of coil.
- 35 b. Tube Material: Copper.
- 36 c. Tube Thickness: 0.025 inches (0.635 mm).
- 37 d. Tube Diameter: 0.625 inches (16 mm).
- 38 e. Fin Type: Plate.
- 39 f. Fin Material: Aluminum.
- 40 g. Fin Spacing: Maximum 12 fins per inch (2.1 mm).
- 41 h. Fin Thickness: 0.0075 inches (0.19 mm).
- 42 i. Fin and Tube Joint: Mechanical bond.
- 43 j. Headers:
 - 44 1) Seamless copper tube with brazed joints, prime coated.
- 45 k. Frames: Channel frame, 0.0625-inch- (1.58-mm-) thick, stainless steel.
- 46 l. Coil Working-Pressure Ratings: 200 psig (1380 kPa), 325 deg F (163 deg C).
- 47 m. Coating: None.

48 C. Heating Coils:

- 49 1. Hot-Water Coils: Self-draining.

- 1 a. Piping Connections: Threaded, same end of coil.
- 2 b. Tube Material: Copper.
- 3 c. Tube Thickness: 0.025 inches (0.635 mm).
- 4 d. Tube Diameter: 0.625 inches (16 mm).
- 5 e. Fin Type: Plate.
- 6 f. Fin Material: Aluminum.
- 7 g. Fin Spacing: Maximum 12 fins per inch (mm).
- 8 h. Fin Thickness: 0.0075 inches (mm).
- 9 i. Fin and Tube Joint: Mechanical bond.
- 10 j. Headers:
- 11 1) Seamless copper tube with brazed joints, prime coated.
- 12 k. Frames: Channel frame, 0.0625-inch- (1.58-mm-) thick, stainless steel.
- 13 l. Coil Working-Pressure Ratings: 200 psig (1380 kPa), 325 deg F (163 deg C).
- 14 m. Coating: None.

- 15 D. Cooling Coils:
- 16 1. Chilled-Water Coil: Self-draining.
- 17 a. Piping Connections: Threaded, same end of coil.
- 18 b. Tube Material: Copper.
- 19 c. Tube Thickness: 0.025 inches (0.635 mm).
- 20 d. Tube Diameter: 0.625 inches (16 mm)
- 21 e. Maximum Number of Rows: 10.
- 22 f. Fin Type: Plate.
- 23 g. Fin Material: Aluminum.
- 24 h. Fin Spacing: Maximum 12 fins per inch (mm) .
- 25 i. Fin Thickness: 0.0075 inches (0.19 mm).
- 26 j. Fin and Tube Joint: Mechanical bond.
- 27 k. Headers:
- 28 1) Seamless copper tube with brazed joints, prime coated.
- 29 l. Frames: Channel frame, 0.0625-inch- (1.58-mm-) thick, stainless steel.
- 30 m. Coatings: None.
- 31 n. Working-Pressure Ratings: 200 psig (1380 kPa), 325 deg F (163 deg C).

32 2.7 AIR FILTRATION SECTION

- 33 A. Particulate air filtration is specified in Section 23 41 00 "Particulate Air Filtration."
- 34 B. Front- or Back-Access Filter Mounting Frames:
- 35 1. Particulate Air Filter Frames: Aluminum framing members with access for filter servicing,
- 36 cut to size and prepunched for assembly into modules. Vertically support filters to prevent
- 37 deflection of horizontal members without interfering with either filter installation or
- 38 operation.
- 39 a. Sealing: Full periphery foam gaskets.
- 40 C. Side-Access Filter Mounting Frames:
- 41 1. Particulate Air Filter Frames: Match inner casing and outer casing material, and insulation
- 42 thickness. Aluminum track.
- 43 a. Sealing: Incorporate positive-sealing device to ensure seal between gasketed
- 44 material on channels to seal top and bottom of filter cartridge frames to prevent
- 45 bypass of unfiltered air.

1 **2.8 DAMPERS**

- 2 A. Outdoor- and Return-Air Dampers: Low-leakage, double-skin, airfoil-blade, extruded-aluminum
 3 dampers with compressible jamb seals and extruded-vinyl blade edge seals in opposed-blade
 4 arrangement with zinc-plated steel operating rods rotating in stainless steel sleeve bearings
 5 mounted in a single aluminum extruded-aluminum frame, and with operating rods connected
 6 with a common linkage. Leakage rate shall not exceed 4 cfm/sq. ft. (20 L/s per sq. m) at 1-inch
 7 wg (250 Pa) and 8 cfm/sq. ft. (40 L/s per sq. m) at 4-inch wg (1.0 MPa), leakage Class 1.
- 8 B. Damper Operators: Comply with requirements in Section 250923.12 "Control Damper
 9 Accessories."

10 **2.9 ADDITIONAL SECTIONS**

- 11 A. Combination Filter and Mixing Section:
- 12 1. Cabinet support members shall hold 2-inch- (50-mm-) thick, pleated, flat, permanent or
 13 throwaway filters.
- 14 B. Access Sections: Provide to allow access between coils and as otherwise required or indicated.
 15 Access section shall be a minimum of 30 inches (762 mm) deep.
- 16 C. Custom Section(s): Provided by the air handler manufacturer as an integral section of the unit
 17 for field installation of special components.
- 18 D. Inlet and/or Discharge Plenum: Provide with single or multiple openings as indicated.

19 **2.10 SOUND ATTENUATORS**

- 20 A. General Requirements:
- 21 1. Factory fabricated. Provide as an integral section of the air-handling unit to attenuate fan
 22 noise at the source.
- 23 2. Fire Performance Characteristics: Adhesives, sealants, packing materials, and accessory
 24 materials with flame-spread index not exceeding 25 and smoke-developed index not
 25 exceeding 50, ASTM E84.
- 26 3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with
 27 ASHRAE 62.1.
- 28 B. Principal Sound-Absorbing Mechanism:
- 29 1. Dissipative Type: Polymer film-lined absorptive fill material.
- 30 a. Fill Material: Inert and vermin-proof fibrous material.

31 **2.11 MATERIALS**

- 32 A. Steel:
- 33 1. ASTM A36/A36M for carbon structural steel.
- 34 2. ASTM A568/A568M for steel sheet.
- 35 B. Stainless Steel:

- 1 1. Manufacturer's standard grade for casing.
- 2 2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or
- 3 moisture.

- 4 C. Galvanized Steel: ASTM A653/A653M.

- 5 D. Aluminum: ASTM B 09 (ASTM B209M).

- 6 E.

7 **2.12 SOURCE QUALITY CONTROL**

- 8 A. AHRI 430 Certification: Air-handling units and their components shall be factory tested
- 9 according to AHRI 430 and shall be listed and labeled by AHRI.

- 10 B. AHRI 1060 Certification: Air-handling units that include air-to-air energy recovery devices shall
- 11 be factory tested according to AHRI 1060 and shall be listed and labeled by AHRI.

- 12 C. AMCA 301 or AHRI 260: Air-handling unit fan sound ratings shall comply with AMCA 301,
- 13 "Methods for Calculating Fan Sound Ratings from Laboratory Test Data," or AHRI 260, "Sound
- 14 Rating of Ducted Air Moving and Conditioning Equipment."

- 15 D. Fan Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound
- 16 Ratings from Laboratory Test Data." Test fans according to AMCA 300, "Reverberant Room
- 17 Method for Sound Testing of Fans." Fans shall bear AMCA-certified sound ratings seal.

- 18 E. Fan Performance Rating: Factory test fan performance for airflow, pressure, power, air density,
- 19 rotation speed, and efficiency. Rate performance according to AMCA 210, "Laboratory Methods
- 20 of Testing Fans for Aerodynamic Performance Rating."

- 21 F. Water Coils: Factory tested to 300 psig (2070 kPa) according to AHRI 410 and ASHRAE 33.

22 **PART 3 - EXECUTION**

23 **3.1 EXAMINATION**

- 24 A. Examine areas and conditions, with Installer present, for compliance with requirements for
- 25 installation tolerances and other conditions affecting performance of the Work.

- 26 B. Examine casing insulation materials and filter media before air-handling unit installation. Reject
- 27 insulation materials and filter media that are wet, moisture damaged, or mold damaged.

- 28 C. Examine roughing-in for steam, hydronic, and condensate drainage piping systems and
- 29 electrical services to verify actual locations of connections before installation.

- 30 D. Proceed with installation only after unsatisfactory conditions have been corrected.

31 **3.2 DELIVERY, STORAGE, AND HANDLING**

- 32 A. Deliver, store, protect, and handle products to site.

- 1 B. Accept products on site in factory-fabricated protective containers, with factory-installed
- 2 shipping skids. Inspect for damage.
- 3 C. Store in clean dry place and protect from weather and construction traffic. Handle carefully to
- 4 avoid damage to components, enclosures, and finish.
- 5 D. Knockdown and re-assemble air handling unit(s), as required, to accommodate any installation
- 6 limitations. The knockdown and re-assembly of the air handling unit(s) shall be performed by
- 7 personnel approved by the equipment manufacturer, such as not to void the equipment
- 8 warranty.

9 **3.3 INSTALLATION**

- 10 A. Equipment Mounting:
 - 11 1. Install air-handling units on cast-in-place concrete equipment bases with elastomeric
 - 12 mounts. Coordinate sizes and locations of concrete bases with actual equipment
 - 13 provided. Comply with requirements for equipment bases and foundations specified in
 - 14 Division 03
 - 15 2. Comply with requirements for vibration isolation devices specified in Section 23 05 48.13
 - 16 "Vibration Controls for HVAC."
- 17 B. Arrange installation of units to provide access space around air-handling units for service and
- 18 maintenance.
- 19 C. Do not operate fan system until filters (temporary or permanent) are in place. Replace
- 20 temporary filters used during construction and testing, with new, clean filters.
- 21 D. Install filter-gauge, static-pressure taps upstream and downstream of filters. Mount filter gauges
- 22 on outside of filter housing or filter plenum in accessible position. Provide filter gauges on filter
- 23 banks, installed with separate static-pressure taps upstream and downstream of filters.
- 24 E. Connect duct to air-handling units with flexible connections. Comply with requirements in
- 25 Section 23 33 00 "Air Duct Accessories."

26 **3.4 PIPING CONNECTIONS**

- 27 A. Piping installation requirements are specified in other Sections. Drawings indicate general
- 28 arrangement of piping, fittings, and specialties.
- 29 B. Where installing piping adjacent to air-handling unit, allow for service and maintenance.
- 30 C. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.
- 31 D. Connect condensate drain pans using, ASTM B88, Type M (ASTM B88M, Type C) copper
- 32 tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain
- 33 pan and install cleanouts at changes in direction.
- 34 E. Hot- and Chilled-Water Piping: Comply with applicable requirements in Section 23 21 13
- 35 "Hydronic Piping" and Section 23 21 16 "Hydronic Piping Specialties." Install shutoff valve and
- 36 union or flange at each coil supply connection. Install balancing valve and union or flange at
- 37 each coil return connection.

1 **3.5 ELECTRICAL CONNECTIONS**

- 2 A. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and
3 Cables."
- 4 B. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical
5 Systems."
- 6 C. Install electrical devices furnished by manufacturer, but not factory mounted, according to
7 NFPA 70 and NECA 1.
- 8 D. Install nameplate for each electrical connection, indicating electrical equipment designation and
9 circuit number feeding connection.
 - 10 1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in
11 Section 26 05 53 "Identification for Electrical Systems."
 - 12 2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background
13 and engraved white letters at least 1/2 inch (13 mm) high.

14 **3.6 CONTROL CONNECTIONS**

- 15 A. Install control and electrical power wiring to field-mounted control devices.
- 16 B. Connect control wiring according to Section 250523 "Control-Voltage Electrical Power Cables."

17 **3.7 STARTUP SERVICE**

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

1 **3.8 ADJUSTING**

- 2 A. Adjust damper linkages for proper damper operation.
- 3 B. Comply with requirements in Section 23 05 93 "Testing, Adjusting, and Balancing for HVAC" for
4 air-handling system testing, adjusting, and balancing.

5 **3.9 CLEANING**

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

10 **3.10 FIELD QUALITY CONTROL**

- 11 A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and
12 inspect components, assemblies, and equipment installations, including connections.
- 13 B. Perform the following tests and inspections:
- 14 1. Leak Test: After installation, fill water and steam coils with water, and test coils and
15 connections for leaks.
- 16 2. Charge refrigerant coils with refrigerant and test for leaks.
- 17 3. Fan Operational Test: After electrical circuitry has been energized, start units to confirm
18 proper motor rotation and unit operation.
- 19 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and
20 equipment.
- 21 C. Air-handling unit or components will be considered defective if unit or components do not pass
22 tests and inspections.
- 23 D. Prepare test and inspection reports.

24 **3.11 DEMONSTRATION**

- 25 A. Train Owner's maintenance personnel to adjust, operate, and maintain air-handling units.

26 **END OF SECTION 23 73 13.16**

1 **SECTION 23 81 26.11 - AIR-COOLED, SPLIT-SYSTEM AIR-CONDITIONERS (5 TONS AND**
2 **SMALLER)**

3 **PART 1 - GENERAL**

4 **1.1 RELATED DOCUMENTS**

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

7 **1.2 SUMMARY**

- 8 A. Section includes small capacity, air-cooled, split-system air-conditioning and heat-pump units (5
9 tons and smaller) consisting of separate evaporator-fan and compressor-condenser
10 components.

11 **1.3 ACTION SUBMITTALS**

- 12 A. Product Data: For each type of product indicated. Include rated capacities, operating
13 characteristics, and furnished specialties and accessories. Include performance data in terms of
14 capacities, outlet velocities, static pressures, sound power characteristics, motor requirements,
15 and electrical characteristics.
- 16 B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
- 17 1. Detail equipment assemblies and indicate dimensions, weights, loads, required
18 clearances, method of field assembly, components, and location and size of each field
19 connection.
- 20 2. Wiring Diagrams: For power, signal, and control wiring.

21 **1.4 CLOSEOUT SUBMITTALS**

- 22 A. Operation and Maintenance Data: For split-system air-conditioning units to include in
23 emergency, operation, and maintenance manuals.

24 **1.5 MAINTENANCE MATERIAL SUBMITTALS**

- 25 A. Furnish extra materials that match products installed and that are packaged with protective
26 covering for storage and identified with labels describing contents.

- 27 1. Filters: One set(s) for each air-handling unit.

28 **1.6 QUALITY ASSURANCE**

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

- 1 B. ASHRAE Compliance:
- 2 1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for
3 Refrigeration Systems."
- 4 2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor
5 Air Quality," Section 5 - "Systems and Equipment," Section 6 - " Procedures," and
6 Section 7 - "Construction and System Start-up."
- 7 C. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.

8 **1.7 COORDINATION**

- 9 A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-
10 bolt inserts into bases. Concrete, reinforcement, and formwork are specified in Division 03.
- 11 B. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with
12 actual equipment provided.

13 **1.8 WARRANTY**

- 14 A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or
15 replace components of split-system air-conditioning units that fail in materials or workmanship
16 within specified warranty period.
- 17 1. Warranty Period:
- 18 a. For Compressor: Five year(s) from date of Substantial Completion.
- 19 b. For Parts: One year(s) from date of Substantial Completion.
- 20 c. For Labor: One year(s) from date of Substantial Completion.

21 **PART 2 - PRODUCTS**

22 **2.1 MANUFACTURERS**

- 23 A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on
24 Drawings or comparable product by one of the following:
- 25 1. Carrier Corporation; a unit of United Technologies Corp.
- 26 2. Daikin Industries, Ltd.
- 27 3. Lennox Industries, Inc.; Lennox International.
- 28 4. Mitsubishi Electric & Electronics USA, Inc.
- 29 5. Trane.
- 30 6. YORK; a Johnson Controls company.

31 **2.2 INDOOR UNITS (5 TONS (18 kW) OR LESS)**

- 32 A. Concealed Evaporator-Fan Components:
- 33 1. Chassis: Galvanized steel with flanged edges, removable panels for servicing, and
34 insulation on back of panel.

- 1 2. Insulation: Faced, glass-fiber duct liner.
- 2 3. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 206/110.
- 3
- 4 4. 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.
- 5
- 6
- 7
- 8 5. Fan: Forward-curved, double-width wheel of galvanized steel; directly connected to motor.
- 9
- 10 6. Fan Motors:
- 11 a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 23 05 13 "Common Motor Requirements for HVAC Equipment."
- 12
- 13 b. Multitapped, multispeed with internal thermal protection and permanent lubrication.
- 14 c. Wiring Terminations: Connect motor to chassis wiring with plug connection.
- 15
- 16 7. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- 17
- 18 8. Air Filtration Section:
- 19 a. General Requirements for Air Filtration Section:
- 20 1) Comply with NFPA 90A.
- 21 2) Comply with Section 234100 "Particulate Air Filtration" for filters
- 22 3) Filter-Holding Frames: Arranged for flat or angular orientation. Filters shall be removable from one side.
- 23
- 24 b. Extended-Surface, Disposable Panel Filters:
- 25 1) Factory-fabricated, dry, extended-surface type.
- 26 2) Thickness: 1 inch (25 mm).
- 27 3) Mounting Frames: Welded, galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.
- 28
- 29 9. Condensate Drain Pans:
- 30 a. Fabricated with two 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.
- 31
- 32
- 33 1) Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1.
- 34 2) Depth: A minimum of 1 inches (25 mm) deep.
- 35
- 36 b. Single-wall, galvanized-steel sheet or rust-resistant, polycarbonate.
- 37 c. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.
- 38
- 39 1) Minimum Connection Size: NPS 3/4 (DN 19).
- 40 d. Pan-Top Surface Coating: Asphaltic waterproofing compound.
- 41 e. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.
- 42

- 1 B. Wall-Mounted, Evaporator-Fan Components:
- 2 1. Cabinet: Enameled steel with removable panels on front and ends in color selected by
3 Architect, and discharge drain pans with drain connection.
- 4 2. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-
5 expansion valve. Comply with ARI 206/110.
- 6 3. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements; with refractory
7 ceramic support bushings, automatic-reset thermal cutout, built-in magnetic contactors,
8 manual-reset thermal cutout, airflow proving device, and one-time fuses in terminal box
9 for overcurrent protection.
- 10 4. Fan: Direct drive, centrifugal.
- 11 5. Fan Motors:
- 12 a. Comply with NEMA designation, temperature rating, service factor, enclosure type,
13 and efficiency requirements specified in Section 23 05 13 "Common Motor
14 Requirements for HVAC Equipment."
- 15 b. Multitapped, multispeed with internal thermal protection and permanent lubrication.
- 16 c. Enclosure Type: Totally enclosed, fan cooled.
- 17 d. NEMA Premium (TM) efficient motors as defined in NEMA MG 1.
- 18 e. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical
19 devices and connections specified in electrical Sections.
- 20 f. Mount unit-mounted disconnect switches on interior of unit.
- 21 6. Airstream Surfaces: Surfaces in contact with the airstream shall comply with
22 requirements in ASHRAE 62.1.
- 23 7. Condensate Drain Pans:
- 24 a. Fabricated with one percent slope in at least two planes to collect condensate from
25 cooling coils (including coil piping connections, coil headers, and return bends) and
26 humidifiers, and to direct water toward drain connection.
- 27 1) Length: Extend drain pan downstream from leaving face to comply with
28 ASHRAE 62.1.
- 29 2) Depth: A minimum of 1 inch (25 mm) deep.
- 30 b. Single-wall, galvanized-steel sheet.
- 31 c. Drain Connection: Located at lowest point of pan and sized to prevent overflow.
32 Terminate with threaded nipple on one end of pan.
- 33 1) Minimum Connection Size: NPS 3/4 (DN 19).
- 34 d. Pan-Top Surface Coating: Asphaltic waterproofing compound.
- 35 8. Air Filtration Section:
- 36 a. General Requirements for Air Filtration Section:
- 37 1) Comply with NFPA 90A.
- 38 2) Comply with Section 234100 "Particulate Air Filtration" for filters.
- 39 3) Filter-Holding Frames: Arranged for flat. Filters shall be removable from one
40 side.
- 41 b. Extended-Surface, Disposable Panel Filters:
- 42 1) Factory-fabricated, dry, extended-surface type.

