

PROJECT TABLE OF CONTENTS

DIVISION 01 - GENERAL REQUIREMENTS

01100 GENERAL  
01312A QUALITY CONTROL SYSTEM (QCS)  
01320A PROJECT SCHEDULE  
01330 SUBMITTAL PROCEDURES  
01355A ENVIRONMENTAL PROTECTION  
01451A CONTRACTOR QUALITY CONTROL  
01500A TEMPORARY CONSTRUCTION FACILITIES  
01780A CLOSEOUT SUBMITTALS

DIVISION 03 - CONCRETE

03307a CONCRETE FOR MINOR STRUCTURES  
03330a CAST-IN-PLACE ARCHITECTURAL CONCRETE

DIVISION 04 - MASONRY

04200a MASONRY

DIVISION 05 - METALS

05500a MISCELLANEOUS METAL

DIVISION 06 - WOODS & PLASTICS

06100a ROUGH CARPENTRY  
06200a FINISH CARPENTRY  
06410a LAMINATE CLAD ARCHITECTURAL CASEWORK  
06650 SOLID POLYMER (SOLID SURFACING) FABRICATIONS

DIVISION 07 - THERMAL & MOISTURE PROTECTION

07131 ELASTOMERIC SHEET WATERPROOFING  
07413a METAL SIDING  
07600a SHEET METALWORK, GENERAL  
07840a FIRESTOPPING  
07900a JOINT SEALING

DIVISION 08 - DOORS & WINDOWS

08110 STEEL DOORS AND FRAMES  
08210 WOOD DOORS  
08710 DOOR HARDWARE

DIVISION 09 - FINISHES

09250 GYPSUM BOARD  
09310A CERAMIC TILE  
09510 ACOUSTICAL CEILINGS  
09671 SEAMLESS RESINOUS FLOOR SYSTEM  
09900 PAINTS AND COATINGS  
09920 CONTRACTOR COLOR BOARDS

DIVISION 10 - SPECIALTIES

10160A TOILET PARTITIONS

10180 SHOWER DOOR  
10260 WALL AND CORNER GUARDS  
10500 LOCKERS  
10800 TOILET ACCESSORIES

DIVISION 13 - SPECIAL CONSTRUCTION

13080 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT  
13850A FIRE DETECTION AND ALARM SYSTEM, DIRECT CURRENT LOOP  
13930A WET PIPE SPRINKLER SYSTEM, FIRE PROTECTION  
13955A AQUEOUS FILM-FORMING FOAM (AFFF) FIRE PROTECTION SYSTEM

DIVISION 15 - MECHANICAL

15070A AT/FORCE PROTECTION FOR MECHANICAL EQUIPMENT  
15080A THERMAL INSULATION FOR MECHANICAL SYSTEMS  
15182A REFRIGERANT PIPING  
15190A GAS PIPING SYSTEMS  
15400A PLUMBING, GENERAL PURPOSE  
15566A WARM AIR HEATING SYSTEMS  
15569A WATER AND STEAM HEATING; OIL, GAS OR BOTH; UP TO 20 MBTUH  
15700A UNITARY HEATING AND COOLING EQUIPMENT  
15895A AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM  
15951A DIRECT DIGITAL CONTROL FOR HVAC  
15990A TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS  
15995A COMMISSIONING OF HVAC SYSTEMS

DIVISION 16 - ELECTRICAL

16070A AT/FORCE PROTECTION FOR ELECTRICAL EQUIPMENT  
16415A ELECTRICAL WORK, INTERIOR  
16710A PREMISES DISTRIBUTION SYSTEM

-- End of Project Table of Contents --

SECTION TABLE OF CONTENTS

DIVISION 13 - SPECIAL CONSTRUCTION

SECTION 13080

SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT

04/99

PART 1 GENERAL

- 1.1 REFERENCES
- 1.2 SYSTEM DESCRIPTION
  - 1.2.1 General Requirements
  - 1.2.2 Miscellaneous Equipment and Systems
- 1.3 SUBMITTALS
- 1.4 EQUIPMENT REQUIREMENTS
  - 1.4.1 Rigidly Mounted Equipment
  - 1.4.2 Nonrigid or Flexibly-Mounted Equipment

PART 2 PRODUCTS

- 2.1 BOLTS AND NUTS
- 2.2 SWAY BRACING

PART 3 EXECUTION

- 3.1 BRACING
- 3.2 BUILDING DRIFT
- 3.3 ANCHOR BOLTS
  - 3.3.1 Cast-In-Place
  - 3.3.2 Expansion or Chemically Bonded Anchors
    - 3.3.2.1 General Testing
    - 3.3.2.2 Torque Wrench Testing
- 3.4 RESILIENT VIBRATION ISOLATION DEVICES
  - 3.4.1 Resilient and Spring-Type Vibration Devices
  - 3.4.2 Multidirectional Seismic Snubbers
- 3.5 SWAY BRACES FOR PIPING
  - 3.5.1 Longitudinal Sway Bracing
  - 3.5.2 Anchor Rods, Angles, and Bars
  - 3.5.3 Maximum Length for Anchor Braces
  - 3.5.4 Bolts
- 3.6 EQUIPMENT SWAY BRACING
  - 3.6.1 Suspended Equipment and Light Fixtures
  - 3.6.2 Floor or Pad Mounted Equipment
    - 3.6.2.1 Shear Resistance
    - 3.6.2.2 Overturning Resistance

-- End of Section Table of Contents --

## SECTION 13080

SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT  
04/99

## PART 1 GENERAL

## 1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

## AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 36/A 36M	(1997a) Carbon Structural Steel
ASTM A 53	(1999) Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A 153/A 153M	(1998) Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A 307	(1997) Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength
ASTM A 500	(1999) Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
ASTM A 563	(1997) Carbon and Alloy Steel Nuts
ASTM A 572/A 572M	(1999) High-Strength Low-Alloy Columbium-Vanadium Structural Steel
ASTM A 603	(1998) Zinc-Coated Steel Structural Wire Rope
ASTM A 653/A 653M	(1999) Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM E 488	(1996) Strength of Anchors in Concrete and Masonry Elements

## ASME INTERNATIONAL (ASME)

ASME B18.2.1	(1996) Square and Hex Bolts and Screws (Inch Series)
ASME B18.2.2	(1987; R 1999) Square and Hex Nuts (Inch Series)

## U.S. ARMY CORPS OF ENGINEERS (USACE)

TI 809-04	(1998) Seismic Design for Buildings
-----------	-------------------------------------

## 1.2 SYSTEM DESCRIPTION

### 1.2.1 General Requirements

The requirements for seismic protection measures described in this section shall be applied to the mechanical equipment and systems outlined in Section 15070 SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT, the electrical equipment and systems outlined in Section 16070 SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT, and the miscellaneous equipment and systems listed below. Seismic protection requirements shall be in accordance with TI 809-04 and additional data furnished by the Contracting Officer, and shall be provided in addition to any other requirements called for in other sections of these specifications. The design for seismic protection shall be based on a Seismic Use Group I building occupancy and on site response coefficients for  $S_{MS} = 0.14$  and  $S_{M1} = 0.06$ . Resistance to lateral forces induced by earthquakes shall be accomplished without consideration of friction resulting from gravity loads. The basic force formulas, for Ground Motions A and B in Chapter 3 of TI 809-04, use the design spectral response acceleration parameters for the performance objective of the building, not for equipment in the building; therefore, corresponding adjustments to the formulas shall be required.

### 1.2.2 Miscellaneous Equipment and Systems

The bracing for the following miscellaneous equipment and systems shall be developed by the Contractor in accordance with the requirements of this specification:

Storage cabinets	Furnishings
Storage Racks	
Shelving	
Partitions	

## 1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

#### SD-02 Shop Drawings

Bracing; G, EC  
Resilient Vibration Isolation Devices; G, EC  
Equipment Requirements; G, EC

Detail drawings along with catalog cuts, templates, and erection and installation details, as appropriate, for the items listed. Submittals shall be complete in detail; shall indicate thickness, type, grade, class of metal, and dimensions; and shall show construction details, reinforcement, anchorage, and installation with relation to the building construction. For equipment and systems in buildings that have a performance objective higher than life-safety, the drawings shall be stamped by the registered engineer who stamps the calculations required above.

#### SD-03 Product Data

Bracing; G, EC  
 Equipment Requirements; G, EC

Copies of the design calculations with the detail drawings. Calculations shall be stamped by a registered engineer and shall verify the capability of structural members to which bracing is attached for carrying the load from the brace.

#### 1.4 EQUIPMENT REQUIREMENTS

##### 1.4.1 Rigidly Mounted Equipment

Rigidly mounted equipment is defined as having a period of vibration of 0.06 seconds or less for the equipment plus its mounting. Equipment with a fundamental period greater than 0.06 seconds should be assumed to be flexibly mounted or nonrigid. RIGIDLY MOUNTED EQUIPMENT to be furnished under this contract shall be constructed and assembled to withstand the seismic forces specified in TI 809-04, Chapter 10. For any rigid equipment which is rigidly attached on both sides of a building expansion joint, flexible joints for piping, electrical conduit, etc., that are capable of accommodating displacements equal to the full width of the joint in both orthogonal directions, shall be provided.

##### 1.4.2 Nonrigid or Flexibly-Mounted Equipment

The following specific items of equipment to be furnished: Flexibly mounted shall be constructed and assembled to resist a horizontal lateral force of 0.65 times the operating weight of the equipment at the vertical center of gravity of the equipment.

### PART 2 PRODUCTS

#### 2.1 BOLTS AND NUTS

Squarehead and hexhead bolts, and heavy hexagon nuts, ASME B18.2.1, ASME B18.2.2, or ASTM A 307 for bolts and ASTM A 563 for nuts. Bolts and nuts used underground and/or exposed to weather shall be galvanized in accordance with ASTM A 153/A 153M.

#### 2.2 SWAY BRACING

Material used for members listed in this section, shall be structural steel conforming with the following:

- a. Plates, rods, and rolled shapes, ASTM A 36/A 36M. If the Contractor does the design, both ASTM A 36/A 36M and ASTM A 572/A 572M, grade 503 will be allowed.
- b. Wire rope, ASTM A 603.
- c. Tubes, ASTM A 500, Grade B.
- d. Pipes, ASTM A 53, Type E or S, Grade B.
- e. Light gauge angles, less than 6 mm thickness, ASTM A 653/A 653M.

### PART 3 EXECUTION

### 3.1 BRACING

Bracing shall conform to the arrangements shown. Trapeze-type hanger shall be secured with not less than two 13 mm bolts.

### 3.2 BUILDING DRIFT

Sway braces for a piping run shall not be attached to two dissimilar structural elements of a building that may respond differentially during an earthquake unless a flexible joint is provided.

### 3.3 ANCHOR BOLTS

#### 3.3.1 Cast-In-Place

Floor or pad mounted equipment shall use cast-in-place anchor bolts, except as specified below. One nut shall be provided on each bolt. Anchor bolts shall conform to ASTM A 307. Anchor bolts shall have an embedded straight length equal to at least 12 times nominal diameter of the bolt. Anchor bolts that exceed the normal depth of equipment foundation piers or pads shall either extend into concrete floor or the foundation shall be increased in depth to accommodate bolt lengths.

#### 3.3.2 Expansion or Chemically Bonded Anchors

Expansion or chemically bonded anchors shall not be used unless test data in accordance with ASTM E 488 has been provided to verify the adequacy of the specific anchor and application. Expansion or chemically bonded anchors shall not be used to resist pull-out in overhead and wall installations if the adhesive is manufactured with temperature sensitive epoxies and the location is accessible to a building fire. Expansion and chemically bonded anchors shall be installed in accordance with the manufacturer's recommendations. The allowable forces shall be adjusted for the spacing between anchor bolts and the distance between the anchor bolt and the nearest edge, as specified by the manufacturer.

##### 3.3.2.1 General Testing

Expansion and chemically bonded anchors shall be tested in place after installation. The tests shall occur not more than 24 hours after installation of the anchor and shall be conducted by an independent testing agency; testing shall be performed on random anchor bolts as described below.

##### 3.3.2.2 Torque Wrench Testing

Torque wrench testing shall be done on not less than 50 percent of the total installed expansion anchors and at least one anchor for every piece of equipment containing more than two anchors. The test torque shall equal the minimum required installation torque as required by the bolt manufacturer. Torque wrenches shall be calibrated at the beginning of each day the torque tests are performed. Torque wrenches shall be recalibrated for each bolt diameter whenever tests are run on bolts of various diameters. The applied torque shall be between 20 and 100 percent of wrench capacity. The test torque shall be reached within one half turn of the nut, except for 9 mm sleeve anchors which shall reach their torque by one quarter turn of the nut. If any anchor fails the test, similar anchors not previously tested shall be tested until 20 consecutive anchors pass.

Failed anchors shall be retightened and retested to the specified torque; if the anchor still fails the test it shall be replaced.

3.4 RESILIENT VIBRATION ISOLATION DEVICES

Where the need for these devices is determined, based on the magnitude of the design seismic forces, selection of anchor bolts for vibration isolation devices and/or snubbers for equipment base and foundations shall follow the same procedure as in paragraph ANCHOR BOLTS, except that an equipment weight equal to five times the actual equipment weight shall be used.

3.4.1 Resilient and Spring-Type Vibration Devices

Vibration isolation devices shall be selected so that the maximum movement of equipment from the static deflection point shall be 13 mm.

3.4.2 Multidirectional Seismic Snubbers

Multidirectional seismic snubbers employing elastomeric pads shall be installed on floor- or slab-mounted equipment. These snubbers shall provide 6 mm free vertical and horizontal movement from the static deflection point. Snubber medium shall consist of multiple pads of cotton duct and neoprene or other suitable materials arranged around a flanged steel trunnion so both horizontal and vertical forces are resisted by the snubber medium.

3.5 SWAY BRACES FOR PIPING

Transverse sway bracing for steel and copper pipe shall be provided at intervals not to exceed those shown on the drawings. Transverse sway bracing for pipes of materials other than steel and copper shall be provided at intervals not to exceed the hanger spacing as specified in Section 15400 PLUMBING, GENERAL PURPOSE. Bracing shall consist of at least one vertical angle 50 x 50 mm x 16 gauge and one diagonal angle of the same size.

3.5.1 Longitudinal Sway Bracing

Longitudinal sway bracing shall be provided in accordance with Section 15070 SEISMIC CONTROL FOR MECHANICAL EQUIPMENT.

3.5.2 Anchor Rods, Angles, and Bars

Anchor rods, angles, and bars shall be bolted to either pipe clamps or pipe flanges at one end and cast-in-place concrete or masonry insert or clip angles bolted to the steel structure on the other end. Rods shall be solid metal or pipe as specified below. Anchor rods, angles, and bars shall not exceed lengths given in the tabulation below.

3.5.3 Maximum Length for Anchor Braces

Type	Size (millimeters)	Maximum Length* (meters)
Angles	38 x 38 x 6	1.5
	50 x 50 x 6	2.0
	64 x 38 x 6	2.5

Type	Size (millimeters)	Maximum Length* (meters)
	75 x 64 x 6	2.5
	75 x 75 x 6	3.0
Rods	91	1.0
	22	1.0
Flat Bars	38 x 6	0.4
	50 x 6	0.4
	50 x 10	0.5
Pipes (40s)	25	2.0
	32	2.8
	40	3.2
	50	4.0

3.5.4 Bolts

Bolts used for attachment of anchors to pipe and structure shall be not less than 13 mm diameter.

3.6 EQUIPMENT SWAY BRACING

3.6.1 Suspended Equipment and Light Fixtures

Equipment sway bracing shall be provided for items supported from overhead floor or roof structural systems, including light fixtures. Braces shall consist of angles, rods, wire rope, bars, or pipes arranged as shown and secured at both ends with not less than 13 mm bolts. Sufficient braces shall be provided for equipment to resist a horizontal force equal to 0.65 times the weight of equipment without exceeding safe working stress of bracing components. Details of equipment bracing shall be submitted for acceptance. In lieu of bracing with vertical supports, these items may be supported with hangers inclined at 45 degrees directed up and radially away from equipment and oriented symmetrically in 90-degree intervals on the horizontal plane, bisecting the angles of each corner of the equipment, provided that supporting members are properly sized to support operating weight of equipment when hangers are inclined at a 45-degree angle.

3.6.2 Floor or Pad Mounted Equipment

3.6.2.1 Shear Resistance

Floor mounted equipment shall be bolted to the floor. Requirements for the number and installation of bolts to resist shear forces shall be in accordance with paragraph ANCHOR BOLTS.

3.6.2.2 Overturning Resistance

The ratio of the overturning moment from seismic forces to the resisting moment due to gravity loads shall be used to determine if overturning forces need to be considered in the sizing of anchor bolts. Calculations shall be provided to verify the adequacy of the anchor bolts for combined shear and overturning.

-- End of Section --



SECTION TABLE OF CONTENTS

DIVISION 13 - SPECIAL CONSTRUCTION

SECTION 13955A

AQUEOUS FILM-FORMING FOAM (AFFF) FIRE PROTECTION SYSTEM

12/01

PART 1 GENERAL

- 1.1 REFERENCES
- 1.2 SUBMITTALS
- 1.3 SUBMITTAL PREPARER'S QUALIFICATIONS
- 1.4 INSTALLER'S QUALIFICATIONS
- 1.5 REGULATORY REQUIREMENTS

PART 2 PRODUCTS

- 2.1 STANDARD PRODUCTS
- 2.2 REQUIREMENTS FOR FIRE PROTECTION SERVICE
- 2.3 PRESSURE RATINGS
- 2.4 NAMEPLATES
- 2.5 ABOVEGROUND PIPING SYSTEMS HANDLING WATER OR AFFF SOLUTION
  - 2.5.1 Pipe
  - 2.5.2 Grooved Fittings and Couplings
  - 2.5.3 Non-Grooved Fittings
  - 2.5.4 Flanges and Gaskets
    - 2.5.4.1 Bolts
    - 2.5.4.2 Nuts
    - 2.5.4.3 Washers
  - 2.5.5 Pipe Hangers
  - 2.5.6 Control Valve
  - 2.5.7 Check Valve
- 2.6 ABOVEGROUND PIPING SYSTEMS HANDLING AFFF CONCENTRATE
  - 2.6.1 Pipe
  - 2.6.2 Fittings
  - 2.6.3 Pipe Hangers
  - 2.6.4 Control Valves
- 2.7 AFFF CONCENTRATE CONTROL VALVE ASSEMBLY
- 2.8 VALVE SUPERVISORY (TAMPER) SWITCH

PART 3 EXECUTION

- 3.1 INSTALLATION
  - 3.1.1 Aboveground Piping
    - 3.1.1.1 Joints
    - 3.1.1.2 Reducers
    - 3.1.1.3 Sprinkler Riser Nipples (Sprigs)
    - 3.1.1.4 Sprinkler Deflectors
    - 3.1.1.5 Pipe Supports and Hangers
    - 3.1.1.6 Pipe Penetrations
    - 3.1.1.7 Piping Pitch
    - 3.1.1.8 Escutcheons
    - 3.1.1.9 Drains

- 3.1.1.10 Identification Signs
- 3.2 PIPE PAINTING AND LABELING
  - 3.2.1 Painting
  - 3.2.2 Pipe Identification
- 3.3 PRELIMINARY TESTS
  - 3.3.1 Hydrostatic Tests
  - 3.3.2 Alarm Check and Automatic Water Control Valves
  - 3.3.3 Nozzles
  - 3.3.4 AFFF Concentrate System
  - 3.3.5 Control System Tests
- 3.4 FINAL TEST
  - 3.4.1 Requirements
    - 3.4.1.1 Pretest Requirements
    - 3.4.1.2 Videotaping
    - 3.4.1.3 Manufacturer's Services
    - 3.4.1.4 Materials and Equipment
    - 3.4.1.5 Facility and Environmental Protection
  - 3.4.2 Control System Tests
  - 3.4.3 AFFF Proportioning System Tests
  - 3.4.4 Post-discharge Test Requirements

-- End of Section Table of Contents --

## SECTION 13955A

AQUEOUS FILM-FORMING FOAM (AFFF) FIRE PROTECTION SYSTEM  
12/01

## PART 1 GENERAL

## 1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

## AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI A13.1 (1996) Scheme for the Identification of Piping Systems

## AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 183 (1998) Carbon Steel Track Bolts and Nuts

ASTM A 193/A 193M (2001a) Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service

ASTM A 312/A 312M (2000) Seamless and Welded Austenitic Stainless Steel Pipes

ASTM A 351/A 351M (2000) Castings, Austenitic, Austenitic-Ferritic (Duplex), for Pressure-Containing Parts

ASTM A 403/A 403M (2000) Wrought Austenitic Stainless Steel Piping Fittings

ASTM A 449 (2000) Quenched and Tempered Steel Bolts and Studs

ASTM A 47/A 47M (1999) Ferritic Malleable Iron Castings

ASTM A 53/A 53M (2001) Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

ASTM A 536 (1984; R 1999e1) Ductile Iron Castings

ASTM A 795 (2000) Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Fire Protection Use

ASTM F 436M (1993) Hardened Steel Washers (Metric)

## ASME INTERNATIONAL (ASME)

ASME B16.1 (1998) Cast Iron Pipe Flanges and Flanged Fittings

ASME B16.3 (1998) Malleable Iron Threaded Fittings

ASME B16.4 (1998) Gray Iron Threaded Fittings

FACTORY MUTUAL ENGINEERING AND RESEARCH (FM)

FM P7825a (1998) Approval Guide Fire Protection

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 13 (1999) Installation of Sprinkler Systems

NFPA 16 (1999) Installation of Deluge Foam-Water Sprinkler and Foam-Water Spray Systems

NFPA 16A (1994) Installation of Closed-Head Foam-Water Sprinkler Systems

NATIONAL INSTITUTE FOR CERTIFICATION IN ENGINEERING TECHNOLOGIES (NICET)

NICET 1014-7 (1995) Program Detail Manual for Certification in the Field of Fire Protection Engineering Technology (Field Code 003) Subfield of Automatic Sprinkler System Layout

UNDERWRITERS LABORATORIES (UL)

UL Fire Prot Dir (1999) Fire Protection Equipment Directory

## 1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

### SD-02 Shop Drawings

#### AFFF Systems; G, EC

Detail drawings conforming to the requirements prescribed in NFPA 13; drawings shall be 841 x 594 mm. Drawings shall include plan and elevation views which establish that the equipment will fit the allotted spaces with clearance for installation and maintenance. Each set of drawings shall include the following:

c. Piping plan for each each nozzle system. Nozzles and associated piping shall be shown. Abbreviated presentation forms will not be accepted. Each type of fitting used and the locations of bushings, reducing couplings, and welded joints shall be identified. A separate plan shall be provided for each overhead sprinkler system and each nozzle system.

d. Piping plan and isometric drawing of the AFFF concentrate system and details of all associated valves, fittings, and other components.

i. Details of each type of pipe hanger, sway bracing for earthquake protection.

#### As-built Drawings; G, EC

One set of reproducible and six copies, within 14 calendar days after successful completion of required testing. A separate set of approved submittal drawings of the overall system, marked up to indicate as-built conditions, shall be maintained on site. These drawings shall be maintained in a current condition at all times and shall be made available for review immediately upon request during normal working hours. Variations from the approved drawings, for whatever reason, including those occasioned by modifications, change orders, optional materials, and/or required for coordination between trades shall be indicated in sufficient detail to accurately reflect the as-built conditions.

#### SD-03 Product Data

##### Materials and Equipment; G, EC

Manufacturer's catalog data for each separate piece of equipment proposed for use in the system. Data shall indicate the name of the manufacturer of each item of equipment, with data highlighted to indicate model, size, options, etc. proposed for installation. In addition, a complete equipment list with equipment description, model number, and quantity shall be provided.

##### Spare Parts; G, EC

Spare parts data for each different item of material and equipment specified. The data shall include a complete list of parts and supplies, with current unit prices and source of supply, and a list of parts recommended by the manufacturer to be replaced after 1 year and 3 years of service. A list of special tools and test equipment required for maintenance and testing of the products supplied by the Contractor shall be included.

##### Post-discharge Test Requirements; G, EC

Details of method proposed for required tests at Final Acceptance, including step-by-step test procedures; list of equipment to be used; names, titles, and affiliations and qualifications of personnel who will participate in the tests; methods for protecting the facility and equipment during testing; means for containing the AFFF solution during discharge tests; and proposed means for disposal. Test plan shall include a drawing showing proposed number and arrangement of fire hoses and nozzles proposed for use in testing foam proportioners. Blank forms the Contractor plans to use to record test results shall be included.

## SD-06 Test Reports

Tests; G, EC

Reports for tests, as follows:

- a. Reports as outlined in NFPA 13 documenting results of flushing and hydrostatic tests.
- b. Trip tests of alarm check and automatic water control valves.
- c. Test report of AFFF concentrate proportioning system. Report shall include all pressure readings and settings of pumps, pressure sustaining valves, relief valves and similar system components. Report shall include conductivity readings for foam samples taken from each AFFF proportioner. Report shall be signed by the factory-trained technical representative employed by the AFFF concentrate manufacturer.
- d. Test report of the foam system control panel and initiating and indicating devices. Report shall include a unique identifier for each device with an indication of test results. Report shall be signed by the factory-trained technician employed by the control panel manufacturer.
- e. Videotapes of tests specified to be recorded.

## 1.3 SUBMITTAL PREPARER'S QUALIFICATIONS

The fire protection system submittals, including as-built drawings, shall be prepared by an individual who is either a registered professional engineer with ten years experience designing AFFF systems or who is certified as a Level IV Technician by National Institute for Certification in Engineering Technologies (NICET) in the Automatic Sprinkler System Layout subfield of Fire Protection Engineering Technology in accordance with NICET 1014-7.

## 1.4 INSTALLER'S QUALIFICATIONS

The installer shall be experienced and regularly engaged in the installation of the type and complexity of fire protection system included in this project. A statement prior to submittal of any other data or drawings, that the proposed installer is regularly engaged in the installation of the type and complexity of system included in this project shall be provided. In addition, data identifying the locations of at least three systems recently installed by the proposed installer which are comparable to the system specified shall be submitted. Contractor shall certify that each system has performed satisfactorily, in the manner intended, for a period of not less than 6 months.

## 1.5 REGULATORY REQUIREMENTS

The advisory provisions of NFPA standards and recommended practices specified shall be considered mandatory, as though the word "shall" had been substituted for "should" wherever it appears. In the event of a conflict between referenced NFPA standards and this specification, this specification shall govern. Reference to "authority having jurisdiction"

shall be interpreted to mean the Contracting Officer.

## PART 2 PRODUCTS

### 2.1 STANDARD PRODUCTS

Materials and equipment shall be standard products of a manufacturer regularly engaged in the manufacture of such products and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening.

### 2.2 REQUIREMENTS FOR FIRE PROTECTION SERVICE

All equipment and material shall have been tested by Underwriters Laboratories, and listed in UL Fire Prot Dir or approved by Factory Mutual and listed in FM P7825a. Where the terms "listed" or "approved" appear in this specification, such shall mean listed in UL Fire Prot Dir or FM P7825a. The omission of these terms under the description of any item of equipment described shall not be construed as waiving this requirement.

### 2.3 PRESSURE RATINGS

Valves, fittings, couplings, proportioners, alarm switches, strainers, and similar devices shall be rated for the maximum working pressures that can be experienced in the system, but in no case less than 1200 kPa .

### 2.4 NAMEPLATES

Major components of equipment shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate permanently affixed to the item of equipment.

### 2.5 ABOVEGROUND PIPING SYSTEMS HANDLING WATER OR AFFF SOLUTION

#### 2.5.1 Pipe

Pipe shall be standard weight conforming to ASTM A 795 or ASTM A 53/A 53M. Pipe 150 mm diameter and smaller shall be Schedule 40. Pipe shall be marked as to the brand or name of the manufacturer, kind of pipe and the ASTM designation in accordance with the "Product Marking" provisions of the ASTM standard.

#### 2.5.2 Grooved Fittings and Couplings

Grooved fittings, couplings and bolts shall be provided by the same manufacturer. Fittings and couplings shall be malleable iron complying with ASTM A 47/A 47M or ductile iron complying with ASTM A 536. Couplings shall be of the rigid type except that flexible type will be provided where flexible joints are specifically required by NFPA 13. Coupling gaskets shall be Grade E (EPDM) approved for dry pipe fire protection service. Gasket shall be the flush type that fills the entire cavity between the coupling and the pipe. Nuts and bolts shall be heat-treated steel conforming to ASTM A 183 and shall be cadmium plated or zinc electroplated.

#### 2.5.3 Non-Grooved Fittings

Non-grooved fittings shall be threaded or flanged. Threaded fittings shall be cast iron conforming to ASME B16.4 or malleable iron conforming to ASME

B16.3. Flanged fittings shall be cast iron conforming to ASME B16.1. Fittings into which sprinklers, drop nipples or riser nipples (sprigs) are screwed shall be threaded type. Plain-end fittings with mechanical couplings, fittings which require drilling a hole in the pipe, and fittings which use steel gripping devices to bite into the pipe, shall not be used.

#### 2.5.4 Flanges and Gaskets

Flanges shall conform to NFPA 13 and ASME B16.1. Flanges shall be the type that are welded or threaded to the pipe. Flanges which are bolted to grooved pipe will not be permitted. Gaskets shall be full face type EPDM or other approved material.

##### 2.5.4.1 Bolts

Bolts shall be ASTM A 449, Type 1. Bolts shall extend no less than three full threads beyond the nut with bolts tightened to the required torque.

##### 2.5.4.2 Nuts

Nuts shall be ASTM A 193/A 193M, Grade 5.

##### 2.5.4.3 Washers

Washers shall meet the requirements of ASTM F 436M . Flat circular washers shall be provided under all bolt heads and nuts.

#### 2.5.5 Pipe Hangers

Hangers shall be listed in UL Fire Prot Dir or FM P7825a and be of the type suitable for the application, construction and size pipe involved.

#### 2.5.6 Control Valve

Unless otherwise indicated, valves shall be indicating type in accordance with NFPA 13. Valves 65 mm and larger shall be flanged outside screw and yoke (OS&Y) type.

#### 2.5.7 Check Valve

Check valves 100 mm and larger shall be flanged, swing type, cast or ductile iron body and cover, cast or ductile iron clapper with replaceable EPDM rubber facing. Valves shall be suitable for either vertical or horizontal mounting and equipped with a removable handhole cover. The direction of flow shall be indicated by an arrow cast in the valve body. The valve body shall include plugged pipe thread connections for a 50 mm drain.

### 2.6 ABOVEGROUND PIPING SYSTEMS HANDLING AFFF CONCENTRATE

#### 2.6.1 Pipe

Pipe shall be standard weight stainless steel conforming to ASTM A 312/A 312M, Grade TP 304L.

#### 2.6.2 Fittings

Seamless socket weld type or flanged type fittings shall conform to ASTM A 403/A 403M, Grade WP 304L, and shall be compatible with the pipe. Grooved

type fittings and couplings shall be of Type 316 Stainless Steel conforming to ASTM A 351/A 351M.

### 2.6.3 Pipe Hangers

Hangers shall be listed in UL Fire Prot Dir or FM P7825a and be of the type suitable for the application, construction and size pipe involved.

### 2.6.4 Control Valves

Valve shall be indicating type with full port ball and operating handle that indicates the on/off position of the valve. Unit shall be socket weld or flanged type. Valve body and ball shall be of 316 stainless steel complying with ASTM A 351/A 351M. The valve handle shall be provided with a suitable and substantial means for securing the valve open with a key-operated locking device.

## 2.7 AFFF CONCENTRATE CONTROL VALVE ASSEMBLY

Assembly shall be specifically designed and constructed to control AFFF concentrate to proportioners and shall be arranged to open upon application of water or AFFF solution pressure from the alarm check or automatic water control valve to which it is connected. Valve shall be a listed or approved automatic control valve specifically intended for this application or a full port ball valve. All components shall be constructed of brass, bronze or stainless steel, except that the internal portions of listed or approved fire protection valves subjected to AFFF concentrate may be provided with a coating warranted by the manufacturer to protect the valve from the deleterious effects of the concentrate. All components shall be rated for working pressure of 1200 kPa or maximum working pressure to which they could be subjected, whichever is greater. Valve shall be certified by the manufacturer to be operable with water inlet pressure as low as 207 kPa . Valve components shall be brass, bronze or stainless steel.

## 2.8 VALVE SUPERVISORY (TAMPER) SWITCH

Switch shall be designed to monitor the open condition of each water or AFFF concentrate control valve to which it is mounted. It shall include a cast aluminum housing, tamper proof cover, two sets of single pole, double throw (SPDT) contacts and brackets and J-bolts needed for mounting. Removal of the cover shall cause both switches to operate.

## PART 3 EXECUTION

### 3.1 INSTALLATION

#### 3.1.1 Aboveground Piping

Piping shall be installed straight and bear evenly on hangers and supports. Preaction sprinkler system piping shall be pitched as if it were being installed in areas subject to freezing. Piping shall be concealed in areas with suspended ceiling and shall be inspected, tested and approved before being concealed.

##### 3.1.1.1 Joints

Pipe joints shall conform to NFPA 13. Not more than four threads shall show after joint is made up. Joint compound shall be applied to male

threads only. Joints shall be faced true, provided with gaskets and made square and tight. Flanged joints or mechanical groove couplings shall be provided where indicated or required by NFPA 13. Grooved pipe and fittings shall be prepared in accordance with the manufacturer's latest published installation instructions. All grooved couplings and fittings shall be from the same manufacturer. Grooved joints shall not be used in concealed locations, such as behind solid walls or ceilings, unless an access panel is shown on the drawings for servicing or adjusting the joint.

#### 3.1.1.2 Reducers

Reductions in pipe sizes shall be made with one-piece tapered reducing fittings. The use of grooved-end or rubber-gasketed reducing couplings will not be permitted. When standard fittings of the required size are not manufactured, single bushings of the face type will be permitted. Where used, face bushings shall be installed with the outer face flush with the face of the fitting opening being reduced. Bushings shall not be used in elbow fittings, in more than one outlet of a tee, in more than two outlets of a cross, or where the reduction in size is less than 13 mm .

#### 3.1.1.3 Sprinkler Riser Nipples (Sprigs)

Riser nipples (sprigs) 25 mm in size between sprinkler branch lines and individual sprinklers shall not be used unless necessitated by roof or ceiling conditions. In such cases, fittings shall not be installed between the branch line tee and the reducing coupling below the sprinkler.

#### 3.1.1.4 Sprinkler Deflectors

Sprinkler deflectors shall be installed parallel to the roof or ceiling. Deflector distances from the underside of the roof or ceiling shall be in accordance with NFPA 13 except that in no case shall distance exceed 300 mm . Sprinkler clearances from obstructions shall be in accordance with NFPA 13.

#### 3.1.1.5 Pipe Supports and Hangers

Installation methods outlined in NFPA 13 are mandatory. Protection of piping against damage from earthquakes shall be provided. Longitudinal and lateral sway bracing shall be provided for piping 65 mm diameter and larger.

#### 3.1.1.6 Pipe Penetrations

Cutting structural members for passage of pipes or for pipe-hanger fastenings will not be permitted. Pipes penetrating concrete or masonry walls or concrete floors shall be provided with pipe sleeves fitted into place at the time of construction through its respective wall or floor, and shall be cut flush with each surface. Sleeve sizes and clearance between pipe and sleeve shall be in accordance with NFPA 13. Where pipes pass through fire walls, fire partitions, or floors, a fire seal shall be placed between the pipe and sleeve in accordance with Section 07840A FIRESTOPPING.

#### 3.1.1.7 Piping Pitch

Piping shall be pitched to the main drain or to auxiliary drains provided as required to facilitate draining. Branch lines shall be pitched at least 4 mm in 1 m and crossmains and feedmains shall be pitched to at least 2 mm in 1 m .

### 3.1.1.8 Escutcheons

Escutcheons shall be provided at finished surfaces where exposed piping passes through floors, walls, or ceilings except in boiler, utility, or equipment rooms. Escutcheons shall be fastened securely to pipe and shall be chromium-plated iron or chromium-plated brass, either one-piece or split-pattern, held in place by internal spring tension or setscrew.

### 3.1.1.9 Drains

Main drain piping shall be provided to discharge at safe points outside each building. Drains shall be of adequate size to readily receive the full flow from each drain under maximum pressure. Auxiliary drains shall be provided as required by NFPA 13 except that drain valves shall be used where drain plugs are otherwise permitted. Where branch lines terminate at low points and form trapped sections, such branch lines shall be manifolded to a common drain line. Each drain valve shall be provided with a metal sign identifying the type of drain connection or function of the valve.

### 3.1.1.10 Identification Signs

Signs shall be in accordance with NFPA 13. Properly lettered and approved metal signs shall be suitably affixed to each control valve, inspector test valve, main drain, auxiliary drain, test valve, and similar valves as appropriate.

## 3.2 PIPE PAINTING AND LABELING

### 3.2.1 Painting

Black steel pipe shall be painted in accordance with the requirements specified under SECTION 09900 PAINTING, GENERAL. Pipe in equipment rooms shall be painted red. Pipe in other areas shall be painted to match finishes in those areas. Stainless steel pipe shall not be painted.

### 3.2.2 Pipe Identification

Aboveground pipe 50 mm diameter and larger shall be identified with legends. Legends shall include FOAM CONCENTRATE, FOAM-WATER SPRINKLER, FOAM-WATER NOZZLE, and FIRE PROTECTION WATER. Legends shall utilize WHITE letters on a RED color field and shall include arrows to indicate the direction of flow. Length of color field, letter size and locations on piping shall be as recommended in ANSI A13.1.

## 3.3 PRELIMINARY TESTS

Tests shall be performed to make adjustments in the fire protection system operation and to verify that the system will function as intended and that it is ready for service. Such tests shall include all components and subsystems. Test results shall be clearly documented and included with the written request for Final Test.

### 3.3.1 Hydrostatic Tests

The AFFF concentrate pipe shall be hydrostatically tested in accordance with NFPA 13 at not less than 1379 kPa , or 345 kPa in excess of maximum system operating pressure, for 2 hours. There shall be no visible leakage from the piping when the system is subjected to the hydrostatic test.

### 3.3.2 Alarm Check and Automatic Water Control Valves

Each valve shall be tested to verify operation in accordance with manufacturer's published operating instructions. This shall include tests of valves and switches connected thereto.

### 3.3.3 Nozzles

Nozzles shall be discharge tested for proper operation and coverage. Oscillating nozzles shall be operated to verify that angle of elevation, angle of oscillation, and discharge range, are in accordance with requirements.

### 3.3.4 AFFF Concentrate System

Tests shall be conducted under the supervision of a technical representative employed by the AFFF concentrate manufacturer. The complete AFFF concentrate system shall be adjusted and tested to assure proper operation. Test results, including all pressure settings and readings, shall be recorded on an appropriate test form signed and dated by manufacturer's representative certifying that the system is in compliance with contract requirements and the manufacturer's recommended practices. Testing shall include, but not be limited to, the following:

- c. Collection of AFFF samples and testing with a conductivity meter to verify proportioning accuracy.
- f. Other operational checks recommended by the AFFF proportioner manufacturer.

### 3.3.5 Control System Tests

Tests shall be conducted under the supervision of a factory-trained representative of the control panel manufacturer. The electrical control system shall be tested to verify that the control panel and all wiring have been installed correctly and that all components function as intended. Tests shall be conducted using normal operating and battery power. Testing shall include, but not be limited to, each of the following:

- a. Alarm initiating circuit and device. This shall include heat detectors, manual actuation stations, waterflow and pressure switches, and similar devices connected to the control panel.
- b. Supervisory circuit and device. This shall include valve supervisory (tamper) switches, pump power circuits, pump running, low liquid level in foam concentrate tank, and similar circuits and devices.
- c. Actuation circuit and device. This shall include circuits to automatic water control valves, foam concentrate pumps, fire pumps, and similar circuits related to system activation.
- d. Annunciator lamp and notification appliance. This shall include bells, horns, electronic signaling, and similar devices.

## 3.4 FINAL TEST

### 3.4.1 Requirements

The Final Test shall be a repeat of Preliminary Tests, except that flushing and hydrostatic tests shall not be repeated. In addition, the system shall be automatically actuated and allowed to discharge for a period of at least one minute prior to shutting the system off. The Contractor shall correct system failures and other deficiencies identified during testing and shall retest portions of the system affected by the required corrections.

#### 3.4.1.1 Pretest Requirements

The system will be considered ready for final testing only after the following have been accomplished.

- a. The required test plan has been submitted and approved.
- b. Preliminary tests have been made and deficiencies determined to have been corrected to the satisfaction of the equipment manufacturer's technical representatives and the Contracting Officer.
- c. Test reports, including the required videotape of the preliminary tests, have been submitted and approved.
- d. The control panels and detection systems shall have been in service for a break-in period of at least 14 consecutive days prior to the final test.
- e. The Contractor has provided written notification to the Contracting Officer, at least 21 days prior to date of Final Test, that preliminary tests have been successfully completed.

#### 3.4.1.2 Videotaping

Contractor shall videotape the tests in VHS format and shall record the date and time-lapse, in seconds, from start to finish of each portion of the test as directed by the Contracting Officer. Four copies of the tape shall be submitted before the system will be considered accepted.

#### 3.4.1.3 Manufacturer's Services

Experienced technicians regularly employed by the Contractor in the installation of the system and manufacturer's representative referred to elsewhere in this specification shall conduct the testing.

#### 3.4.1.4 Materials and Equipment

Contractor shall provide AFFF concentrate, gauges, AFFF sample collection apparatus, instruments, hose, personnel, elevating platforms, scaffolding, ladders, appliances and any other equipment necessary to fulfill testing requirements specified.

#### 3.4.1.5 Facility and Environmental Protection

Contractor shall provide protection for the facility, including electrical and mechanical equipment exposed to possible damage during discharge tests.

This shall include provision of sandbags or similar means for preventing migration of foam solution into adjacent areas. Temporary measures shall be provided to prevent AFFF solution from entering storm drains, sanitary sewers, drainage ditches, streams and other water sources. Discharged AFFF

shall be contained on paved surfaces and shall not be allowed to come in contact with the earth.

#### 3.4.2 Control System Tests

Operational features of the control system shall be tested and demonstrated. This shall include testing of control panels and each input and output circuit. Tests of circuits shall include actuation and simulated circuit fault at each initiating, notification, supervisory and actuation device or appliance. As a practical matter, these tests shall be a repeat of preliminary tests required under paragraph PRELIMINARY TESTS.

#### 3.4.3 AFFF Proportioning System Tests

Each AFFF proportioner (ratio controller) shall be flow tested to determine that proportioning accuracy is within specified limits. Each proportioner supplying sprinkler systems with closed heads shall be tested at two flow rates; the minimum flow rate specified in the manufacturer's published data and a flow rate at least four times the minimum. Each proportioner supplying a deluge system or a nozzle system shall be tested at the design flow rate. Collecting AFFF samples from each proportioner shall be accomplished in accordance with NFPA 16, NFPA 16A and the approved test plan. Foam solution concentrations shall be determined using the methods outlined in NFPA 16 and NFPA 16A. Proportioning for nominal 3 percent concentrate shall be between 3 percent and 4 percent. If test results indicate proportioning below or above this range, the Contractor shall make necessary adjustments and retest as directed by the Contracting Officer.

#### 3.4.4 Post-discharge Test Requirements

Following the successful completion of the tests, the Contractor shall remove the foam solution from the site as indicated on the approved AFFF waste containment and disposal plan. Contractor shall replenish AFFF concentrate consumed during the tests. The entire fire protection system shall be returned to automatic operation and the facility restored to operational capability. Discharged solution shall be contained and disposed of in a manner acceptable to local authorities and as identified on the approved test plan. Once tests are completed, systems shall be returned to fully operational status, including filling of AFFF concentrate tanks with concentrate and filling of solution piping with premix as required.

-- End of Section --

SECTION TABLE OF CONTENTS

DIVISION 15 - MECHANICAL

SECTION 15070A

AT/FORCE PROTECTION FOR MECHANICAL EQUIPMENT

PART 1 GENERAL

- 1.1 REFERENCES (Not Applicable)
- 1.2 SYSTEM DESCRIPTION
  - 1.2.1 General Requirements
  - 1.2.2 Mechanical Equipment
  - 1.2.3 Mechanical Systems
  - 1.2.4 Bracing
  - 1.2.5 Items Not Covered By This Section
    - 1.2.5.1 Fire Protection Systems
    - 1.2.5.2 Items Requiring No AT/Force Restraints
- 1.3 SUBMITTALS

PART 2 PRODUCTS

- 2.1 SWAY BRACING MATERIALS

PART 3 EXECUTION

- 3.1 [Enter Appropriate Subpart Title Here]
- 3.2 [Enter Appropriate Subpart Title Here]
- 3.3 SPREADERS
- 3.4 SWAY BRACES FOR PIPING
  - 3.4.1 Transverse Sway Bracing
  - 3.4.2 Longitudinal Sway Bracing
  - 3.4.3 Vertical Runs
  - 3.4.4 Clamps and Hangers

-- End of Section Table of Contents --

## SECTION 15070A

## AT/FORCE PROTECTION FOR MECHANICAL EQUIPMENT

## PART 1 GENERAL

## 1.1 REFERENCES (Not Applicable)

## 1.2 SYSTEM DESCRIPTION

## 1.2.1 General Requirements

The requirements for AT/Force protection measures described in this section shall be applied to the mechanical equipment and systems listed below. These requirements do not need to be applied to mechanical equipment located in mechanical, electrical, or communications rooms. Structural requirements shall be in accordance with Section 13080 AT/FORCE PROTECTION FOR MISCELLANEOUS EQUIPMENT.

## 1.2.2 Mechanical Equipment

Mechanical equipment to be AT/Force protected shall include the following items to the extent required on the drawings or in other sections of these specifications:

Piping and suspended mechanical equipment.

## 1.2.3 Mechanical Systems

The following mechanical systems shall be installed as required on the drawings and other sections of these specifications and shall be AT/Force protected in accordance with this specification:

All Piping and suspended equipment inside the building Except as Specifically Stated Below Under "Items Not Covered By This Section".

## 1.2.4 Bracing

Bracing shall be provided according to the details on the contract drawings and in accordance with the specifications.

## 1.2.5 Items Not Covered By This Section

## 1.2.5.1 Fire Protection Systems

AT/Force protection of piping for fire protection systems shall be installed as specified in 13930A WET PIPE SPRINKLER SYSTEM, FIRE PROTECTION.

## 1.2.5.2 Items Requiring No AT/Force Restraints

AT/Force restraints are not required for the following items:

- a. Gas piping less than 25 mm inside diameter.

- b. Piping in boiler and mechanical equipment rooms less than 32 mm inside diameter.
- c. All other piping less than 64 mm inside diameter.
- d. Rectangular air handling ducts less than 0.56 square meters in cross sectional area.
- e. Round air handling ducts less than 711 mm in diameter.
- f. Piping suspended by individual hangers 300 mm or less in length from the top of pipe to the bottom of the supporting structural member where the hanger is attached, except as noted below.
- g. Ducts suspended by hangers 300 mm or less in length from the top of the duct to the bottom of the supporting structural member, except as noted below.

In exemptions f. and g. all hangers shall meet the length requirements. If the length requirement is exceeded by one hanger in the run, the entire run shall be braced. Interior piping and ducts not listed above shall be AT/Force protected in accordance with the provisions of this specification.

### 1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

#### SD-02 Shop Drawings

Bracing; G-EC.

Detail drawings along with catalog cuts, templates, and erection and installation details, as appropriate, for the items listed. Submittals shall be complete in detail; shall indicate thickness, type, grade, class of metal, and dimensions; and shall show construction details, reinforcement, anchorage, and installation with relation to the building construction.

## PART 2 PRODUCTS

### 2.1 SWAY BRACING MATERIALS

Sway bracing materials (e.g. rods, plates, rope, angles, etc.) shall be as specified in Section 13080 AT/FORCE PROTECTION FOR MISCELLANEOUS EQUIPMENT.

## PART 3 EXECUTION

3.1 [Enter Appropriate Subpart Title Here] 3.2 [Enter Appropriate Subpart Title Here]

### 3.3 SPREADERS

Spreaders shall be provided between adjacent piping runs to prevent contact during AT/Force activity whenever pipe or insulated pipe surfaces are less than 100 mm apart. Spreaders shall be applied at same interval as sway braces at an equal distance between the sway braces. If rack type hangers

are used where the pipes are restrained from contact by mounting to the rack, spreaders are not required for pipes mounted in the rack. Spreaders shall be applied to surface of bare pipe and over insulation on insulated pipes utilizing high-density inserts and pipe protection shields in accordance with the requirements of Section 15080A THERMAL INSULATION FOR MECHANICAL SYSTEMS.

### 3.4 SWAY BRACES FOR PIPING

Sway braces shall be provided to prevent movement of the pipes under AT/Force loading. Braces shall be provided in both the longitudinal and transverse directions, relative to the axis of the pipe. The bracing shall not interfere with thermal expansion requirements for the pipes as described in other sections of these specifications.

#### 3.4.1 Transverse Sway Bracing

Transverse sway bracing for steel and copper pipe shall be provided as specified in Section 13080 AT/FORCE PROTECTION FOR MISCELLANEOUS EQUIPMENT.

All runs (length of pipe between end joints) shall have a minimum of two transverse braces. Transverse sway bracing for pipes of materials other than steel and copper shall be provided at intervals not to exceed the hanger spacing as specified in Section 15400A PLUMBING, GENERAL PURPOSE.

#### 3.4.2 Longitudinal Sway Bracing

Longitudinal sway bracing shall be provided at 12 m intervals unless otherwise indicated. All runs (length of pipe between end joints) shall have one longitudinal brace minimum. Sway braces shall be constructed in accordance with the drawings. Branch lines, walls, or floors shall not be used as sway braces.

#### 3.4.3 Vertical Runs

Run is defined as length of pipe between end joints. Vertical runs of piping shall be braced at not more than 3 m vertical intervals. Braces for vertical runs shall be above the center of gravity of the segment being braced. All sway braces shall be constructed in accordance with the drawings. Sway branches shall not be connected to branch lines, walls, or floors.

#### 3.4.4 Clamps and Hangers

Clamps or hangers on uninsulated pipes shall be applied directly to pipe. Insulated piping shall have clamps or hangers applied over insulation in accordance with Section 15080A THERMAL INSULATION FOR MECHANICAL SYSTEMS.

-- End of Section --

SECTION TABLE OF CONTENTS

DIVISION 15 - MECHANICAL

SECTION 15569A

WATER AND STEAM HEATING; OIL, GAS OR BOTH; UP TO 20 MBTUH

02/03

PART 1 GENERAL

- 1.1 REFERENCES
- 1.2 SUBMITTALS
- 1.3 GENERAL REQUIREMENTS
  - 1.3.1 Standard Products
  - 1.3.2 Asbestos Prohibition
  - 1.3.3 Nameplates
  - 1.3.4 Equipment Guards
  - 1.3.5 Verification of Dimensions
  - 1.3.6 Welding
  - 1.3.7 Spare Parts
- 1.4 MANUFACTURER'S SERVICES
- 1.5 DELIVERY AND STORAGE

PART 2 PRODUCTS

- 2.1 PUMPS
  - 2.1.1 Condensate Return Unit CR-1 & CR-2
    - 2.1.1.1 Rating and Testing
- 2.2 COLD WATER CONNECTIONS
- 2.3 AIR HANDLING UNITS
- 2.4 FITTINGS AND ACCESSORIES
  - 2.4.1 Steel Sheets
    - 2.4.1.1 Galvanized Steel
    - 2.4.1.2 Uncoated Steel
  - 2.4.2 Gaskets
  - 2.4.3 Steel Pipe and Fittings
    - 2.4.3.1 Steel Pipe
    - 2.4.3.2 Steel Pipe Fittings
    - 2.4.3.3 Steel Flanges
    - 2.4.3.4 Welded Fittings
    - 2.4.3.5 Cast-Iron Fittings
    - 2.4.3.6 Malleable-Iron Fittings
    - 2.4.3.7 Unions
    - 2.4.3.8 Threads
  - 2.4.4 Copper Tubing and Fittings
    - 2.4.4.1 Copper Tubing
    - 2.4.4.2 Solder-Joint Pressure Fittings
    - 2.4.4.3 Adapters
    - 2.4.4.4 Threaded Fittings
    - 2.4.4.5 Brazing Material
    - 2.4.4.6 Brazing Flux
    - 2.4.4.7 Solder Material
    - 2.4.4.8 Solder Flux
  - 2.4.5 Dielectric Waterways and Flanges

- 2.4.6 Pipe Supports
- 2.4.7 Pipe Expansion
  - 2.4.7.1 Expansion Loops
- 2.4.8 Valves
  - 2.4.8.1 Gate Valves
  - 2.4.8.2 Globe Valves
  - 2.4.8.3 Check Valves
  - 2.4.8.4 Angle Valves
  - 2.4.8.5 Ball Valves
  - 2.4.8.6 Butterfly Valves
  - 2.4.8.7 Drain valves
  - 2.4.8.8 Safety Valves
- 2.4.9 Strainers
- 2.4.10 Pressure Gauges
- 2.4.11 Thermometers
- 2.4.12 Air Vents
  - 2.4.12.1 Manual Air Vents
  - 2.4.12.2 Automatic Air Vents
- 2.4.13 Steam Traps
  - 2.4.13.1 Float-and-Thermostatic Traps
- 2.4.14 UNFIRED STEAM TO STEAM GENERATOR SG-1 & SG-2 WITH CCU-1 & 2 DISTRIBUTOR
- 2.4.15 Water Softener WS-1& WS-2
- 2.5 ELECTRICAL EQUIPMENT
- 2.6 INSULATION

### PART 3 EXECUTION

- 3.1 PIPING INSTALLATION
  - 3.1.1 Vent Piping and Fittings
  - 3.1.2 Gauge Piping
  - 3.1.3 Steam Piping and Fittings
  - 3.1.4 Condensate Return Pipe and Fittings
  - 3.1.5 Joints
    - 3.1.5.1 Threaded Joints
    - 3.1.5.2 Welded Joints
    - 3.1.5.3 Soldered Joints
  - 3.1.6 Flanges and Unions
  - 3.1.7 Branch Connections
    - 3.1.7.1 Branch Connections for Steam Systems
  - 3.1.8 Steam Connections to Equipment
  - 3.1.9 Steam Risers
  - 3.1.10 Air Vents for Steam Systems
  - 3.1.11 Supports
    - 3.1.11.1 Seismic Requirements for Supports and Structural Bracing
    - 3.1.11.2 Pipe Hangers, Inserts, and Supports
    - 3.1.11.3 Multiple Pipe Runs
  - 3.1.12 Anchors
  - 3.1.13 Valves
  - 3.1.14 Pipe Sleeves
    - 3.1.14.1 Fire Seal
  - 3.1.15 Thermometer Wells
  - 3.1.16 Drains
  - 3.1.17 Strainer Blow-Down Piping
- 3.2 COLOR CODE MARKING AND FIELD PAINTING
- 3.3 CLEANING
  - 3.3.1 Boilers and Piping
- 3.4 FIELD TRAINING

-- End of Section Table of Contents --

## SECTION 15569A

WATER AND STEAM HEATING; OIL, GAS OR BOTH; UP TO 20 MBTUH  
02/03

## PART 1 GENERAL

## 1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

## ASTM INTERNATIONAL (ASTM)

ASTM A 105/A 105M	(2001) Carbon Steel Forgings for Piping Applications
ASTM A 167	(1999) Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A 193/A 193M	(2001b) Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service
ASTM A 234/A 234M	(2001a) Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
ASTM A 366/A 366M	(1997e1) Steel, Sheet, Carbon, Cold-Rolled, Commercial Quality
ASTM A 515/A 515M	(2001) Pressure Vessel Plates, Carbon Steel, for Intermediate- and Higher-Temperature Service
ASTM A 516/A 516M	(2001) Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service
ASTM A 53/A 53M	(1999b) Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A 653/A 653M	(2001a) Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM B 32	(2000) Solder Metal
ASTM B 75M	(1999) Seamless Copper Tube (Metric)
ASTM B 813	(2000) Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube
ASTM B 828	(2000) Making Capillary Joints by

## Soldering of Copper and Copper Alloy Tube and Fittings

ASTM B 88	(1999e1) Seamless Copper Water Tube
ASTM B 88M	(1999) Seamless Copper Water Tube (Metric)
ASTM F 1139	(1988; R 1998) Standard Specification for Steam Traps and Drains

## AMERICAN WATER WORKS ASSOCIATION(AWWA)

AWWA C606	(1997) Grooved and Shouldered Joints
-----------	--------------------------------------

## AMERICAN WELDING SOCIETY (AWS)

AWS A5.8	(1992) Filler Metals for Brazing and Braze Welding
----------	--

## ASME INTERNATIONAL (ASME)

ASME B1.20.1	(1983; R 2001) Pipe Threads, General Purpose, Inch
ASME B16.11	(2001) Forged Fittings, Socket-Welding and Threaded
ASME B16.15	(1985; R 1994) Cast Bronze Threaded Fittings Classes 125 and 250
ASME B16.18	(2001) Cast Copper Alloy Solder Joint Pressure Fittings
ASME B16.21	(1992) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.22	(1995) Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.3	(1998) Malleable Iron Threaded Fittings
ASME B16.39	(1998) Malleable Iron Threaded Pipe Unions
ASME B16.4	(1998) Gray Iron Threaded Fittings
ASME B16.5	(1996) Pipe Flanges and Flanged Fittings
ASME B16.9	(2001) Factory-Made Wrought Steel Buttwelding Fittings
ASME B31.1	(2001) Power Piping
ASME B31.5	(2001) Refrigeration Piping and Heat Transfer Components
ASME B40.1	(1991) Gauges - Pressure Indicating Dial Type - Elastic Element
ASME BPVC SEC IV	(2001) Boiler and Pressure Vessel Code;

Section IV, Rules for construction of  
Heating Boilers

COPPER DEVELOPMENT ASSOCIATION (CDA)

CDA A4015 (1994; R 1995) Copper Tube Handbook

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS  
INDUSTRY (MSS)

MSS SP-110 (1996) Ball Valves Threaded,  
Socket-Welding, Solder Joint, Grooved and  
Flared Ends

MSS SP-25 (1998) Standard Marking System for Valves,  
Fittings, Flanges and Unions

MSS SP-58 (1993) Pipe Hangers and Supports -  
Materials, Design and Manufacture

MSS SP-69 (1996) Pipe Hangers and Supports -  
Selection and Application

MSS SP-70 (1998) Cast Iron Gate Valves, Flanged and  
Threaded Ends

MSS SP-71 (1997) Gray Iron Swing Check Valves,  
Flanges and Threaded Ends

MSS SP-72 (1999) Ball Valves with Flanged or  
Butt-Welding Ends for General Service

MSS SP-80 (1997) Bronze Gate, Globe, Angle and Check  
Valves

MSS SP-85 (1994) Cast Iron Globe & Angle Valves,  
Flanged and Threaded Ends

## 1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only or as otherwise designated. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

### SD-02 Shop Drawings

Piping Installation; G, EC  
Installation; G, EC

Detail drawings consisting of equipment layout including installation details and electrical connection diagrams; combustion and safety control diagrams; ductwork layout showing the location of supports and hangers, typical hanger details, gauge reinforcement, reinforcement spacing rigidity classification, and static pressure and seal classifications; and piping layout showing the location of guides and anchors, the load

imposed on each support or anchor (not required for radiant floor tubing), and typical support details. Drawings shall include any information required to demonstrate that the system has been coordinated and will properly function as a unit and shall show equipment relationship to other parts of the work, including clearances required for operation and maintenance.

SD-03 Product Data

Materials and Equipment; G, EC

Manufacturer's catalog data shall be included with the detail drawings for the following items:

Steam to Steam Generators and Associated Components; G, EC.  
Steam Piping; G, EC.  
Pipe Flexible Connections; G, EC.  
Valves; G, EC.  
Steam Traps; G, EC.  
Condensate Pumps, Receivers and Accessories; G, EC.

The data shall show model, size, options, etc., that are intended for consideration. Data submitted shall be adequate to demonstrate compliance with contract requirements.

Spare Parts; G, RE

Spare parts data for each different item of material and equipment specified.

Heating System Tests; G, EC

Welding; G, RE

A copy of qualified welding procedures, at least 2 weeks prior to the start of welding operations.

A list of names and identification symbols of qualified welders and welding operators, at least 2 weeks prior to the start of welding operations.

Qualifications; G, RE

A statement from the firms proposed to prepare submittals and perform installation and testing, demonstrating successful completion of similar services of at least five projects of similar size or scope, at least 2 weeks prior to the submittal of any other item required by this section.

Field Instructions; G, RE

System layout diagrams that show the layout of equipment, piping, and ductwork and typed condensed operation manuals explaining preventative maintenance procedures, methods of checking the system for normal, safe operation, and procedures for safely starting and stopping the system, framed under glass or laminated plastic, at least 2 weeks prior to the start of related testing. After approval, these items shall be posted where directed.

Tests; G, RE

Proposed test schedules for the heating system and humidification system tests, at least 2 weeks prior to the start of related testing.

#### SD-06 Test Reports

Heating System Tests; G, RE  
Humidification System Tests; G, RE

Test reports for the heating system tests and the humidification system test, upon completion of testing complete with results.

#### SD-07 Certificates

Bolts; G, RE.

Written certification by the bolt manufacturer that the bolts furnished comply with the requirements of this specification. The certification shall include illustrations of product markings, the date of manufacture, and the number of each type of bolt to be furnished based on this certification.

#### SD-10 Operation and Maintenance Data

Operation and Maintenance Instructions; G, RE.

Six complete manuals listing step-by-step procedures required for system startup, operation, shutdown, and routine maintenance, at least 2 weeks prior to field training. The manuals shall include the manufacturer's name, model number, parts list, simplified wiring and control diagrams, troubleshooting guide, and recommended service organization (including address and telephone number) for each item of equipment. Each service organization shall be capable of providing 4 hour onsite response to a service call on an emergency basis.

### 1.3 GENERAL REQUIREMENTS

#### 1.3.1 Standard Products

Materials and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of the products and shall essentially duplicate items that have been in satisfactory use for at least 2 years

prior to bid opening. Equipment shall be supported by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site.

#### 1.3.2 Asbestos Prohibition

Asbestos and asbestos-containing products shall not be used.

#### 1.3.3 Nameplates

Each major component of equipment shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the equipment. Each pressure vessel shall have an approved ASME stamp.

#### 1.3.4 Equipment Guards

Belts, pulleys, chains, gears, couplings, projecting setscrews, keys, and other rotating parts exposed to personnel contact shall be fully enclosed or guarded in accordance with OSHA requirements. High temperature equipment and piping exposed to contact by personnel or where it creates a potential fire hazard shall be properly guarded or covered with insulation of a type specified. Catwalks, operating platforms, ladders, and guardrails shall be provided where shown and shall be constructed in accordance with Section 05500A MISCELLANEOUS METAL.

#### 1.3.5 Verification of Dimensions

The Contractor shall become familiar with details of the work, verify dimensions in the field, and shall advise the Contracting Officer of any discrepancy before performing any work or ordering any materials.

#### 1.3.6 Welding

Welding and nondestructive testing procedures for piping are specified in Section 05093A WELDING PRESSURE PIPING.

#### 1.3.7 Spare Parts

The Contractor shall submit spare parts data for each different item of material and equipment specified, after approval of the detail drawings and no later than 2 months prior to the date of beneficial occupancy. The data shall include a complete list of parts and supplies, with current unit prices and source of supply, and a list of the parts recommended by the manufacturer to be replaced after 1 and 3 years of service.

#### 1.4 MANUFACTURER'S SERVICES

Services of a manufacturer's representative who is experienced in the installation, adjustment, and operation of the equipment specified shall be provided. The representative shall supervise the installing, adjusting, and testing of the equipment.

#### 1.5 DELIVERY AND STORAGE

Equipment delivered and placed in storage shall be protected from the weather, humidity and temperature variations, dirt and dust, and other contaminants.

## PART 2 PRODUCTS

### 2.1 PUMPS

#### 2.1.1 Condensate Return Unit CR-1 & CR-2

Unit shall be Armstrong model FPS-218, except Viton seals shall be installed, or approved equal. Unit shall be as shown on the drawings. Each pump shall have a capacity not less than that indicated when discharging against the specified pressure. The minimum capacity of the tank shall be as indicated. The condensate pumping unit shall be the duplex type as indicated. The unit shall consist of two pumps with electric motor drive, and a single tank, all mounted on a suitable cast-iron or steel base. Pump shall be the centrifugal type, bronze-fitted throughout, with impellers of bronze or other approved corrosion-resisting metal. Mechanical seals shall be Viton to withstand 275 degrees F. Each of the two pumps is activated automatically on alternating pumping cycles so the work load is evenly distributed between the two pumps. The second pump is automatically actuated if the first one fails to start. Pump shall be free from air binding when handling condensate of temperatures up to 93 degrees C (200 degrees F). Pumps shall be directly connected to suitable drip proof enclosed motors. Tank shall be not less than 3/16 inch thick black iron or steel and shall be provided with all the necessary reinforced threaded openings, including condensate return, pressure relief valve, make-up, drain, and pump suction connections. Inlet strainer shall be provided either integral in the tank or separate in the inlet line to the tank. Fittings shall be galvanized malleable iron. The pumps, motors, and tank shall be mounted on a single base with the tank piped to the pump suction. A gate valve and check valve shall be provided in the discharge connection from each pump and a strainer and gate valve shall be provided in the suction line to each pump except where pumps are directly mounted on top of the tank. Tank shall be an ASME rated pressure vessel at 125 psig. An ASME rated pressure relief valve, set as shown on the drawings, shall be installed instead of the normal vent connection. Unit shall have a heavy duty make-up valve actuated by the position of a seamless stainless steel float within the tank. The mechanism shall be readily adjustable for various water levels. Float switches and stainless steel float and rod provide optimum levels in the receiver for pump operation. It shall be mounted in the end of the tank and can be easily removed as a complete unit. A water level gauge shall be installed on the tank. The condensate return inlet to the tank shall not exceed 25 inches above the floor to enable gravity flow from the steam generator outlet.

##### 2.1.1.1 Rating and Testing

The pump manufacturer shall submit a certified test report covering the actual test of the unit and certifying that the equipment complies with the indicated requirements.

### 2.2 COLD WATER CONNECTIONS

Connections shall be provided which includes consecutively in line a strainer, backflow prevention device, and water pressure regulator in that order in the direction of the flow. The backflow prevention device shall be provided as indicated and in compliance with Section 15400A PLUMBING, GENERAL PURPOSE. Cold water fill connections shall be made to the water supply system as indicated. Necessary pipe, fittings, and valves required for water connections between the boiler and cold water main shall be provided as shown. The pressure regulating valve shall be of a type that

will not stick or allow pressure to build up on the low side. The valve shall be set to maintain a terminal pressure of approximately, lately 35 kPa in excess of the static head on the system and shall operate within a 15 kPa tolerance regardless of cold water supply piping pressure and without objectionable noise under any condition of operation.

## 2.3 AIR HANDLING UNITS

Air handling units and associated equipment shall be in accordance with Section 15895 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM.

## 2.4 FITTINGS AND ACCESSORIES

### 2.4.1 Steel Sheets

#### 2.4.1.1 Galvanized Steel

Galvanized steel shall be ASTM A 653/A 653M.

#### 2.4.1.2 Uncoated Steel

Uncoated steel shall be ASTM A 366/A 366M, composition, condition, and finish best suited to the intended use. Gauge numbers specified refer to manufacturer's standard gauge.

### 2.4.2 Gaskets

Gaskets shall be nonasbestos material in accordance with ASME B16.21, full face or self-centering type. The gaskets shall be of the spiral wound type with graphite filler material.

### 2.4.3 Steel Pipe and Fittings

#### 2.4.3.1 Steel Pipe

Steel pipe shall be ASTM A 53/A 53M, Type E or S, Grade A or B, black steel, standard weight.

#### 2.4.3.2 Steel Pipe Fittings

Fittings shall have the manufacturer's trademark affixed in accordance with MSS SP-25 so as to permanently identify the manufacturer.

#### 2.4.3.3 Steel Flanges

Flanged fittings including flanges, bolts, nuts, bolt patterns, etc. shall be in accordance with ASME B16.5 class 150 and shall have the manufacturers trademark affixed in accordance with MSS SP-25. Flange material shall conform to ASTM A 105/A 105M. Flanges for high temperature water systems shall be serrated or raised-face type. Blind flange material shall conform to ASTM A 516/A 516M cold service and ASTM A 515/A 515M for hot service. Bolts shall be high strength or intermediate strength with material conforming to ASTM A 193/A 193M.

#### 2.4.3.4 Welded Fittings

Welded fittings shall conform to ASTM A 234/A 234M with WPA marking.

Buttwelded fittings shall conform to ASME B16.9, and socket-welded fittings shall conform to ASME B16.11.

#### 2.4.3.5 Cast-Iron Fittings

Fittings shall be ASME B16.4, Class 125, type required to match connecting piping.

#### 2.4.3.6 Malleable-Iron Fittings

Fittings shall be ASME B16.3, type as required to match connecting piping.

#### 2.4.3.7 Unions

Unions shall be ASME B16.39, Class 150.

#### 2.4.3.8 Threads

Pipe threads shall conform to ASME B1.20.1.

#### 2.4.4 Copper Tubing and Fittings

##### 2.4.4.1 Copper Tubing

Tubing shall be ASTM B 88, ASTM B 88M, Type K or L. Adapters for copper tubing shall be brass or bronze for brazed fittings.

##### 2.4.4.2 Solder-Joint Pressure Fittings

Wrought copper and bronze solder-joint pressure fittings shall conform to ASME B16.22 and ASTM B 75M. Cast copper alloy solder-joint pressure fittings shall conform to ASME B16.18 and ASTM B 828.

##### 2.4.4.3 Adapters

Adapters may be used for connecting tubing to flanges and to threaded ends of valves and equipment. Extracted brazed tee joints produced with an acceptable tool and installed as recommended by the manufacturer may be used.

##### 2.4.4.4 Threaded Fittings

Cast bronze threaded fittings shall conform to ASME B16.15.

##### 2.4.4.5 Brazing Material

Brazing material shall conform to AWS A5.8.

##### 2.4.4.6 Brazing Flux

Flux shall be in paste or liquid form appropriate for use with brazing material. Flux shall be as follows: lead-free; have a 100 percent flushable residue; contain slightly acidic reagents; contain potassium borides, and contain fluorides. Silver brazing materials shall be in accordance with AWS A5.8.

##### 2.4.4.7 Solder Material

Solder metal shall conform to ASTM B 32 95-5 tin-antimony.

#### 2.4.4.8 Solder Flux

Flux shall be either liquid or paste form, non-corrosive and conform to ASTM B 813.

#### 2.4.5 Dielectric Waterways and Flanges

Dielectric waterways shall have temperature and pressure rating equal to or greater than that specified for the connecting piping. Waterways shall have metal connections on both ends suited to match connecting piping. Dielectric waterways shall be internally lined with an insulator specifically designed to prevent current flow between dissimilar metals. Dielectric flanges shall meet the performance requirements described herein for dielectric waterways.

#### 2.4.6 Pipe Supports

Pipe supports shall conform to MSS SP-58 and MSS SP-69.

#### 2.4.7 Pipe Expansion

##### 2.4.7.1 Expansion Loops

Expansion loops and offsets shall provide adequate expansion of the main straight runs of the system within the stress limits specified in ASME B31.1. The loops and offsets shall be cold-sprung and installed where indicated. Pipe guides and anchors shall be provided as indicated.

#### 2.4.8 Valves

Valves shall be Class 125 and shall be suitable for the application. Grooved ends per AWWA C606 may be used for water service only. Valves in nonboiler external piping shall meet the material, fabrication and operating requirements of ASME B31.1. The connection type of all valves shall match the same type of connection required for the piping on which installed.

##### 2.4.8.1 Gate Valves

Gate valves 65 mm and smaller shall conform to MSS SP-80 bronze rising stem, threaded, solder, or flanged ends. Gate valves 80 mm (3 inches) and larger shall conform to MSS SP-70 cast iron bronze trim, outside screw and yoke, flanged, or threaded ends.

##### 2.4.8.2 Globe Valves

Globe valves 65 mm (2-1/2 inches) and smaller shall conform to MSS SP-80, bronze, threaded, soldered, or flanged ends. Globe valves 80 mm and larger shall conform to MSS SP-85, cast iron, bronze trim, flanged, or threaded ends.

##### 2.4.8.3 Check Valves

Check valves 65 mm and smaller shall conform to MSS SP-80, bronze, threaded, soldered, or flanged ends. Check valves 80 mm and larger shall conform to MSS SP-71, cast iron, bronze trim, flanged, or threaded ends.

##### 2.4.8.4 Angle Valves

Angle valves 65 mm and smaller shall conform to MSS SP-80 bronze, threaded, soldered, or flanged ends. Angle valves 80 mm and larger shall conform to MSS SP-85, cast iron, bronze trim, flanged, or threaded ends.

#### 2.4.8.5 Ball Valves

Ball valves 15 mm and larger shall conform to MSS SP-72 or MSS SP-110, ductile iron or bronze, threaded, soldered, or flanged ends.

#### 2.4.8.6 Butterfly Valves

Butterfly valves shall be 2-flange type or lug wafer type, and shall be bubbletight at 1135 kPa. Valve bodies shall be cast iron, malleable iron, or steel. ASTM A 167, Type 404 or Type 316, corrosion resisting steel stems, bronze, or corrosion resisting steel discs, and synthetic rubber seats shall be provided. Valves smaller than 200 mm shall have throttling handles with a minimum of seven locking positions. Valves 200 mm and larger shall have totally enclosed manual gear operators with adjustable balance return stops and position indicators. Valves in insulated lines shall have extended neck to accommodate insulation thickness.

#### 2.4.8.7 Drain valves

Drain valves shall be provided at each drain point of blowdown as recommended by the boiler manufacturer. Piping shall conform to ASME BPVC SEC IV and ASTM A 53/A 53M.

#### 2.4.8.8 Safety Valves

Safety valves shall have steel bodies and shall be equipped with corrosion-resistant trim and valve seats. The valves shall be properly guided and shall be positive closing so that no leakage can occur. Adjustment of the desired back-pressure shall cover the range between 15 and 70 kPa. The adjustment shall be made externally, and any shafts extending through the valve body shall be provided with adjustable stuffing boxes having renewable packing. Each discharge pipe for steam service shall be provided with a drip pan elbow to prevent accumulation of water on the valve. A slip joint shall be provided between drip pan elbow and riser.

#### 2.4.9 Strainers

Basket and "Y" type strainers shall be the same size as the pipelines in which they are installed. The strainer bodies shall be heavy and durable, fabricated of cast iron, and shall have bottoms drilled and tapped with a gate valve attached for blowdown purposes. Strainers shall be designed for [\_\_\_\_\_] kPa ([\_\_\_\_\_] psig) service and [\_\_\_\_\_] degrees C ([\_\_\_\_\_] degrees F). The bodies shall have arrows clearly cast on the sides indicating the direction of flow. Each strainer shall be equipped with an easily removable cover and sediment screen. The screen shall be made of 0.795 mm thick corrosion-resistant steel with small perforations numbering not less than 620,000 per square m to provide a net free area through the basket of at least 3.30 times that of the entering pipe. The flow shall be into the screen and out through the perforations.

#### 2.4.10 Pressure Gauges

Gauges shall conform to ASME B40.1 and shall be provided with throttling

type needle valve or a pulsation dampener and shutoff valve. Minimum dial size shall be 90 mm. A pressure gauge shall be provided for each boiler in a visible location on the boiler. Pressure gauges shall be provided with readings in Kpa and psi. Pressure gauges shall have an indicating pressure range that is related to the operating pressure of the fluid in accordance with the following table:

Operating Pressure (kPa)	Pressure Range (kPa)
519-1030	0-1400
105-518	0-690
14-104	0-210 (retard)

Operating Pressure (psi)	Pressure Range (psi)
76-150	0-200
16-75	0-100
2-15	0-30 (retard)

#### 2.4.11 Thermometers

Thermometers shall be provided with wells and separable corrosion-resistant steel sockets. Mercury shall not be used in thermometers. Thermometers shall have brass, malleable iron, or aluminum alloy case and frame, clear protective face, permanently stabilized glass tube with indicating-fluid column, white face, black numbers, and a minimum 225 mm (9 inch) scale. The operating range of the thermometers shall be 0-100 degrees centigrade (32 - 212 degrees Fahrenheit). The thermometers shall be provided with readings in degrees centigrade and Fahrenheit.

#### 2.4.12 Air Vents

##### 2.4.12.1 Manual Air Vents

Manual air vents shall be brass or bronze valves or cocks suitable for the pressure rating of the piping system and furnished with threaded plugs or caps.

##### 2.4.12.2 Automatic Air Vents

Automatic air vents shall be 20 mm quick-venting float and vacuum air valves. Each air vent valve shall have a large port permitting the expulsion of the air without developing excessive back pressure, a noncollapsible metal float which will close the valve and prevent the loss of water from the system, an air seal that will effectively close and prevent the re-entry of air into the system when subatmospheric pressures prevail therein, and a thermostatic member that will close the port against the passage of steam from the system. The name of the manufacturer shall be clearly stamped on the outside of each valve. The air vent valve shall be suitable for the pressure rating of the piping system.

#### 2.4.13 Steam Traps

##### 2.4.13.1 Float-and-Thermostatic Traps

Float-and-thermostatic traps shall conform to the requirements of ASTM F 1139 and be designed for a steam working pressure of 100 kPa (15 psig) but

shall operate with a supply pressure of approximately 34 kPa (5 psig). The trap capacity shall be based on a pressure differential of 15 kPa (2 psig). Each float-and-thermostatic trap shall have a cast iron body and shall be provided with a hard bronze, monel, or corrosion-resisting steel valve seat and mechanism, an open- or closed-type float of brass or equally corrosion-resistant metal, and a corrosion-resisting steel thermostatic air vent, all of which can be easily removed for inspection or replacement without disturbing the piping connections. The inlet to each trap shall have a brass or stainless steel strainer, either as an integral part of the trap or as a separate item of equipment.

#### 2.4.14 UNFIRED STEAM TO STEAM GENERATOR SG-1 & SG-2 WITH CCU-1 & 2 DISTRIBUTOR

Unfired Steam to Steam Generator, Nortec model SE600 with six CSD duct mounted distributors, or approved equal. Unit shall be as indicated on drawings. Unit provides precise humidity control with existing building steam boiler. The existing building boiler steam is used as the heat source passing through and internal heat exchanger submerged in water to create pure atmospheric steam. The chemical additives from the existing building boiler steam remain in the closed loop with no risk of entering the air stream. Uses regular type cold potable water supply and 15psig treated boiler plant source steam supplied to control valve.

Units shall be furnished with the following features:

- a. 316L stainless steel construction
- b. automatic blowdown controls that are adjustable for varying water conditions.
- c. low water, and high water, shutdown
- d. Packaged water level control system with float switches mounted externally to tank to control water level through factory solenoid valve. Tank fill is automatic through solenoid valve.
- e. factory mounted water trap to prevent steam leakage to drain, 18 inches w.g.
- f. two float and thermostatic steam traps per steam generator, Spirax Sarco model FT-15 (Nortec part number 159-9601) or equal, 15psig, 3/4 inch npt, cast iron body and cover. The valve seat, gasket, ball float, float arm, air vent assembly, and other internal associated parts, and made of stainless steel.
- g. pneumatic modulating steam control valve, SIEBE Environmental Control model VB-7263 or equal, valve Cv is 40 (english), 76 to 1 ratio of rated flow to minimum controllable flow, two way normally closed with equal percentage flow characteristics, and positive shutoff against steam, complies with ANSI16.15, class 250 pressure and temperature rating, B16.014 class IV control valve shutoff leakage and ANSI/ISA-575.11 flow characteristic standard. Bronze body, stainless steel inlet, stainless steel stem, teflon plug and cone.
- h. ASME rated pressure relief valve.
- i. Factory wired 24 volts AC control panel compatible with building

management system.

- j. Option of wall, floor, or ceiling mounting.
- k. Per Steam Generator, six Nortec model CSD or equal steam distributors for mounting in Climate Control Units CCU-1 and CCU-2 (air handling units). Each of the six distributors is suitable for 105 lbs/hr, stainless steel construction, holes on top center, 3/4 inch diameter steam inlet, 2 1/8 inch outside diameter manifold, 3/8 inch condensate return, 9 inch mounting plate height.
- l. Removeable 316L stainless steel heat exchanger with modular horizontal design for easy maintenance.
- m. Stainless steel tank lid easily removed for maintenance and gasketed for leak tight enclosure.
- n. Inlet potable water supply valve controlled by 24 volts AC double solenoid valve.
- o. "Y" steam strainer, 2 inch nominal diameter, 20 mesh stainless steel screen material, cast iron body, 250psig pressure rating non-shock.
- p. A pressure gauge shall be installed in a visible location on the unit.

#### 2.4.15 Water Softener WS-1& WS-2

Water softener shall provide a continuous flow rate is 8 gallons per minute (gpm) at 4 psi pressure drop, peak flow is 12 gpm at 7psi. Unit includes fiberglass reinforced polyester resin tanks with covered polyethylene brine tank, fleck valve, VIP electronic demand controller, alternating twin tanks, tanks pressure tested to 100psig, regeneration type, exchanges soft sodium ions for hard calcium and magnesium ions, flow meter, 30,000grains at 8gpm, 30,000grain per cubic feet or resin, 1 cubic feet resin per tank, 120 volts AC, single phase, 15 amps maximum.

#### 2.5 ELECTRICAL EQUIPMENT

Electric motor-driven equipment shall be provided complete with motors, motor starters, and necessary control devices. Electrical equipment, motor control devices, motor efficiencies and wiring shall be as specified in Section 16415A ELECTRICAL WORK, INTERIOR.

#### 2.6 INSULATION

Shop and field-applied insulation shall be as specified in Section 15080A THERMAL INSULATION FOR MECHANICAL SYSTEMS.

### PART 3 EXECUTION

#### 3.1 PIPING INSTALLATION

Unless otherwise specified, nonboiler external pipe and fittings shall conform to the requirements of ASME B31.1. Pipe installed shall be cut accurately to suit field conditions, shall be installed without springing

or forcing, and shall properly clear windows, doors, and other openings. Cutting or other weakening of the building structure to facilitate piping installation will not be permitted. Pipes shall be free of burrs, oil, grease and other foreign material and shall be installed to permit free expansion and contraction without damaging the building structure, pipe, pipe joints, or pipe supports. Changes in direction shall be made with fittings, except that bending of pipe 100 mm and smaller will be permitted provided a pipe bender is used and wide sweep bends are formed. The centerline radius of bends shall not be less than 6 diameters of the pipe. Bent pipe showing kinks, wrinkles, flattening, or other malformations will not be accepted. Vent pipes shall be carried through the roof as directed and shall be properly flashed. Unless otherwise indicated, horizontal supply mains shall pitch down in the direction of flow with a grade of not less than 0.2 percent. Open ends of pipelines and equipment shall be properly capped or plugged during installation to keep dirt or other foreign materials out of the systems. Pipe not otherwise specified shall be uncoated. Unless otherwise specified or shown, final connections to equipment shall be made with malleable-iron unions for steel pipe 65 mm or less in diameter and with flanges for pipe 80 mm or more in diameter. Unions for copper pipe or tubing shall be brass or bronze. Reducing fittings shall be used for changes in pipe sizes. In horizontal hot water lines, reducing fittings shall be eccentric type to maintain the top of the lines at the same level to prevent air binding.

#### 3.1.1 Vent Piping and Fittings

Vent piping shall be black steel. Fittings shall be black malleable iron or cast iron to suit piping.

#### 3.1.2 Gauge Piping

Piping shall be copper tubing.

#### 3.1.3 Steam Piping and Fittings

Piping shall be black steel. Fittings shall be black, malleable iron, cast iron or steel. Fittings adjacent to valves shall suit valves specified. Grooved mechanical fittings will not be allowed for steam piping.

#### 3.1.4 Condensate Return Pipe and Fittings

Piping shall be black steel. Fittings shall be malleable iron, cast iron, or steel. Grooved mechanical fittings will not be allowed for condensate piping.

#### 3.1.5 Joints

Joints between sections of steel pipe and between steel pipe and fittings shall be threaded, grooved, flanged or welded as indicated or specified. Except as otherwise specified, fittings 25 mm and smaller shall be threaded; fittings 32 mm and up to but not including 80 mm shall be either threaded, grooved, or welded; and fittings 80 mm and larger shall be either flanged, grooved, or welded. Pipe and fittings 32 mm and larger installed in inaccessible conduit or trenches beneath concrete floor slabs shall be welded. Connections to equipment shall be made with black malleable-iron unions for pipe 65 mm or smaller in diameter and with flanges for pipe 80 mm inches or larger in diameter. Joints between sections of copper tubing or pipe shall be flared, soldered, or brazed.

#### 3.1.5.1 Threaded Joints

Threaded joints shall be made with tapered threads properly cut and shall be made perfectly tight with a stiff mixture of graphite and oil or with polytetrafluoroethylene tape applied to the male threads only and in no case to the fittings.

#### 3.1.5.2 Welded Joints

Welded joints shall be in accordance with paragraph GENERAL REQUIREMENTS unless otherwise specified. Changes in direction of piping shall be made with welding fittings only; mitering or notching pipe to form elbows and tees or other similar type construction will not be permitted. Branch connections may be made with either welding tees or forged branch outlet fittings, either being acceptable without size limitation. Branch outlet fittings, where used, shall be forged, flared for improved flow characteristics where attached to the run, reinforced against external strains, and designed to withstand full pipe bursting strength. Socket weld joints shall be assembled so that the space between the end of the pipe and the bottom of the socket is no less than 1.5 mm and no more than 3 mm.

#### 3.1.5.3 Soldered Joints

Soldered joints shall be made with flux and are only acceptable for lines 50 mm and smaller. Soldered joints shall conform to ASME B31.5 and CDA A4015.

#### 3.1.6 Flanges and Unions

Flanges shall be faced true, provided with 1.6 mm thick gaskets, and made square and tight. Where steel flanges mate with cast-iron flanged fittings, valves, or equipment, they shall be provided with flat faces and full face gaskets. Union or flange joints shall be provided in each line immediately preceding the connection to each piece of equipment or material requiring maintenance such as coils, pumps, control valves, and other similar items. Dielectric pipe unions shall be provided between ferrous and nonferrous piping to prevent galvanic corrosion. The dielectric unions shall have metal connections on both ends. The ends shall be threaded, flanged, or brazed to match adjacent piping. The metal parts of the union shall be separated so that the electrical current is below 1 percent of the galvanic current which would exist upon metal-to-metal contact. Gaskets, flanges, and unions shall be installed in accordance with manufacturer's recommendations.

#### 3.1.7 Branch Connections

##### 3.1.7.1 Branch Connections for Steam Systems

Branches shall be taken from the supply mains at an angle of 45 degrees above the horizontal, unless otherwise indicated. The branches from return mains shall be taken from the top or sides, unless indicated otherwise. Branches shall pitch up from the mains toward the undrilled risers or radiator connections with a grade of not less than 8 mm in 1 m. Connections to ensure unrestricted circulation, eliminate air pockets, and permit the complete drainage of the system.

#### 3.1.8 Steam Connections to Equipment

Steam supply and return connections shall be provided as shown. Connections shall be made with malleable-iron unions or with steel flanges, to match equipment. Valves and traps shall be installed in accordance with the manufacturer's recommendations. The size of the supply and return pipes to each piece of equipment shall not be smaller than the outlets on the equipment.

### 3.1.9 Steam Risers

The location of risers is approximate. The exact locations of the risers shall be approved. Downfeed risers shall terminate in a dirt pocket and shall be dripped through a trap to the return line.

### 3.1.10 Air Vents for Steam Systems

Automatic balanced pressure thermostatic air vents shall be installed at the ends of the steam lines and where shown on the drawings. The vents shall be rated for 862 kPa steam service. The outlet of the vent shall be routed to a point designated by the Contracting Officer's Representative. The inlet line shall have a gate valve or ball valve.

### 3.1.11 Supports

Hangers used to support piping 50 mm and larger shall be fabricated to permit adequate adjustment after erection while still supporting the load. Pipe guides and anchors shall be installed to keep pipes in accurate alignment, to direct the expansion movement, and to prevent buckling, swaying, and undue strain. Piping subjected to vertical movement when operating temperatures exceed ambient temperatures shall be supported by variable spring hangers and supports or by constant support hangers. Threaded rods which are used for support shall not be formed or bent. Supports shall not be attached to the underside of concrete filled floors or concrete roof decks unless approved by the Contracting Officer.

#### 3.1.11.1 Seismic Requirements for Supports and Structural Bracing

Piping and attached valves shall be supported and braced to resist seismic loads as specified in Sections 13080 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT and 15070A SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT as shown on the drawings. Structural steel required for reinforcement to properly support piping, headers, and equipment, but not shown, shall be provided in this section. Material used for supports shall be as specified in Section 05120 STRUCTURAL STEEL.

#### 3.1.11.2 Pipe Hangers, Inserts, and Supports

Pipe hangers, inserts, and supports shall conform to MSS SP-58 and MSS SP-69, except as modified herein.

- a. Types 5, 12, and 26 shall not be used.
- b. Type 3 shall not be used on insulated pipe which has a vapor barrier. Type 3 may be used on insulated pipe that does not have a vapor barrier if clamped directly to the pipe, if the clamp bottom does not extend through the insulation, and if the top clamp attachment does not contact the insulation during pipe movement.
- c. Type 18 inserts shall be secured to concrete forms before concrete

is placed. Continuous inserts which allow more adjustment may be used if they otherwise meet the requirements for Type 18 inserts.

- d. Type 19 and 23 C-clamps shall be torqued per MSS SP-69 and have both locknuts and retaining devices furnished by the manufacturer. Field fabricated C-clamp bodies or retaining devices are not acceptable.
- e. Type 20 attachments used on angles and channels shall be furnished with an added malleable-iron heel plate or adapter.
- f. Type 24 may be used only on trapeze hanger systems or on fabricated frames.
- g. Horizontal pipe supports shall be spaced as specified in MSS SP-69 and a support shall be installed not over 300 mm from the pipe fitting joint at each change in direction of the piping. Pipe supports shall be spaced not over 1500 mm apart at valves.
- h. Vertical pipe shall be supported at each floor, except at slab-on-grade, and at intervals of not more than 4500 mm, not more than 2400 mm from end of risers, and at vent terminations.
- i. Type 35 guides using steel, reinforced polytetrafluoroethylene (PTFE) or graphite slides shall be provided where required to allow longitudinal pipe movement. Lateral restraints shall be provided as required. Slide materials shall be suitable for the system operating temperatures, atmospheric conditions, and bearing loads encountered.
  - (1) Where steel slides do not require provisions for restraint of lateral movement, an alternate guide method may be used. On piping 100 mm (4 inches) and larger, a Type 39 saddle may be welded to the pipe and freely rested on a steel plate. On piping under 100 mm (4 inches), a Type 40 protection shield may be attached to the pipe or insulation and freely rested on a steel slide plate.
  - (2) Where there are high system temperatures and welding to piping is not desirable, the Type 35 guide shall include a pipe cradle welded to the guide structure and strapped securely to the pipe. The pipe shall be separated from the slide material by at least 100 mm or by an amount adequate for the insulation, whichever is greater.
- j. Except for Type 3, pipe hangers on horizontal insulated pipe shall be the size of the outside diameter of the insulation.
- k. Piping in trenches shall be supported as indicated.
- l. Structural steel attachments and brackets required to support piping, headers, and equipment, but not shown, shall be provided under this section. Material and installation shall be as specified under Section 05120 STRUCTURAL STEEL. Pipe hanger loads suspended from steel joist between panel points shall not exceed 22 kg. Loads exceeding 22 kg shall be suspended from panel points.

### 3.1.11.3 Multiple Pipe Runs

In the support of multiple pipe runs on a common base member, a clip or clamp shall be used where each pipe crosses the base support member. Spacing of the base support member shall not exceed the hanger and support spacing required for any individual pipe in the multiple pipe run. The clips or clamps shall be rigidly attached to the common base member. A clearance of 3 mm shall be provided between the pipe insulation and the clip or clamp for piping which may be subjected to thermal expansion.

#### 3.1.12 Anchors

Anchors shall be provided where necessary to localize expansion or to prevent undue strain on piping. Anchors shall consist of heavy steel collars with lugs and bolts for clamping and attaching anchor braces, unless otherwise indicated. Anchor braces shall be installed in the most effective manner to secure the desired results, using turnbuckles where required. Supports, anchors, or stays shall not be attached where they will injure the structure or adjacent construction during installation or by the weight of expansion of the pipeline.

#### 3.1.13 Valves

Valves shall be installed where indicated, specified, and required for functioning and servicing of the systems. Valves shall be safely accessible. Swing check valves shall be installed upright in horizontal lines and in vertical lines only when flow is in the upward direction. Gate and globe valves shall be installed with stems horizontal or above. Valves to be brazed shall be disassembled prior to brazing and all packing removed. After brazing, the valves shall be allowed to cool before reassembling.

#### 3.1.14 Pipe Sleeves

Pipe passing through concrete or masonry walls or concrete floors or roofs shall be provided with pipe sleeves fitted into place at the time of construction. A waterproofing clamping flange shall be installed as indicated where membranes are involved. Sleeves shall not be installed in structural members except where indicated or approved. Rectangular and square openings shall be as detailed. Each sleeve shall extend through its respective wall, floor, or roof. Sleeves through walls shall be cut flush with wall surface. Sleeves through floors shall be cut flush with floor surface. Sleeves through roofs shall extend above the top surface of roof at least 150 mm for proper flashing or finishing. Unless otherwise indicated, sleeves shall be sized to provide a minimum clearance of 6 mm between bare pipe and sleeves or between jacket over insulation and sleeves. Sleeves in waterproofing membrane floors, bearing walls, and wet areas shall be galvanized steel pipe or cast-iron pipe. Sleeves in nonbearing walls, floors, or ceilings may be galvanized steel pipe, cast-iron pipe, or galvanized sheet metal with lock-type longitudinal seam.

Except in pipe chases or interior walls, the annular space between pipe and sleeve or between jacket over insulation and sleeve in nonfire rated walls shall be sealed as indicated and specified in Section 07900A JOINT SEALING. Metal jackets shall be provided over insulation passing through exterior walls, firewalls, fire partitions, floors, or roofs.

- a. Metal jackets shall not be thinner than 0.1524 mm (0.006 inch) thick aluminum, if corrugated, and 0.4 mm (0.016 inch) thick aluminum, if smooth.

- b. Metal jackets shall be secured with aluminum or stainless steel bands not less than 9 mm wide and not more than 200 mm apart. When penetrating roofs and before fitting the metal jacket into place, a 15 mm wide strip of sealant shall be run vertically along the inside of the longitudinal joint of the metal jacket from a point below the backup material to a minimum height of 1000 mm above the roof. If the pipe turns from vertical to horizontal, the sealant strip shall be run to a point just beyond the first elbow. When penetrating waterproofing membrane for floors, the metal jacket shall extend from a point below the back-up material to a minimum distance of 50 mm above the flashing. For other areas, the metal jacket shall extend from a point below the backup material to a point 300 mm above material to a minimum distance of 50 mm above the flashing. For other areas, the metal jacket shall extend from a point below the backup material to a point 300 mm above the floor; when passing through walls above grade, the jacket shall extend at least 100 mm beyond each side of the wall.

#### 3.1.14.1 Fire Seal

Where pipes pass through firewalls, fire partitions, or floors, a fire seal shall be provided as specified in Section 07840A FIRESTOPPING.

#### 3.1.15 Thermometer Wells

A thermometer well shall be provided in each return line for each circuit in multicircuit systems.

#### 3.1.16 Drains

25 mm (1 inch) 20 mm (3/4 inch A threaded drain connections with threaded cap or plug shall be installed on the heat exchanger coil on each unit heater or unit ventilator and wherever required for thorough draining of the system.

#### 3.1.17 Strainer Blow-Down Piping

Strainer blow-down connections shall be fitted with a black steel blow-down pipeline routed to an accessible location and provided with a blow-down valve.

### 3.2 COLOR CODE MARKING AND FIELD PAINTING

Color code marking of piping shall be as specified in Section 09900 PAINTS AND COATINGS. Ferrous metal not specified to be coated at the factory shall be cleaned, prepared, and painted as specified in Section 09900 PAINTS AND COATINGS. Exposed pipe covering shall be painted as specified in Section 09900 PAINTS AND COATINGS. Aluminum sheath over insulation shall not be painted.

### 3.3 CLEANING

#### 3.3.1 Boilers and Piping

Strainers and valves shall be thoroughly cleaned.

### 3.4 FIELD TRAINING

The Contractor shall conduct a training course for the operating staff as designated by the Contracting Officer. The training period shall consist of a total of 24 hours of normal working time and shall start after the system is functionally completed but prior to final acceptance tests. The field instructions shall cover all of the items contained in the approved operation and maintenance instructions, as well as demonstrations of routine maintenance operations and boiler safety devices. The Contracting Officer shall be notified at least 14 days prior to date of proposed conduction of the training course.

-- End of Section --

SECTION TABLE OF CONTENTS

DIVISION 15 - MECHANICAL

SECTION 15895A

AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM

04/02

PART 1 GENERAL

- 1.1 REFERENCES
- 1.2 COORDINATION OF TRADES
- 1.3 DELIVERY AND STORAGE
- 1.4 SUBMITTALS

PART 2 PRODUCTS

- 2.1 STANDARD PRODUCTS
- 2.2 ASBESTOS PROHIBITION
- 2.3 NAMEPLATES
- 2.4 EQUIPMENT GUARDS AND ACCESS
- 2.5 ELECTRICAL WORK
- 2.6 CONTROLS
- 2.7 DUCTWORK COMPONENTS
  - 2.7.1 Metal Ductwork
    - 2.7.1.1 Transitions
    - 2.7.1.2 Metallic Flexible Duct
    - 2.7.1.3 Insulated Nonmetallic Flexible Duct Runouts
    - 2.7.1.4 General Service Duct Connectors
    - 2.7.1.5 High Temperature Service Duct Connections
  - 2.7.2 Ductwork Accessories
    - 2.7.2.1 Duct Access Doors
    - 2.7.2.2 Fire Dampers
    - 2.7.2.3 Manual Balancing Dampers
    - 2.7.2.4 Deleted Paragraph
  - 2.7.3 Duct Sleeves, Framed Prepared Openings, Closure Collars
    - 2.7.3.1 Duct Sleeves
    - 2.7.3.2 Framed Prepared Openings
    - 2.7.3.3 Closure Collars
  - 2.7.4 Diffusers, Registers, and Grilles
    - 2.7.4.1 Diffusers
    - 2.7.4.2 Registers and Grilles
  - 2.7.5 Louvers
  - 2.7.6 Air Vents, Penthouses, and Goosenecks
  - 2.7.7 Bird Screens and Frames
- 2.8 AIR SYSTEMS EQUIPMENT
  - 2.8.1 Fans
    - 2.8.1.1 Centrifugal Fans
    - 2.8.1.2 In-Line Centrifugal Fans
    - 2.8.1.3 Axial Flow Fans
  - 2.8.2 Steam Heating Coils
    - 2.8.2.1 Steam Heating Coils
  - 2.8.3 Air Filters
    - 2.8.3.1 Extended Surface Pleated Panel Filters

- 2.8.3.2 Holding Frames
- 2.8.3.3 Filter Gauges
- 2.9 CLIMATE CONTROL UNITS CCU-1 AND CCU-2
  - 2.9.1 Factory-Fabricated Air Handling Units
    - 2.9.1.1 Casings
    - 2.9.1.2 Steam Heating Coils
    - 2.9.1.3 Direct Expansion Cooling Coils, Condenser, and Related Equipment
    - 2.9.1.4 Steam Humidifiers
    - 2.9.1.5 Air Filters
    - 2.9.1.6 Fans
    - 2.9.1.7 Access Sections and Filter/Mixing Boxes
    - 2.9.1.8 Diffuser Sections
    - 2.9.1.9 Dampers
- 2.10 FACTORY PAINTING

PART 3 EXECUTION

- 3.1 INSTALLATION
  - 3.1.1 Anchors
  - 3.1.2 Condensate Drain Lines
  - 3.1.3 Equipment and Installation
  - 3.1.4 Access Panels
  - 3.1.5 Flexible Connectors
  - 3.1.6 Sleeved and Framed Openings
  - 3.1.7 Metal Ductwork
  - 3.1.8 Insulation
  - 3.1.9 Duct Test Holes
  - 3.1.10 Power Transmission Components Adjustment
- 3.2 FIELD PAINTING AND COLOR CODE MARKING
- 3.3 DUCTWORK LEAK TEST
- 3.4 CLEANING AND ADJUSTING
- 3.5 TESTING, ADJUSTING, AND BALANCING
- 3.6 PERFORMANCE TESTS
- 3.7 FIELD TRAINING

-- End of Section Table of Contents --

## SECTION 15895A

AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM  
04/02

## PART 1 GENERAL

## 1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

## AIR CONDITIONING AND REFRIGERATION INSTITUTE (ARI)

ARI 410	(1991) Forced-Circulation Air-Cooling and Air-Heating Coils
ARI 430	(1989) Central-Station Air-Handling Units
ARI Guideline D	(1996) Application and Installation of Central Station Air-Handling Units

## AIR MOVEMENT AND CONTROL ASSOCIATION (AMCA)

AMCA 210	(1999) Laboratory Methods of Testing Fans for Rating
AMCA 300	(1996) Reverberant Room Method for Sound Testing of Fans

## AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

ABMA 11	(1990; R 1999) Load Ratings and Fatigue Life for Roller Bearings
ABMA 9	(1990; R 2000) Load Ratings and Fatigue Life for Ball Bearings

## AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 123/A 123M	(2001) Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 53/A 53M	(2001) Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A 924/A 924M	(1999) General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process
ASTM B 117	(1997) Operating Salt Spray (Fog) Apparatus
ASTM C 1071	(1998) Thermal and Acoustical Insulation (Glass Fiber, Duct Lining Material)

ASTM D 1654	(1992) Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
ASTM D 3359	(1997) Measuring Adhesion by Tape Test
ASTM D 520	(2000) Zinc Dust Pigment
ASTM E 437	(1992; R 1997) Industrial Wire Cloth and Screens (Square Opening Series)
AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)	
ASHRAE 52.1	(1992) Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter
ASHRAE 70	(1991) Method of Testing for Rating the Performance of Air Outlets and Inlets
NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)	
NEMA MG 1	(1998) Motors and Generators
NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)	
NFPA 90A	(1999) Installation of Air Conditioning and Ventilating Systems
SHEET METAL & AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)	
SMACNA HVAC Duct Const Stds	(1995; Addenda Nov 1997) HVAC Duct Construction Standards - Metal and Flexible
SMACNA Install Fire Damp HVAC	(1992) Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems
SMACNA Leakage Test Mnl	(1985) HVAC Air Duct Leakage Test Manual
UNDERWRITERS LABORATORIES (UL)	
UL 181	(1996; Rev Dec 1998) Factory-Made Air Ducts and Air Connectors
UL 214	(1997) Tests for Flame-Propagation of Fabrics and Films
UL 555	(1999) Fire Dampers
UL 586	(1996; Rev thru Aug 1999) High-Efficiency, Particulate, Air Filter Units
UL 900	(1994; Rev thru Nov 1999) Test Performance of Air Filter Units
UL Bld Mat Dir	(1999) Building Materials Directory

UL Elec Const Dir	(1999) Electrical Construction Equipment Directory
UL Fire Resist Dir	(1999) Fire Resistance Directory (2 Vol.)

## 1.2 COORDINATION OF TRADES

Ductwork, piping offsets, fittings, and accessories shall be furnished as required to provide a complete installation and to eliminate interference with other construction.

## 1.3 DELIVERY AND STORAGE

Equipment delivered and placed in storage shall be stored with protection from the weather, humidity and temperature variations, dirt and dust, or other contaminants.

## 1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

All items designated with a G, EC including product literature, calculations, component data, certificates, diagrams and drawings, shall be submitted concurrently in one complete system submittal. Omission of any required submittal item from the package shall be sufficient cause for disapproval of the entire submittal. Unless otherwise indicated in the submittal review commentary, disapproval of any item within the package shall require a re-submittal of the entire system package, in which all deficiencies shall be corrected.

### SD-02 Shop Drawings

Drawings; G, EC  
Installation; G, EC

Drawings shall consist of equipment layout including assembly and installation details and electrical connection diagrams; ductwork layout showing the location of all supports and hangers, typical hanger details, gauge reinforcement, reinforcement spacing rigidity classification, and static pressure and seal classifications; and piping layout showing the location of all guides and anchors, the load imposed on each support or anchor, and typical support details. Drawings shall include any information required to demonstrate that the system has been coordinated and will properly function as a unit and shall show equipment relationship to other parts of the work, including clearances required for operation and maintenance.

### Test Procedures

Proposed test procedures for piping hydrostatic test, ductwork leak test, and performance tests of systems, at least 2 weeks

prior to the start of related testing.

#### Welding Procedures

A copy of qualified welding procedures, at least 2 weeks prior to the start of welding operations.

#### System Diagrams; G, RE

Proposed diagrams, at least 2 weeks prior to start of related testing. System diagrams that show the layout of equipment, piping, and ductwork, and typed condensed operation manuals explaining preventative maintenance procedures, methods of checking the system for normal, safe operation, and procedures for safely starting and stopping the system shall be framed under glass or laminated plastic. After approval, these items shall be posted where directed.

#### Similar Services

Statement demonstrating successful completion of similar services on at least 5 projects of similar size and scope, at least 2 weeks prior to submittal of other items required by this section.

#### Welding Joints

A list of names and identification symbols of qualified welders and welding operators, at least 2 weeks prior to the start of welding operations.

### SD-03 Product Data

Ductwork and Fittings; G, EC.

Dampers; G, EC.

Exhaust Fans; G, EC.

Diffusers, Registers and Grilles; G, EC.

Louvers; G, EC.

Climate Control Units; G, EC.

Complete product literature and supporting data to demonstrate compliance with the contract requirements. Data shall indicate specific item and model proposed. Performance and material specifications shall be clearly identified.

### SD-06 Test Reports

Performance Tests; ,

Test reports for the piping hydrostatic test, ductwork leak test, and performance tests in booklet form, upon completion of testing. Reports shall document phases of tests performed including initial test summary, repairs/adjustments made, and final test results.

### SD-07 Certificates

Bolts; ,

Written certification from the bolt manufacturer that the bolts furnished comply with the requirements of this specification. The certification shall include illustrations of product markings, and the number of each type of bolt to be furnished.

### SD-10 Operation and Maintenance Data

Operating and Maintenance Instructions;G, RE  
Six manuals listing step-by-step procedures required for system startup, operation, shutdown, and routine maintenance, at least 2 weeks prior to field training. The manuals shall include the manufacturer's name, model number, parts list, list of parts and tools that should be kept in stock by the owner for routine maintenance including the name of a local supplier, simplified wiring and controls diagrams, troubleshooting guide, and recommended service organization (including address and telephone number) for each item of equipment. Each service organization submitted shall be capable of providing 4 hour onsite response to a service call on an emergency basis.

## PART 2 PRODUCTS

### 2.1 STANDARD PRODUCTS

Components and equipment shall be standard products of a manufacturer regularly engaged in the manufacturing of products that are of a similar material, design and workmanship. The standard products shall have been in satisfactory commercial or industrial use for 2 years before bid opening. The 2-year experience shall include applications of components and equipment under similar circumstances and of similar size. The 2 years must be satisfactorily completed by a product which has been sold or is offered for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures. Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation, for not less than 6000 hours exclusive of the manufacturer's factory tests, can be shown. The equipment items shall be supported by a service organization.

### 2.2 ASBESTOS PROHIBITION

Asbestos and asbestos-containing products shall not be used.

### 2.3 NAMEPLATES

Equipment shall have a nameplate that identifies the manufacturer's name, address, type or style, model or serial number, and catalog number.

### 2.4 EQUIPMENT GUARDS AND ACCESS

Belts, pulleys, chains, gears, couplings, projecting setscrews, keys, and other rotating parts exposed to personnel contact shall be fully enclosed or guarded according to OSHA requirements. High temperature equipment and piping exposed to contact by personnel or where it creates a potential fire hazard shall be properly guarded or covered with insulation of a type specified. shall be provided where shown and shall be constructed according to Section 05500A MISCELLANEOUS METAL.

### 2.5 ELECTRICAL WORK

Electrical motor-driven equipment specified shall be provided complete with motor, motor starter, and controls. Unless otherwise specified, electric equipment, including wiring and motor efficiencies, shall be according to Section 16415A ELECTRICAL WORK, INTERIOR. Electrical characteristics and enclosure type shall be as shown. Unless otherwise indicated, motors of 745 W and above shall be high efficiency type. Motor starters shall be provided complete with thermal overload protection and other appurtenances

necessary. Each motor shall be according to NEMA MG 1 and shall be of sufficient size to drive the equipment at the specified capacity without exceeding the nameplate rating of the motor. Manual or automatic control and protective or signal devices required for the operation specified, and any control wiring required for controls and devices, but not shown, shall be provided. Where two-speed or variable-speed motors are indicated, solid-state variable-speed controller may be provided to accomplish the same function. Solid-state variable-speed controllers shall be utilized for motors rated 7.45 kW (10 hp) or less. Adjustable frequency drives shall be used for larger motors.

## 2.6 CONTROLS

Controls shall be provided as specified in Section 15950A HEATING, VENTILATING AND AIR CONDITIONING (HVAC) CONTROL SYSTEMS.

## 2.7 DUCTWORK COMPONENTS

### 2.7.1 Metal Ductwork

All aspects of metal ductwork construction, including all fittings and components, shall comply with SMACNA HVAC Duct Const Stds unless otherwise specified. Elbows shall be radius type with a centerline radius of 1-1/2 times the width or diameter of the duct where space permits. Otherwise, elbows having a minimum radius equal to the width or diameter of the duct or square elbows with factory fabricated turning vanes may be used. Static pressure Class 125, 250, and 500 Pa (1/2, 1, and 2 inch w.g.) ductwork shall meet the requirements of Seal Class A. Class 750 through 2500 Pa (3 through 10 inch) shall meet the requirements of Seal Class A. Sealants shall conform to fire hazard classification specified in Section 15080A THERMAL INSULATION FOR MECHANICAL SYSTEMS. Pressure sensitive tape shall not be used as a sealant. Spiral lock seam duct, and flat oval shall be made with duct sealant and locked with not less than 3 equally spaced drive screws or other approved methods indicated in SMACNA HVAC Duct Const Stds. The sealant shall be applied to the exposed male part of the fitting collar so that the sealer will be on the inside of the joint and fully protected by the metal of the duct fitting. One brush coat of the sealant shall be applied over the outside of the joint to at least 50 mm band width covering all screw heads and joint gap. Dents in the male portion of the slip fitting collar will not be acceptable. Outdoor air intake ducts and plenums shall be fabricated with watertight soldered or brazed joints and seams.

#### 2.7.1.1 Transitions

Diverging air flow transitions shall be made with each side pitched out a maximum of 15 degrees, for an included angle of 30 degrees. Transitions for converging air flow shall be made with each side pitched in a maximum of 30 degrees, for an included angle of 60 degrees, or shall be as indicated.

#### 2.7.1.2 Metallic Flexible Duct

Metallic type duct shall be single-ply galvanized steel. Duct shall be of corrugated/interlocked, folded and knurled type seam construction, bendable without damage through 180 degrees with a throat radius equal to 1/2 duct diameter. Duct shall conform to UL 181 and shall be rated for positive or negative working pressure of 3.75 kPa (15 inches water gauge) at 177 degrees C (350 degrees F) when duct is aluminum, and 343 degrees C (650

degrees F) when duct is galvanized steel or stainless steel.

#### 2.7.1.3 Insulated Nonmetallic Flexible Duct Runouts

Flexible duct runouts shall be used only where indicated. Runout length shall be as shown on the drawings, but shall in no case exceed 3 m. Runouts shall be preinsulated, factory fabricated, and shall comply with NFPA 90A and UL 181. Either field or factory applied vapor barrier shall be provided. Where coil induction or high velocity units are supplied with vertical air inlets, a streamlined and vaned and mitered elbow transition piece shall be provided for connection to the flexible duct or hose. The last elbow to these units, other than the vertical air inlet type, shall be a die-stamped elbow and not a flexible connector. Insulated flexible connectors may be used as runouts. The insulated material and vapor barrier shall conform to the requirements of Section 15080A THERMAL INSULATION FOR MECHANICAL SYSTEMS. The insulation material surface shall not be exposed to the air stream.

#### 2.7.1.4 General Service Duct Connectors

A flexible duct connector approximately 150 mm in width shall be provided where sheet metal connections are made to fans or where ducts of dissimilar metals are connected. For round/oval ducts, the flexible material shall be secured by stainless steel or zinc-coated, iron clinch-type draw bands. For rectangular ducts, the flexible material locked to metal collars shall be installed using normal duct construction methods. The composite connector system shall comply with UL 214 and be classified as "flame-retarded fabrics" in UL Bld Mat Dir.

#### 2.7.1.5 High Temperature Service Duct Connections

Material shall be approximately 2.38 mm thick, 1.2 to 1.36 kg per square meter (35 to 40-ounce per square yard) weight, plain weave fibrous glass cloth with, nickel/chrome wire reinforcement for service in excess of 650 degrees C.

#### 2.7.2 Ductwork Accessories

##### 2.7.2.1 Duct Access Doors

Access doors shall be provided in ductwork and plenums where indicated and at all air flow measuring primaries, automatic dampers, fire dampers, coils, thermostats, and other apparatus requiring service and inspection in the duct system, and unless otherwise shown, shall conform to SMACNA HVAC Duct Const Stds. Access doors shall be provided upstream and downstream of air flow measuring primaries and heating and cooling coils. Doors shall be minimum 375 x 450 mm, unless otherwise shown. Where duct size will not accommodate this size door, the doors shall be made as large as practicable. Doors 600 x 600 mm or larger shall be provided with fasteners operable from both sides. Doors in insulated ducts shall be the insulated type.

##### 2.7.2.2 Fire Dampers

Fire dampers shall be 1-1/2 hour fire rated unless otherwise indicated. Fire dampers shall conform to the requirements of NFPA 90A and UL 555. A positive pressure relief door shall be provided upstream of fire dampers which are provided in the supply air and exhaust ducts. A negative pressure relief door shall be provided downstream of fire dampers which are

provided in the return air ducts. The size and pressure relief rating of the relief doors shall be in accordance with the manufacturer's recommendations. The pressure relief door may be a combined pressure relief and access door unit if it is specifically listed by the manufacturer as such. A pressure relief door shall be provided upstream of the fire damper. If the ductwork connected to the fire damper is to be insulated then this pressure relief damper shall be factory insulated. Fire dampers shall be automatic operating type and shall have a dynamic rating suitable for the maximum air velocity and pressure differential to which it will be subjected. Fire dampers shall be approved for the specific application, and shall be installed according to their listing. Fire dampers shall be equipped with a steel sleeve or adequately sized frame installed in such a manner that disruption of the attached ductwork, if any, will not impair the operation of the damper. Sleeves or frames shall be equipped with perimeter mounting angles attached on both sides of the wall or floor opening. Ductwork in fire-rated floor-ceiling or roof-ceiling assembly systems with air ducts that pierce the ceiling of the assemblies shall be constructed in conformance with UL Fire Resist Dir. Fire dampers shall be curtain type with damper blades in the air stream out of the air stream or single blade type or multi-blade type. Dampers shall not reduce the duct or the air transfer opening cross-sectional area. Dampers shall be installed so that the centerline of the damper depth or thickness is located in the centerline of the wall, partition or floor slab depth or thickness. Unless otherwise indicated, the installation details given in SMACNA Install Fire Damp HVAC and in manufacturer's instructions for fire dampers shall be followed.

#### 2.7.2.3 Manual Balancing Dampers

Manual balancing dampers shall be furnished with accessible operating mechanisms. Where operators occur in finished portions of the building, operators shall be chromium plated with all exposed edges rounded. Manual volume control dampers shall be operated by locking-type quadrant operators. Dampers and shall be 2 gauges heavier than the duct in which installed. Unless otherwise indicated, multileaf dampers shall be opposed blade type with maximum blade width of 300 mm. Access doors or panels shall be provided for all concealed damper operators and locking setscrews. Unless otherwise indicated, the locking-type quadrant operators for dampers, when installed on ducts to be thermally insulated, shall be provided with stand-off mounting brackets, bases, or adapters to provide clearance between the duct surface and the operator not less than the thickness of the insulation. Stand-off mounting items shall be integral with the operator or standard accessory of the damper manufacturer. Volume dampers shall be provided where indicated.

#### 2.7.2.4 Deleted Paragraph

### 2.7.3 Duct Sleeves, Framed Prepared Openings, Closure Collars

#### 2.7.3.1 Duct Sleeves

Duct sleeves shall be provided for round ducts 375 mm in diameter or less passing through floors, walls, ceilings, or roof, and installed during construction of the floor, wall, ceiling, or roof. Round ducts larger than 375 mm in diameter and square, rectangular, and oval ducts passing through floors, walls, ceilings, or roof shall be installed through framed prepared openings. The Contractor shall be responsible for the proper size and location of sleeves and prepared openings. Sleeves and framed openings are

also required where grilles, registers, and diffusers are installed at the openings. Framed prepared openings shall be fabricated from 1.0 mm (20 gauge) galvanized steel, unless otherwise indicated. Where sleeves are installed in bearing walls or partitions, black steel pipe, ASTM A 53/A 53M, Schedule 20 shall be used. Sleeve shall provide 25 mm clearance between the duct and the sleeve or 25 mm clearance between the insulation and the sleeve for insulated ducts.

#### 2.7.3.2 Framed Prepared Openings

Openings shall have 25 mm clearance between the duct and the opening or 25 mm clearance between the insulation and the opening for insulated ducts.

#### 2.7.3.3 Closure Collars

Collars shall be fabricated of galvanized sheet metal not less than 100 mm wide, unless otherwise indicated, and shall be installed on exposed ducts on each side of walls or floors where sleeves or prepared openings are provided. Collars shall be installed tight against surfaces. Collars shall fit snugly around the duct or insulation. Sharp edges of the collar around insulated duct shall be ground smooth to preclude tearing or puncturing the insulation covering or vapor barrier. Collars for round ducts 375 mm in diameter or less shall be fabricated from 1.0 mm (20 gauge) galvanized steel. Collars for round ducts larger than 375 mm and square, and rectangular ducts shall be fabricated from 1.3 mm (18 gauge) galvanized steel. Collars shall be installed with fasteners on maximum 150 mm centers, except that not less than 4 fasteners shall be used.

#### 2.7.4 Diffusers, Registers, and Grilles

Units shall be factory-fabricated of steel, corrosion-resistant steel, or aluminum and shall distribute the specified quantity of air evenly over space intended without causing noticeable drafts, air movement faster than 0.25 m/s (50 fpm) in occupied zone, or dead spots anywhere in the conditioned area. Outlets for diffusion, spread, throw, and noise level shall be as required for specified performance. Performance shall be certified according to ASHRAE 70. Inlets and outlets shall be sound rated and certified according to ASHRAE 70. Sound power level shall be as indicated. Diffusers and registers shall be provided with volume damper with accessible operator, unless otherwise indicated; or if standard with the manufacturer, an automatically controlled device will be acceptable. Volume dampers shall be opposed blade type for all diffusers and registers, except linear slot diffusers. Linear slot diffusers shall be provided with round or elliptical balancing dampers. Where the inlet and outlet openings are located less than 2 m above the floor, they shall be protected by a grille or screen according to NFPA 90A.

##### 2.7.4.1 Diffusers

Diffuser types shall be as indicated. Ceiling mounted units shall be furnished with anti-smudge devices, unless the diffuser unit minimizes ceiling smudging through design features. Diffusers shall be provided with air deflectors of the type indicated. Air handling troffers or combination light and ceiling diffusers shall conform to the requirements of UL Elec Const Dir for the interchangeable use as cooled or heated air supply diffusers or return air units. Ceiling mounted units shall be installed with rims tight against ceiling. Sponge rubber gaskets shall be provided between ceiling and surface mounted diffusers for air leakage control. Suitable trim shall be provided for flush mounted diffusers. Duct collar

connecting the duct to diffuser shall be airtight and shall not interfere with volume controller. Return or exhaust units shall be similar to supply diffusers.

#### 2.7.4.2 Registers and Grilles

Units shall be four-way directional-control type, except that return and exhaust registers may be fixed horizontal or vertical louver type similar in appearance to the supply register face. Registers shall be provided with sponge-rubber gasket between flanges and wall or ceiling. Wall supply registers shall be installed at least 150 mm below the ceiling unless otherwise indicated. Return and exhaust registers shall be located 150 mm above the floor unless otherwise indicated. Four-way directional control may be achieved by a grille face which can be rotated in 4 positions or by adjustment of horizontal and vertical vanes. Grilles shall be as specified for registers, without volume control damper.

#### 2.7.5 Louvers

Louvers for installation in exterior walls which are associated with the air supply and distribution system shall be as specified in Section 07600A SHEET METALWORK, GENERAL.

#### 2.7.6 Air Vents, Penthouses, and Goosenecks

Air vents, penthouses, and goosenecks shall be fabricated from galvanized steel or aluminum sheets with galvanized or aluminum structural shapes. Sheet metal thickness, reinforcement, and fabrication shall conform to SMACNA HVAC Duct Const Stds. Louver blades shall be accurately fitted and secured to frames. Edges of louver blades shall be folded or beaded for rigidity and baffled to exclude driving rain. Air vents, penthouses, and goosenecks shall be provided with bird screen.

#### 2.7.7 Bird Screens and Frames

Bird screens shall conform to ASTM E 437, No. 2 mesh, aluminum or stainless steel. Aluminum screens shall be rated "medium-light". Stainless steel screens shall be rated "light". Frames shall be removable type, or stainless steel or extruded aluminum.

### 2.8 AIR SYSTEMS EQUIPMENT

#### 2.8.1 Fans

Fans shall be rated for spark resistant AMCA Type A construction as shown on the drawings. Fans shall be tested and rated according to AMCA 210. Fans may be connected to the motors either directly or indirectly with V-belt drive. V-belt drives shall be designed for not less than 150 percent of the connected driving capacity. Motor sheaves shall be variable pitch for 11 kW (15 hp) and below and fixed pitch as defined by ARI Guideline D. Variable pitch sheaves shall be selected to drive the fan at a speed which will produce the specified capacity when set at the approximate midpoint of the sheave adjustment. When fixed pitch sheaves are furnished, a replaceable sheave shall be provided when needed to achieve system air balance. Motors for V-belt drives shall be provided with adjustable rails or bases. Removable metal guards shall be provided for all exposed V-belt drives, and speed-test openings shall be provided at the center of all rotating shafts. Fans shall be provided with personnel screens or guards on both suction and supply ends, except where ducts are

connected to the fan. Fan and motor assemblies shall be provided with vibration-isolation supports. Vibration-isolation units shall be standard products with published loading ratings. Each fan shall be selected to produce the capacity required at the fan static pressure indicated. Sound power level shall be as indicated. The sound power level values shall be obtained according to AMCA 300. Standard AMCA arrangement, rotation, and discharge shall be as indicated.

#### 2.8.1.1 Centrifugal Fans

Centrifugal fans shall be fully enclosed, single-width single-inlet, or double-width double-inlet, AMCA Pressure Class I, II, or III as required or indicated for the design system pressure. Impeller wheels shall be rigidly constructed, accurately balanced both statically and dynamically. Climate Control Units CCU-1 and CCU-2 fan blades shall be backward-inclined as shown on the drawings. 750 mm (30 inches). Fan wheels over 900 mm (36 inches) in diameter shall have overhung pulleys and a bearing on each side of the wheel. Fan wheels 900 mm (36 inches) or less in diameter may have one or more extra long bearings between the fan wheel and the drive. Bearings shall be sleeve type, self-aligning and self-oiling with oil reservoirs, or precision self-aligning roller or ball-type with accessible grease fittings or permanently lubricated type. Grease fittings shall be connected to tubing and serviceable from a single accessible point. Bearing life shall be L50 rated at not less than 200,000 hours as defined by ABMA 9 and ABMA 11. Fan shafts shall be monel to meet AMCA Type A spark resitant construction, accurately finished, and shall be provided with key seats and keys for impeller hubs and fan pulleys. Each fan outlet shall be of ample proportions and shall be designed for the attachment of angles and bolts for attaching flexible connections. Motors, unless otherwise indicated, shall not exceed 1800 rpm and shall have explosion-proof enclosures.

#### 2.8.1.2 In-Line Centrifugal Fans

In-line centrifugal fans for Exhaust Fans EF-5, EF-12, EF-13, and EF-19, serving Building 1176 trench drain exhaust, shall be suitable for moving explosive concentrations of aviation fuel spill vapors, shall be complete with drive components and belt guard, shall have an aluminum housing, meet spark resitant AMCA Type A constuction, aluminum fan wheel, explosion proof motors, monel diffusers, fan shaft, bearings, and mounting frame as a factory-assembled unit. In-line fans shall have centrifugal backward inclined blades, stationary discharge conversion vanes, internal and external belt guards, and adjustable motor mounts. Air shall enter and leave the fan axially. Inlets shall be streamlined with conversion vanes to eliminate turbulence and provide smooth discharge air flow. Fan bearings and drive shafts shall be enclosed and isolated from the air stream. Fan bearings shall be sealed against dust and dirt and shall be permanently lubricated, and shall be precision self aligning ball or roller type. Bearing life shall be L50 rated at not less than 200,000 hours as defined by ABMA 9 and ABMA 11. Motors shall have explosion-proof enclosure.

#### 2.8.1.3 Axial Flow Fans

Vane Axial Exhaust Fans EF-15 and EF-17 shall be suitable for moving explosive concentrations of aviation fuel spill vapors, shall be complete with drive components and belt guard, shall have an aluminum housing, meet spark resitant AMCA Type A constuction, aluminum fan wheel, explosion proof motors, monel diffusers, fan shaft, bearings, and mounting frame as a

factory-assembled unit. Fan wheels shall have radially projecting blades of airfoil cross section and shall be dynamically balanced and keyed to the fan shaft. Fan bearings and drive shafts shall be enclosed and isolated from the air stream. Fan bearings shall be sealed against dust and dirt, shall be permanently lubricated or with accessible grease fittings, and shall be precision self-aligning ball or roller type. Bearing life shall be L50 rated at not less than 200,000 hours of operation as defined by ABMA 9 and ABMA 11. Fan inlets shall be provided with an aerodynamically shaped bell and an inlet cone. Diffuser or straightening vanes shall be provided at the fan discharge to minimize turbulence and provide smooth discharge air flow. Fan unit shall be provided with inlet and outlet flanges, and operation adjustable inlet vanes. Unless otherwise indicated, motors shall not exceed 1800 rpm.

## 2.8.2 Steam Heating Coils

Coils shall be fin-and-tube type constructed of seamless copper tubes and aluminum fins mechanically bonded or soldered to the tubes. Copper tube wall thickness shall be a minimum of 0.508 mm ( inches). Casing and tube support sheets shall be not lighter than 1.6 mm (16 gauge) galvanized steel, formed to provide structural strength. When required, multiple tube supports shall be provided to prevent tube sag. Each coil shall be tested at the factory under water at not less than 2.76 MPa (400 psi) air pressure and shall be suitable for 1.38 MPa (200 psi) working pressure. Coils shall be mounted for counterflow service. Coils shall be rated and certified according to ARI 410.

### 2.8.2.1 Steam Heating Coils

Steam coils shall be constructed of cast semisteel, welded steel or copper headers, and copper tubes. Headers shall be constructed of cast iron, welded steel or copper. Fin tube and header section shall float within the casing to allow free expansion of tubing for coils subject to high pressure steam service. Each coil shall be provided with a field or factory installed vacuum breaker. Coils shall be single-tube type with tubes not less than 12 mm (1/2 inch) outside diameter, except for steam preheat coils. Supply headers shall distribute steam evenly to all tubes at the indicated steam pressure. Coils shall be factory tested to ensure that, when supplied with a uniform face velocity, temperature across the leaving side will be uniform with a maximum variation of no more than 5 percent.

## 2.8.3 Air Filters

Air filters shall be listed according to requirements of UL 900, except high efficiency particulate air filters of 99.97 percent efficiency by the DOP Test method shall be as listed under the Label Service and shall meet the requirements of UL 586.

### 2.8.3.1 Extended Surface Pleated Panel Filters

Filters shall be 50 mm (2 inch) depth, sectional, disposable type of the size indicated and shall have an average efficiency of 25 to 30 percent when tested according to ASHRAE 52.1. Initial resistance at 2.54 m/s (500 feet per minute) shall not exceed 9 mm water gauge. Filters shall be UL Class 2. Media shall be nonwoven cotton and synthetic fiber mat. A wire support grid bonded to the media shall be attached to a moisture resistant fiberboard frame. All four edges of the filter media shall be bonded to the inside of the frame to prevent air bypass and increase rigidity.

### 2.8.3.2 Holding Frames

Frames shall be fabricated from not lighter than 1.6 mm (16 gauge) sheet steel with rust-inhibitor coating. Each holding frame shall be equipped with suitable filter holding devices. Holding frame seats shall be gasketed. All joints shall be airtight.

### 2.8.3.3 Filter Gauges

Filter gauges shall be dial type, diaphragm actuated draft and shall be provided for all filter stations, including those filters which are furnished as integral parts of factory fabricated air handling units. Gauges shall be at least 98 mm (3-7/8 inches) in diameter, shall have white dials with black figures, and shall be graduated in 0.0025 kPa mm (0.01 inch of water), and shall have a minimum range of 0.25 kPa (1 inch of water) beyond the specified final resistance for the filter bank on which each gauge is applied. Each gauge shall incorporate a screw operated zero adjustment and shall be furnished complete with two static pressure tips with integral compression fittings, two molded plastic vent valves, two 1.5 m (5 foot) minimum lengths of 6.35 mm (1/4 inch) diameter aluminum tubing, and all hardware and accessories for gauge mounting.

## 2.9 CLIMATE CONTROL UNITS CCU-1 AND CCU-2

### 2.9.1 Factory-Fabricated Air Handling Units

Units shall be single-zone draw-through type as indicated. Units shall include fans, coils, airtight insulated casing, prefilters, adjustable V-belt drives, belt guards for externally mounted motors, access sections where indicated, mixing box combination sectional filter-mixing box, spray type humidifier, vibration-isolators, and appurtenances required for specified operation. Vibration isolators shall be as indicated. Each air handling unit shall have physical dimensions suitable to fit space allotted to the unit and shall have the capacity indicated. Air handling unit shall have published ratings based on tests performed according to ARI 430.

#### 2.9.1.1 Casings

Casing sections shall be 2 inch double wall type constructed of a minimum 18 gauge galvanized steel, or 18 gauge steel outer casing protected with a corrosion resistant paint finish according to paragraph FACTORY PAINTING. Inner casing of double-wall units shall be minimum 1.0 mm (20 gauge) solid galvanized steel. Casing shall be designed and constructed with an integral structural steel frame such that exterior panels are non-load bearing. Exterior panels shall be individually removable. Removal shall not affect the structural integrity of the unit. Casings shall be provided with inspection doors, access sections, and access doors as indicated. Inspection and access doors shall be insulated, fully gasketed, double-wall type, of a minimum 1.3 mm (18 gauge) outer and 1.0 mm (20 gauge) inner panels. Doors shall be rigid and provided with heavy duty hinges and latches. Inspection doors shall be a minimum 300 mm wide by 300 mm high.

Access doors shall be minimum 600 mm wide and shall be the full height of the unit casing or a minimum of 1800 mm, whichever is less. A minimum 200 mm by 200 mm sealed glass window suitable for the intended application shall be installed in all access doors. Access Sections shall be according to paragraph AIR HANDLING UNITS. Drain pan shall be double-bottom type constructed of 16 gauge galvanized steel, pitched to the drain connection. Drain pans shall be constructed water tight, treated to prevent corrosion, and designed for positive condensate drainage. When 2 or more cooling

coils are used, with one stacked above the other, condensate from the upper coils shall not flow across the face of lower coils. Intermediate drain pans or condensate collection channels and downspouts shall be provided, as required to carry condensate to the unit drain pan out of the air stream and without moisture carryover. Each casing section handling conditioned air shall be insulated with not less than 25 mm (1 inch) thick, 24 kg per cubic meter (1-1/2 pound density) coated fibrous glass material having a thermal conductivity not greater than 0.033 W/m-K (0.23 Btu/hr-sf-F). Factory applied fibrous glass insulation shall conform to ASTM C 1071, except that the minimum thickness and density requirements do not apply, and shall meet the requirements of NFPA 90A. Foam-type insulation is not acceptable. Foil-faced insulation shall not be an acceptable substitute for use on double-wall access doors and inspections doors and casing sections. Deleted sentence. Exposed insulation edges and joints where insulation panels are butted together shall be protected with a metal nosing strip or shall be coated to conform to meet erosion resistance requirements of ASTM C 1071. A latched and hinged inspection door, shall be provided in the fan and coil sections. Additional inspection doors, access doors and access sections shall be provided where indicated.

#### 2.9.1.2 Steam Heating Coils

Steam heating coils shall be provided as specified in paragraph AIR SYSTEMS EQUIPMENT, for types indicated.

#### 2.9.1.3 Direct Expansion Cooling Coils, Condenser, and Related Equipment

Units shall contain direct expansion cooling coils, condenser, and related equipment as specified in Section 15700A UNITARY HEATING AND COOLING EQUIPMENT.

#### 2.9.1.4 Steam Humidifiers

Unit shall contain humidification steam distributor as specified in Section 15569A WATER AND STEAM HEATING.

#### 2.9.1.5 Air Filters

Air filters shall be as specified in paragraph AIR SYSTEMS EQUIPMENT for types and thickness indicated.

#### 2.9.1.6 Fans

Fans shall be double-inlet, centrifugal backward inclined type with each fan in a separate scroll. Fans and shafts shall be dynamically balanced prior to installation into air handling unit, then the entire fan assembly shall be statically and dynamically balanced at the factory after it has been installed in the air handling unit. Fans shall be mounted on steel shafts accurately ground and finished. Fan bearings shall be sealed against dust and dirt and shall be precision self-aligning ball or roller type. Bearing life shall be L50 rated at not less than 200,000 hours as defined by ABMA 9 and ABMA 11. Bearings shall be permanently lubricated or lubricated type with lubrication fittings readily accessible at the drive side of the unit. Bearings shall be supported by structural shapes, or die formed sheet structural members, or support plates securely attached to the unit casing. Bearings may not be fastened directly to the unit sheet metal casing. Fans and scrolls shall be furnished with coating indicated. Fans shall be driven by a unit-mounted or a floor-mounted motor connected to fans by V-belt drive complete with belt guard for externally mounted

motors. Belt guards shall be the three sided enclosed type with solid or expanded metal face. Belt drives shall be designed for not less than a 1.3 service factor based on motor nameplate rating. Motor sheaves shall be variable pitch for 20 kW and below and fixed pitch above 20 kW as defined by ARI Guideline D. Where fixed sheaves are required, variable pitch sheaves may be used during air balance, but shall be replaced with an appropriate fixed sheave after air balance is completed. Variable pitch sheaves shall be selected to drive the fan at a speed that will produce the specified capacity when set at the approximate midpoint of the sheave adjustment. Motors for V-belt drives shall be provided with adjustable bases. Fan motors shall have open enclosures.

#### 2.9.1.7 Access Sections and Filter/Mixing Boxes

Access sections shall be provided where indicated and shall be furnished with access doors as shown. Access sections and filter/mixing boxes shall be constructed in a manner identical to the remainder of the unit casing and shall be equipped with access doors. Mixing boxes shall be designed to minimize air stratification and to promote thorough mixing of the air streams.

#### 2.9.1.8 Diffuser Sections

Diffuser sections shall be furnished between the discharge of all supply fans. Diffuser sections shall be fabricated by the unit manufacturer in a manner identical to the remainder of the unit casing, shall be designed to be airtight under positive static pressures up to kPa (5 inches water gauge), and shall have an access door on each side for inspection purposes. Diffuser section shall contain a perforated diffusion plate, fabricated of galvanized steel, Type 316 stainless steel, aluminum, or steel treated for corrosion with manufacturer's standard corrosion-resisting finish. The diffusion plate shall be designed to accomplish uniform air flow across the down-stream coil filters while reducing the higher fan outlet velocity to within plus or minus 5 percent of the required face velocity of the downstream component.

#### 2.9.1.9 Dampers

Dampers shall be as specified in paragraph CONTROLS.

### 2.10 FACTORY PAINTING

Units which are not of galvanized construction according to ASTM A 123/A 123M or ASTM A 924/A 924M shall be factory painted with a corrosion resisting paint finish. Internal and external ferrous metal surfaces shall be cleaned, phosphatized and coated with a paint finish which has been tested according to ASTM B 117, ASTM D 1654, and ASTM D 3359. Evidence of satisfactory paint performance for a minimum of 125 hours for units to be installed indoors and 500 hours for units to be installed outdoors shall be submitted. Rating of failure at the scribe mark shall be not less than 6, average creepage not greater than 3 mm. Rating of the inscribed area shall not be less than 10, no failure. On units constructed of galvanized steel which have been welded, exterior surfaces of welds or welds that have burned through from the interior shall receive a final shop docket of zinc-rich protective paint according to ASTM D 520 Type I.

## PART 3 EXECUTION

### 3.1 INSTALLATION

Work shall be installed as shown and according to the manufacturer's diagrams and recommendations.

#### 3.1.1 Anchors

Anchors shall be provided wherever necessary or indicated to localize expansion or to prevent undue strain on piping. Anchors shall consist of heavy steel collars with lugs and bolts for clamping and attaching anchor braces, unless otherwise indicated. Anchor braces shall be installed in the most effective manner to secure the desired results using turnbuckles where required. Supports, anchors, or stays shall not be attached where they will injure the structure or adjacent construction during installation or by the weight of expansion of the pipeline.

#### 3.1.2 Condensate Drain Lines

Water seals shall be provided in the condensate drain from all units. . The depth of each seal shall be 50 mm plus 0.1 mm for each Pa, of the total static pressure rating of the unit to which the drain is connected. Water seals shall be constructed of 2 tees and an appropriate U-bend with the open end of each tee plugged. Pipe cap or plug cleanouts shall be provided where indicated. Drains indicated to connect to the sanitary waste system shall be connected by an indirect waste fitting. Air conditioner drain lines shall be insulated as specified in Section 15080A THERMAL INSULATION FOR MECHANICAL SYSTEMS.

#### 3.1.3 Equipment and Installation

Frames and supports shall be provided for tanks, compressors, pumps, valves, air handling units, fans, coils, dampers, and other similar items requiring supports. Air handling units shall be floor mounted or ceiling hung, as indicated. The method of anchoring and fastening shall be as detailed. Floor-mounted equipment, unless otherwise indicated, shall be set on not less than 150 mm (6 inch) concrete pads or curbs doweled in place. Concrete foundations for circulating pumps shall be heavy enough to minimize the intensity of the vibrations transmitted to the piping and the surrounding structure, as recommended in writing by the pump manufacturer. In lieu of a concrete pad foundation, a concrete pedestal block with isolators placed between the pedestal block and the floor may be provided. The concrete foundation or concrete pedestal block shall be of a mass not less than three times the weight of the components to be supported. Lines connected to the pump mounted on pedestal blocks shall be provided with flexible connectors. Foundation drawings, bolt-setting information, and foundation bolts shall be furnished prior to concrete foundation construction for all equipment indicated or required to have concrete foundations. Concrete for foundations shall be as specified in Section 03300 CAST-IN-PLACE STRUCTURAL CONCRETE.

#### 3.1.4 Access Panels

Access panels shall be provided for concealed valves, vents, controls, dampers, and items requiring inspection or maintenance. Access panels shall be of sufficient size and located so that the concealed items may be serviced and maintained or completely removed and replaced. Access panels shall be as specified in Section 05500A MISCELLANEOUS METAL.

#### 3.1.5 Flexible Connectors

Pre-insulated flexible connectors and flexible duct shall be attached to other components in accordance with the latest printed instructions of the manufacturer to ensure a vapor tight joint. Hangers, when required to suspend the connectors, shall be of the type recommended by the connector or duct manufacturer and shall be provided at the intervals recommended.

### 3.1.6 Sleeved and Framed Openings

Space between the sleeved or framed opening and the duct or the duct insulation shall be packed as specified in Section 07840A FIRESTOPPING for fire rated penetrations. For non-fire rated penetrations, the space shall be packed as specified in Section 07900A JOINT SEALING.

### 3.1.7 Metal Ductwork

Installation shall be according to SMACNA HVAC Duct Const Stds unless otherwise indicated. Duct supports for sheet metal ductwork shall be according to SMACNA HVAC Duct Const Stds, unless otherwise specified. Friction beam clamps indicated in SMACNA HVAC Duct Const Stds shall not be used. Risers on high velocity ducts shall be anchored in the center of the vertical run to allow ends of riser to move due to thermal expansion. Supports on the risers shall allow free vertical movement of the duct. Supports shall be attached only to structural framing members and concrete slabs. Supports shall not be anchored to metal decking unless a means is provided and approved for preventing the anchor from puncturing the metal decking. Where supports are required between structural framing members, suitable intermediate metal framing shall be provided. Where C-clamps are used, retainer clips shall be provided.

### 3.1.8 Insulation

Thickness and application of insulation materials for ductwork, piping, and equipment shall be according to Section 15080A THERMAL INSULATION FOR MECHANICAL SYSTEMS. Outdoor air intake ducts and plenums shall be externally insulated up to the point where the outdoor air reaches the conditioning unit or up to the point where the outdoor air mixes with the outside air stream.

### 3.1.9 Duct Test Holes

Holes with closures or threaded holes with plugs shall be provided in ducts and plenums as indicated or where necessary for the use of pitot tube in balancing the air system. Extensions, complete with cap or plug, shall be provided where the ducts are insulated.

### 3.1.10 Power Transmission Components Adjustment

V-belts and sheaves shall be tested for proper alignment and tension prior to operation and after 72 hours of operation at final speed. Belts on drive side shall be uniformly loaded, not bouncing. Alignment of direct driven couplings shall be to within 50 percent of manufacturer's maximum allowable range of misalignment.

## 3.2 FIELD PAINTING AND COLOR CODE MARKING

Finish painting of items only primed at the factory, surfaces not specifically noted otherwise, and color code marking for piping shall be as specified in Section 09900 PAINTS AND COATINGS.

### 3.3 DUCTWORK LEAK TEST

Ductwork leak test shall be performed for the entire air distribution and exhaust system, including fans, coils, filters, etc. designated as static pressure Class 750 Pa (3 inch water gauge) through Class 2500 Pa (10 inch water gauge). Test procedure, apparatus, and report shall conform to SMACNA Leakage Test Mnl. The maximum allowable leakage rate is 3 l/s per 10 square meters of duct surface. Ductwork leak test shall be completed with satisfactory results prior to applying insulation to ductwork exterior.

### 3.4 CLEANING AND ADJUSTING

Inside of ducts, plenums, and casing shall be thoroughly cleaned of debris and blown free of small particles of rubbish and dust and then shall be vacuum cleaned before installing outlet faces. Equipment shall be wiped clean, with traces of oil, dust, dirt, or paint spots removed. Temporary filters shall be provided prior to startup of all fans that are operated during construction, and new filters shall be installed after all construction dirt has been removed from the building, and the ducts, plenums, casings, and other items specified have been vacuum cleaned. System shall be maintained in this clean condition until final acceptance. Bearings shall be properly lubricated with oil or grease as recommended by the manufacturer. Belts shall be tightened to proper tension. Control valves and other miscellaneous equipment requiring adjustment shall be adjusted to setting indicated or directed. Fans shall be adjusted to the speed indicated by the manufacturer to meet specified conditions.

### 3.5 TESTING, ADJUSTING, AND BALANCING

Testing, adjusting, and balancing shall be as specified in Section 15990A TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS. Testing, adjusting, and balancing shall begin only when the air supply and distribution, including controls, has been completed, with the exception of performance tests.

### 3.6 PERFORMANCE TESTS

After testing, adjusting, and balancing has been completed as specified, each system shall be tested as a whole to see that all items perform as integral parts of the system and temperatures and conditions are evenly controlled throughout the building. Corrections and adjustments shall be made as necessary to produce the conditions indicated or specified. Capacity tests and general operating tests shall be conducted by an experienced engineer. Tests shall cover a period of not less than 5 days for each system and shall demonstrate that the entire system is functioning according to the specifications. Coincidental chart recordings shall be made at points indicated on the drawings for the duration of the time period and shall record the temperature at space thermostats or space sensors, the humidity at space humidistats or space sensors and the ambient temperature and humidity in a shaded and weather protected area.

### 3.7 FIELD TRAINING

The Contractor shall conduct a training course for operating and maintenance personnel as designated by the Contracting Officer. Training shall be provided for a period of 40 hours of normal working time and shall start after the system is functionally complete but prior to the performance tests. The field instruction shall cover all of the items contained in the approved Operating and Maintenance Instructions.

-- End of Section --

SECTION TABLE OF CONTENTS

DIVISION 15 - MECHANICAL

SECTION 15951A

DIRECT DIGITAL CONTROL FOR HVAC

12/01

PART 1 GENERAL

- 1.1 REFERENCES
- 1.2 GENERAL REQUIREMENTS
  - 1.2.1 Dynamic Color Graphic Displays
  - 1.2.1 Nameplates, Lens Caps, and Tags
  - 1.2.2 Verification of Dimensions
  - 1.2.3 Drawings
  - 1.2.4 Power-Line Surge Protection
  - 1.2.5 Surge Protection for Transmitter and Control Wiring
  - 1.2.6 System Overall Reliability Requirement
  - 1.2.7 DDC System Network Accessibility
  - 1.2.8 System Accuracy and Display
    - 1.2.8.1 Space Temperature
    - 1.2.8.2 Duct Temperature
    - 1.2.8.3 Outside Air Temperature
    - 1.2.8.4 Water Temperature
    - 1.2.8.5 High Temperature
    - 1.2.8.6 Relative Humidity
    - 1.2.8.7 Pressure
    - 1.2.8.8 Flow
    - 1.2.8.9 KWh and kW Demand
    - 1.2.8.10 Analog Value Input
- 1.3 SUBMITTALS
- 1.4 OPERATION MANUAL
- 1.5 MAINTENANCE AND REPAIR MANUAL
- 1.6 MAINTENANCE AND SERVICE
  - 1.6.1 Description of Work
  - 1.6.2 Personnel
  - 1.6.3 Scheduled Inspections
  - 1.6.4 Scheduled Work
  - 1.6.5 Emergency Service
  - 1.6.6 Operation
  - 1.6.7 Records and Logs
  - 1.6.8 Work Requests
  - 1.6.9 System Modifications
  - 1.6.10 Software
- 1.7 FACTORY TESTING
  - 1.7.1 Factory Test Setup

PART 2 PRODUCTS

- 2.1 GENERAL EQUIPMENT REQUIREMENTS
  - 2.1.1 Electrical and Electronic Devices
  - 2.1.2 Standard Signals
  - 2.1.3 Ambient Temperature Limits

- 2.1.4 Year 2000 Compliance
- 2.2 TUBING
  - 2.2.1 Copper
  - 2.2.2 Stainless Steel
  - 2.2.3 Plastic
- 2.3 WIRING
  - 2.3.1 Terminal Blocks
  - 2.3.2 Control Wiring for 24-Volt Circuits
  - 2.3.3 Wiring for 120-Volt Circuits
  - 2.3.4 Instrumentation Cable
  - 2.3.5 Transformers
- 2.4 ACTUATORS
  - 2.4.1 Valve Actuators
  - 2.4.2 Positive Positioners
- 2.5 AUTOMATIC CONTROL VALVES
  - 2.5.1 Butterfly Valve Assembly
  - 2.5.2 Two-Way Valves
  - 2.5.3 Three-Way Valves
  - 2.5.4 Valves for Steam Service
- 2.6 DAMPERS
  - 2.6.1 Damper Assembly
  - 2.6.2 Operating Links
  - 2.6.3 Damper Types
    - 2.6.3.1 Outside Air, Return Air, and Relief Air Parallel Blade Dampers
    - 2.6.3.2 Butterfly Dampers
    - 2.6.3.3 Mechanical and Electrical Space Ventilation Dampers
    - 2.6.3.4 Smoke Dampers
  - 2.6.4 Damper End Switches
- 2.7 SMOKE DETECTORS
- 2.8 INSTRUMENTATION
  - 2.8.1 Measurements
  - 2.8.2 Temperature Instruments
    - 2.8.2.1 Resistance Temperature Detectors (RTD)
    - 2.8.2.2 Continuous Averaging RTD
    - 2.8.2.3 RTD Transmitter
  - 2.8.3 Relative Humidity Instruments
  - 2.8.4 Electronic Airflow Measurement Stations and Transmitters
    - 2.8.4.1 Stations
    - 2.8.4.2 Transmitters
  - 2.8.5 Pitot Tube Airflow Measurement Stations and Transmitters
    - 2.8.5.1 Stations
    - 2.8.5.2 Transmitters
  - 2.8.6 Differential Pressure Instruments
  - 2.8.7 Thermowells
  - 2.8.8 Sunshields
- 2.9 THERMOSTATS
  - 2.9.1 Nonmodulating Room Thermostats
  - 2.9.2 Microprocessor Based Room Thermostats
  - 2.9.3 Modulating Room Thermostats
  - 2.9.4 Nonmodulating Capillary Thermostats and Aquastats
  - 2.9.5 Deleted Paragraph
  - 2.9.6 Modulating Capillary Thermostats
- 2.10 PRESSURE SWITCHES AND SOLENOID VALVES
  - 2.10.1 Pressure Switches
  - 2.10.2 Differential-Pressure Switches
  - 2.10.3 Pneumatic Electric (PE) Switches
  - 2.10.4 Solenoid-Operated Pneumatic (EP) Valves
- 2.11 INDICATING DEVICES

- 2.11.1 Thermometers
  - 2.11.1.1 Piping System Thermometers
  - 2.11.1.2 Piping System Thermometer Stems
  - 2.11.1.3 Nonaveraging Air-Duct Thermometers
  - 2.11.1.4 Averaging Air-Duct Thermometers
  - 2.11.1.5 Accuracy
- 2.11.2 Pressure Gauges
  - 2.11.2.1 Pneumatic Actuator Gauges
  - 2.11.2.2 Air Storage Tank and Filter and Dryer Gauge
  - 2.11.2.3 Hydronic System Gauges
- 2.11.3 Low Differential Pressure Gauges
- 2.12 CONTROL DEVICES AND ACCESSORIES
  - 2.12.1 Relays
  - 2.12.2 Current to Pneumatic (IP) Transducers
  - 2.12.3 Joule or Watthour Meters
  - 2.12.4 Joule or Watthour Meters with Demand Register
  - 2.12.5 Joule or Watthour Transducers
  - 2.12.6 Current Sensing Relays
  - 2.12.7 Power-Line Conditioners (PLC)
- 2.13 DIRECT DIGITAL CONTROL (DDC) HARDWARE
  - 2.13.1 Network Control Panel
    - 2.13.1.1 Integral Features
    - 2.13.1.2 Communication Interfaces
    - 2.13.1.3 Memory and Real Time Clock (RTC) Backup
    - 2.13.1.4 Duplex Outlet
    - 2.13.1.5 Locking Enclosures
    - 2.13.1.6 Failure Mode
  - 2.13.2 RIU
    - 2.13.2.1 Integral Features
    - 2.13.2.2 Duplex Outlet
    - 2.13.2.3 Locking Enclosures
    - 2.13.2.4 Failure Mode
  - 2.13.3 Universal Programmable Controller (UPC)
    - 2.13.3.1 Integral Features
    - 2.13.3.2 Communication Interfaces
    - 2.13.3.3 Memory and RTC Backup
    - 2.13.3.4 Specific Requirements
    - 2.13.3.5 Locking Enclosures
    - 2.13.3.6 Failure Mode
  - 2.13.4 Unitary Controller
    - 2.13.4.1 Integral Features
    - 2.13.4.2 Communication Interfaces
    - 2.13.4.3 Specific Requirements
    - 2.13.4.4 Failure Mode
  - 2.13.5 I/O Functions
    - 2.13.5.1 DDC Hardware I/O Functions
    - 2.13.5.2 Failure Mode
  - 2.13.6 Portable Workstation/Tester
- 2.14 DDC SOFTWARE
  - 2.14.1 Operating System
    - 2.14.1.1 Startup
    - 2.14.1.2 Operating Mode
    - 2.14.1.3 Failure Mode
  - 2.14.2 Functions
    - 2.14.2.1 Analog Monitoring
    - 2.14.2.2 Logic (Virtual) Points
    - 2.14.2.3 State Variables
    - 2.14.2.4 Analog Totalization
    - 2.14.2.5 Energy Totalization

- 2.14.2.6 Trending
- 2.14.3 I/O Point Database/Parameter Definition
- 2.14.4 Alarm Processing
  - 2.14.4.1 Digital Alarms Definition
  - 2.14.4.2 Analog Alarms Definition
  - 2.14.4.3 Pulse Accumulator Alarms Definition
- 2.14.5 Constraints
  - 2.14.5.1 Equipment Constraints Definitions
  - 2.14.5.2 Constraints Checks
- 2.14.6 Diagnostics
- 2.14.7 Summer-Winter Operation Monitoring
- 2.14.8 Control Sequences and Control Loops
- 2.14.9 Command Priorities
- 2.14.10 Resident Application Software
  - 2.14.10.1 Program Inputs and Outputs
  - 2.14.10.2 DDC General Conditions
  - 2.14.10.3 Scheduled Start/Stop Program
  - 2.14.10.4 Optimum Start/Stop Program
  - 2.14.10.5 Day-Night Setback Program
  - 2.14.10.6 Ventilation/Recirculation and Flush Programs
  - 2.14.10.7 Heating and Ventilating Unit Program
  - 2.14.10.8 Air Volume Control Program
  - 2.14.10.9 Air Distribution Unitary Controller Software
  - 2.14.10.10 Domestic Hot Water Generator Program

### PART 3 EXECUTION

- 3.1 GENERAL INSTALLATION CRITERIA
  - 3.1.1 HVAC Control System
  - 3.1.2 Software Installation
  - 3.1.3 Device Mounting Criteria
  - 3.1.4 Wiring Criteria
- 3.2 CONTROL SYSTEM INSTALLATION
  - 3.2.1 Damper Actuators
  - 3.2.2 Local Gauges for Actuators
  - 3.2.3 Room Instrument Mounting
  - 3.2.4 Deleted Paragraph
  - 3.2.5 Averaging Temperature Sensing Elements
  - 3.2.6 Foundations and Housekeeping Pads
  - 3.2.7 Compressed Air Stations
  - 3.2.8 Duct Static Pressure Sensing Elements and Transmitters
  - 3.2.9 Indication Devices Installed in Piping and Liquid Systems
  - 3.2.10 Tubing
    - 3.2.10.1 Control System Installation
    - 3.2.10.2 Pneumatic Lines In Mechanical/Electrical Spaces
    - 3.2.10.3 Pneumatic Lines External To Mechanical/Electrical Spaces
    - 3.2.10.4 Connection to Liquid and Steam Lines
    - 3.2.10.5 Connection to Ductwork
    - 3.2.10.6 Tubing in Concrete
    - 3.2.10.7 Final Connection to Actuators
- 3.3 COMMISSIONING PROCEDURES
  - 3.3.1 Evaluations
    - 3.3.1.1 Item Check
    - 3.3.1.2 Weather Dependent Test Procedures
    - 3.3.1.3 Two-Point Accuracy Check
    - 3.3.1.4 Insertion and Immersion Temperatures
    - 3.3.1.5 Averaging Temperature
  - 3.3.2 Space Temperature Controlled Perimeter Radiation
  - 3.3.3 Climate Control Unit CCU-1 & CCU-2 Systems, and Furnace

FUR-1C/EF-1C System

- 3.4 BALANCING, COMMISSIONING, AND TESTING
  - 3.4.1 Coordination with HVAC System Balancing
  - 3.4.2 Control System Calibration, Adjustments, and Commissioning
  - 3.4.3 Performance Verification Test
  - 3.4.4 Endurance Test
  - 3.4.5 Posted and Panel Instructions
- 3.5 TRAINING
  - 3.5.1 Training Course Requirements
  - 3.5.2 Training Course Content

-- End of Section Table of Contents --

## SECTION 15951A

DIRECT DIGITAL CONTROL FOR HVAC  
12/01

## PART 1 GENERAL

## 1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

## AIR MOVEMENT AND CONTROL ASSOCIATION (AMCA)

AMCA 500 (11989; Rev994) Test Methods for Louvers, Dampers and Shutters

## AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.1 (1995) Code for Electricity Metering

## AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 269 (1996) Seamless and Welded Austenitic Stainless Steel Tubing for General Service

ASTM B 88 (1996) Seamless Copper Water Tube

ASTM B 88M (1996) Seamless Copper Water Tube (Metric)

ASTM D 1693 (1997a) Environmental Stress-Cracking of Ethylene Plastics

ASTM D 635 (1997) Rate of Burning and/or Extent and Time of Burning of Self-Supporting Plastics in a Horizontal Position

## ASME INTERNATIONAL (ASME)

ASME B40.1 (1991) Gauges - Pressure Indicating Dial Type - Elastic Element

ASME BPVC SEC VIII D1 (1998) Boiler and Pressure Vessel Code; Section VIII, Pressure Vessels Division 1 - Basic Coverage

## ELECTRONIC INDUSTRIES ALLIANCE (EIA)

EIA ANSI/EIA/TIA-232-F (1991) Interface Between Data Technical Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange

## INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C62.41	(1991; R 1995) Surge Voltages in Low-Voltage AC Power Circuits
IEEE Std 142	(1991) IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(1991) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ICS 1	(1993) Industrial Control and Systems
NEMA ST 1	(1988) Specialty Transformers (Except General-Purpose Type)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(1999) National Electrical Code
NFPA 90A	(1996) Installation of Air Conditioning and Ventilating Systems

UNDERWRITERS LABORATORIES (UL)

UL 268A	(1998) Smoke Detectors for Duct Application
UL 508	(1993; Rev thru Oct 1997) Industrial Control Equipment
UL 555S	(1996) Leakage Rated Dampers for Use in Smoke Control Systems
UL 94	(1996; Rev thru Jul 1998) Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

## 1.2 GENERAL REQUIREMENTS

The direct digital control (DDC) shall be a complete system suitable for the heating, ventilating and air-conditioning (HVAC) system. The DDC system shall be a complete control system consisting of a building automation system and an automatic temperature control system suitable for the HVAC system. The direct digital control system shall be connected to the existing Barber Coleman System (EMCS) at McConnell AFB that has been accepted as an approved interface by the Contracting Officer. All controls added under this project shall be connected to a global network control unit located as shown, and shall communicate to the basewide EMCS via the LAN serving the base. The contractor shall supply all materials required and software generation necessary to enable the DDC to communicate with the Barber Coleman system. The Contractor shall generate all software and install all hardware required to connect the new facilities to the existing EMCS.

### 1.2.1 Dynamic Color Graphic Displays

Color graphic floor plan displays, and system schematics for each piece of

mechanical equipment, including air handling units, chilled water systems and hot water boiler systems, shall be generated to optimize system performance analysis and speed alarm recognition. The existing operator interface workstation located in Building 364 shall be utilized for operator interface.

#### 1.2.1 Nameplates, Lens Caps, and Tags

Nameplates and lens caps bearing legends and tags bearing device-unique identifiers as shown shall have engraved or stamped characters. A plastic or metal tag shall be mechanically attached directly to each device or attached by a metal chain or wire. Each airflow measurement station shall have a tag showing flow rate range for signal output range, duct size, and identifier as shown.

#### 1.2.2 Verification of Dimensions

After becoming familiar with all details of the work, the Contractor shall verify all dimensions in the field, and shall advise the Contracting Officer of any discrepancy before performing any work.

#### 1.2.3 Drawings

Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings, and accessories that may be required. The Contractor shall carefully investigate the mechanical, electrical, and finish conditions that could affect the work to be performed, shall arrange such work accordingly, and shall furnish all work necessary to meet such conditions.

#### 1.2.4 Power-Line Surge Protection

Equipment connected to ac circuits shall be protected from power-line surges. Equipment protection shall meet the requirements of IEEE C62.41. Fuses shall not be used for surge protection.

#### 1.2.5 Surge Protection for Transmitter and Control Wiring

DDC system control-panel equipment shall be protected against surges induced on control and transmitter wiring installed outside. The equipment protection shall be tested in the normal mode and in the common mode, using the following two waveforms:

a. A 10-microsecond by 1,000-microsecond waveform with a peak voltage of 1,500 volts and a peak current of 60 amperes.

b. An eight microsecond by 20-microsecond waveform with a peak voltage of 1,000 volts and a peak current of 500 amperes.

#### 1.2.6 System Overall Reliability Requirement

The system shall be configured and installed to yield a mean time between failure (MTBF) of at least 40,000 hours. Each DDC controller shall be designed, configured, installed and programmed to provide for stand alone operation with minimal performance degradation on failure of other system components to which it is connected or with which it communicates.

#### 1.2.7 DDC System Network Accessibility

Where the systems to be controlled by the DDC system are located in multiple mechanical rooms, each mechanical room shall have at least one communication port for the portable workstation/tester. DDC controllers shall be located in the same room as the equipment being controlled or in an adjacent space which has direct access to the equipment room.

#### 1.2.8 System Accuracy and Display

The system shall maintain an end-to-end accuracy for one year from sensor to operator's console display for the applications specified and shall display the value as specified. Each temperature shall be displayed and printed to nearest 0.05 degree C.

##### 1.2.8.1 Space Temperature

Space temperature with a range of 10 to 30 degrees C plus or minus 0.5 degrees C for conditioned space; minus 1 to plus 55 degrees C plus or minus 0.5 degrees C for unconditioned space.

##### 1.2.8.2 Duct Temperature

Duct temperature with a range of 5 to 60 degrees C plus or minus 1 degree C.

##### 1.2.8.3 Outside Air Temperature

Outside air (OA) temperature with a range of minus 35 to plus 55 degrees C plus or minus 1 degree C; with a subrange of minus 1 to plus 40 degrees C plus or minus 0.5 degree C.

##### 1.2.8.4 Water Temperature

Water temperature with a range of minus 1 to plus 40 degrees C plus or minus 0.5 degree C; the range of 40 to 120 degrees C plus or minus 1 degree C; and water temperatures for the purpose of performing energy calculations using differential temperatures to plus or minus 0.5 degree C using matched sensors.

##### 1.2.8.5 High Temperature

High temperature with a range of 100 to 260 degrees C plus or minus 1 degree C.

##### 1.2.8.6 Relative Humidity

Relative humidity, within a range of 20 to 80 percent, plus or minus 6.0 percent of range (display and print to nearest 1.0 percent).

##### 1.2.8.7 Pressure

Pressure with a range for the specific application plus or minus 2.0 percent of range (display and print to nearest kPa. )

##### 1.2.8.8 Flow

Flow with a range for the specific application plus or minus 3.0 percent of range, and flows for the purpose of thermal calculations to plus or minus 2.0 percent of actual flow (display and print to nearest unit, such as liters per second).

## 1.2.8.9 KWh and kW Demand

KWh and kW demand with a range for the specific application plus or minus 1.0 percent of reading (display and print to nearest kWh or kW).

## 1.2.8.10 Analog Value Input

An analog value input to the system's equipment via an AI with a maximum error of 0.50 percent of range, not including the sensor or transmitter error. This accuracy shall be maintained over the specified environmental conditions.

## 1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. All items designated with a G, EC, including product literature, calculations, component data, certificates, diagrams and drawings, shall be submitted concurrently in one complete system submittal. Omission of any required submittal item from the package shall be sufficient cause for disapproval of the entire submittal. Unless otherwise indicated in the submittal review commentary, disapproval of any item within the package shall require a re-submittal of the entire system package, in which all deficiencies shall be corrected. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

## SD-02 Shop Drawings

## HVAC Control System; G, EC

Drawings shall be on A1 (841 by 594 mm) sheets in the form and arrangement shown. The drawings shall use the same abbreviations, symbols, nomenclature and identifiers shown. Each control system element on a drawing shall have a unique identifier as shown. The HVAC Control System Drawings shall be delivered together as a complete submittal. Deviations must be approved by the Contracting Officer. Drawings shall be submitted along with Submittal SD-01, Data.

## a. HVAC Control System Drawings shall include the following:

Sheet One: Drawing Index, HVAC Control System Legend.  
 Sheet Two: Valve Schedule, Damper Schedule.  
 Sheet Three: Compressed Air Station Schematic.  
 Sheet Four: Control System Schematic and Equipment Schedule.  
 Sheet Five: Sequence of Operation and Data Terminal Strip Layout.  
 Sheet Six: Control Loop Wiring Diagrams.  
 Sheet Seven: Motor Starter and Relay Wiring Diagram.  
 Sheet Eight: Communication Network and Block Diagram.  
 Sheet Nine: DDC Panel Installation and Block Diagram.

(Repeat Sheets Four through Seven for each AHU System.)

b. The HVAC Control System Drawing Index shall show the name and number of the building, military site, State or other similar

designation, and Country. The Drawing Index shall list HVAC Control System Drawings, including the drawing number, sheet number, drawing title, and computer filename when used. The HVAC Control System Legend shall show generic symbols and the name of devices shown on the HVAC Control System Drawings.

c. The valve schedule shall include each valve's unique identifier, size, flow coefficient Kv , pressure drop at specified flow rate, spring range, positive positioner range, actuator size, close-off pressure data, dimensions, and access and clearance requirements data. Valve schedules may be submitted in advance but shall be included in the complete submittal.

d. The damper schedule shall contain each damper's and each actuator's identifier, nominal and actual sizes, orientation of axis and frame, direction of blade rotation, spring ranges, operation rate, positive positioner ranges, locations of actuators and damper end switches, arrangement of sections in multi-section dampers, and methods of connecting dampers, actuators, and linkages. The Damper Schedule shall include the maximum leakage rate at the operating static-pressure differential. The Damper Schedule shall contain actuator selection data supported by calculations of the torque required to move and seal the dampers, access and clearance requirements. Damper schedules may be submitted in advance but shall be included in the complete submittal.

e. The compressed air station schematic diagram shall show all equipment, including: compressor with motor horsepower and voltage; starter; isolators; manual bypasses; tubing sizes; drain piping and drain traps; reducing valves; dryer; and data on manufacturer's names and model numbers, mounting, access, and clearance requirements. Air Compressor and air dryer data shall include calculations of the air consumption of all current-to-pneumatic transducers and of any other control system devices to be connected to the compressed air station, and the compressed air supply dewpoint temperature at 140 kPa . Compressed air station schematic drawings shall be submitted for each compressed air station.

f. The HVAC control system schematics shall be in the form shown, and shall show all control and mechanical devices associated with the HVAC system. A system schematic drawing shall be submitted for each HVAC system.

g. The HVAC control system equipment Schedule shall be in the form shown. All devices shown on the drawings having unique identifiers shall be referenced in the equipment schedule. Information to be included in the equipment schedule shall be the control loop, device unique identifier, device function, setpoint, input range, and additional important parameters (i.e., output range). An equipment schedule shall be submitted for each HVAC system.

h. The HVAC control system sequence of operation shall reflect the language and format of this specification, and shall refer to the devices by their unique identifiers as shown. No operational deviations from specified sequences will be permitted without prior written approval of the Contracting Officer. Sequences of

operation shall be submitted for each HVAC control system including each type of terminal unit control system.

i. The HVAC control system wiring diagrams shall be functional wiring diagrams which show the interconnection of conductors and cables to HVAC control panel terminal blocks and to the identified terminals of devices, starters and package equipment. The wiring diagrams shall show necessary jumpers and ground connections. The wiring diagrams shall show the labels of all conductors. Sources of power required for HVAC control systems and for packaged equipment control systems shall be identified back to the panel board circuit breaker number, HVAC system control panel, magnetic starter, or packaged equipment control circuit. Each power supply and transformer not integral to a controller, starter, or packaged equipment shall be shown. The connected volt-ampere load and the power supply volt-ampere rating shall be shown. Wiring diagrams shall be submitted for each HVAC control system.

#### SD-03 Product Data

Temperature Control Panels TCP-3, TCP-4, TCP-5;G, EC  
Air Flow Measurement Stations and Transmitters;G, EC  
 Surge Protection;G, EC  
 Regulated Power Supplies;G, EC  
 Power Line Conditioners;G, EC  
 Wiring;G, EC  
 Valve Actuators and positive positioners;G, EC  
 Damper Actuators and positive positioners;G, EC  
 Control Valves;G, EC  
 Control Dampers;G, EC  
 Temperature Switches;G, EC  
 Temperature and Pressure Instruments;G, EC  
 Thermostats;G, EC  
 Thermometers and Gauges;G, EC  
 DDC Control Panels and Accessories;G, EC  
 Relays;G, EC  
 Tubing;G, EC  
 IP Transducers;G, EC  
 Manual Switches;G,EC  
 Equipment Compliance Booklet; G, EC  
 Dynamic Color Graphic Display Layout Proposals; G, EC  
 Input Output (I/O) Summary Tables; G, EC

The HVAC Control System Equipment Compliance Booklet (ECB) shall be in booklet form and indexed, with numbered tabs separating the information on each device. It shall consist of, but not be limited to, data sheets and catalog cuts which document compliance of all devices and components with the specifications. The ECB shall be indexed in alphabetical order by the unique identifiers. Devices and components which do not have unique identifiers shall follow the devices and components with unique identifiers and shall be indexed in alphabetical order according to their functional name. The ECB shall include a Bill of Materials for each HVAC Control System. The Bill of Materials shall function as the Table of Contents for the ECB and shall include the device's unique identifier, device function, manufacturer, model/part/catalog number used for ordering, and tab number where the device information is located in the ECB. The ECB shall be submitted along with Submittal SD-04, Drawings.

Service Organizations; G, RE

Six copies of a list of service organizations qualified to service the HVAC control system. The list shall include the service organization name, address, technical point of contact and telephone number, and contractual point of contact and telephone number.

Commissioning Procedures; G, EC

Six copies of the HVAC control system commissioning procedures, in booklet form and indexed, 60 days prior to the scheduled start of commissioning. Commissioning procedures shall be provided for each HVAC control system, and for each type of terminal unit control system. The Commissioning procedures shall reflect the format and language of this specification, and refer to devices by their unique identifiers as shown. The Commissioning procedures shall be specific for each HVAC system, and shall give detailed step-by-step procedures for commissioning of the system.

a. The Commissioning procedures shall include detailed, product specific set-up procedures, configuration procedures, adjustment procedures, and calibration procedures for each device. Where the detailed product specific commissioning procedures are included in manufacturer supplied manuals, reference may be made in the HVAC control system commissioning procedures to the manuals.

b. An HVAC control system commissioning procedures equipment list shall be included that lists the equipment to be used to accomplish commissioning. The list shall include manufacturer name, model number, equipment function, the date of the latest calibration, and the results of the latest calibration.

Performance Verification Test Procedures; G, RE

Six copies of the HVAC Control System Performance Verification Test Procedures, in booklet form and indexed, 60 days before the Contractor's scheduled test dates. The performance verification test procedures shall refer to the devices by their unique identifiers as shown, shall explain, step-by-step, the actions and expected results that will demonstrate that the HVAC control system performs in accordance with the sequences of operation, and other contract documents. An HVAC control system performance verification test equipment list shall be included that lists the equipment to be used during performance verification testing. The list shall include manufacturer name, model number, equipment function, the date of the latest calibration, and the results of the latest calibration.

Training; G, RE

An outline for the HVAC control system training course with a proposed time schedule. Approval of the planned training schedule shall be obtained from the Government at least 60 days prior to the start of the training. Six copies of HVAC control system training course material 30 days prior to the scheduled start of the training course. The training course material shall include the operation manual, maintenance and repair manual, and paper copies of overheads used in the course.

SD-06 Test Reports

Commissioning Report; G, EC,  
Six copies of the HVAC Control System Commissioning Report, in booklet form and indexed, within 30 days after completion of the system commissioning. The commissioning report shall include data collected during the HVAC control system commissioning procedures and shall follow the format of the commissioning procedures. The commissioning report shall include all configuration checksheets with final values listed for all parameters, setpoints, P, I, D setting constants, calibration data for all devices, results of adjustments, and results of testing.

Performance Verification Test; G, RE  
Six copies of the HVAC Control System Performance Verification Test Report, in booklet form and indexed, within 30 days after completion of the test. The HVAC control system performance verification test report shall include data collected during the HVAC control system performance verification test. The original copies of all data gathered during the performance verification test shall be turned over to the Government after Government approval of the test results.

#### SD-07 Certificates

Air Storage Tank; G, RE

An ASME Air Storage Tank Certificate for each storage tank.

#### SD-10 Operation and Maintenance Data

Operation Manual; G, RE  
Maintenance and Repair Manual; G, RE

Six copies of the HVAC Control System Operation Manual and HVAC Control System Maintenance and Repair Manual, for each HVAC control system, 30 days before the date scheduled for the training course.

### 1.4 DELIVERY AND STORAGE

Products shall be stored with protection from the weather, humidity and temperature variations, dirt and dust, and other contaminants, within the storage condition limits published by the equipment manufacturer. Dampers shall be stored so that seal integrity, blade alignment and frame alignment are maintained.

### 1.4 OPERATION MANUAL

An HVAC control system operation manual in indexed booklet form shall be provided for each HVAC control system. The operation manual shall include the HVAC control system sequence of operation, and procedures for the HVAC system start-up, operation and shut-down. The operation manual shall include as-built HVAC control system detail drawings. The operation manual shall include the as-built configuration checksheets, the procedures for changing HVAC control system setpoints, and the procedures for placing HVAC system controllers in the manual control mode.

a. The procedures for changing HVAC control system setpoints shall describe the step-by-step procedures required to change the process

variable setpoints, the alarm setpoints, the bias settings, and setpoint reset schedules.

b. The procedures for placing HVAC system controllers in the manual control mode shall describe step-by-step procedures required to obtain manual control of each controlled device and to manually adjust their positions.

#### 1.5 MAINTENANCE AND REPAIR MANUAL

An HVAC control system maintenance and repair manual in indexed booklet form in hardback binders shall be provided for each HVAC control system. The maintenance and repair manual shall include the routine maintenance checklist, a recommended repair methods list, a list of recommended maintenance and repair tools, the qualified service organization list, the as-built commissioning procedures and report, the as-built performance verification test procedures and report, and the as-built equipment data booklet.

a. The routine maintenance checklist shall be arranged in a columnar format. The first column shall list all devices listed in the equipment compliance booklet, the second column shall state the maintenance activity or state no maintenance required, the third column shall state the frequency of the maintenance activity, and the fourth column for additional comments or reference.

b. The recommended repair methods list shall be arranged in a columnar format and shall list all devices in the equipment data compliance booklet and state the guidance on recommended repair methods, either field repair, factory repair, or whole-item replacement.

c. The as-built equipment data booklet shall include the equipment compliance booklet and manufacturer supplied user manuals and information.

d. If the operation manual and the maintenance and repair manual are provided in a common volume, they shall be clearly differentiated and separately indexed.

#### 1.6 MAINTENANCE AND SERVICE

Services, materials and equipment shall be provided as necessary to maintain the entire system in an operational state as specified for a period of one year after successful completion and acceptance of the Performance Verification Test. Impacts on facility operations shall be minimized.

##### 1.6.1 Description of Work

The adjustment and repair of the system shall include the manufacturer's required adjustments of computer equipment, software updates, transmission equipment and instrumentation and control devices.

##### 1.6.2 Personnel

Service personnel shall be qualified to accomplish work promptly and satisfactorily. The Government shall be advised in writing of the name of the designated service representative, and of any changes in personnel.

##### 1.6.3 Scheduled Inspections

Two inspections shall be performed at six-month intervals and all work required shall be performed. Inspections shall be scheduled in June and December. These inspections shall include:

- a. Visual checks and operational tests of equipment.
- b. Fan checks and filter changes for control system equipment.
- c. Clean control system equipment including interior and exterior surfaces.
- d. Check and calibrate each field device. Check and calibrate 50 percent of the total analog points during the first inspection. Check and calibrate the remaining 50 percent of the analog points during the second major inspection. Certify analog test instrumentation accuracy to be twice that of the device being calibrated. Randomly check at least 25 percent of all digital points for proper operation during the first inspection. Randomly check at least 25 percent of the remaining digital points during the second inspection.
- e. Run system software diagnostics and correct diagnosed problems.
- f. Resolve any previous outstanding problems.

#### 1.6.4 Scheduled Work

This work shall be performed during regular working hours, Monday through Friday, excluding legal holidays.

#### 1.6.5 Emergency Service

The Government will initiate service calls when the system is not functioning properly. Qualified personnel shall be available to provide service to the system. A telephone number where the service supervisor can be reached at all times shall be provided. Service personnel shall be at the site within 4 hours after receiving a request for service. The control system shall be restored to proper operating condition within 1 calendar day or 8 hours.

#### 1.6.6 Operation

Scheduled adjustments and repairs shall include verification of the control system operation as demonstrated by the applicable tests of the performance verification test.

#### 1.6.7 Records and Logs

Dated records and logs shall be kept of each task, with cumulative records for each major component, and for the complete system chronologically. A continuous log shall be maintained for all devices. The log shall contain initial analog span and zero calibration values and digital points. Complete logs shall be kept and shall be available for inspection onsite, demonstrating that planned and systematic adjustments and repairs have been accomplished for the control system.

#### 1.6.8 Work Requests

Each service call request shall be recorded as received and shall include

the serial number identifying the component involved, its location, date and time the call was received, nature of trouble, names of the service personnel assigned to the task, instructions describing what has to be done, the amount and nature of the materials to be used, the time and date work started, and the time and date of completion. A record of the work performed shall be submitted within 5 days after work is accomplished.

#### 1.6.9 System Modifications

Recommendations for system modification shall be submitted in writing. No system modifications, including operating parameters and control settings, shall be made without prior approval of the Government. Any modifications made to the system shall be incorporated into the operations and maintenance manuals, and other documentation affected.

#### 1.6.10 Software

Updates to the software shall be provided for system, operating and application software, and operation in the system shall be verified. Updates shall be incorporated into operations and maintenance manuals, and software documentation. There shall be at least one scheduled update near the end of the first year's warranty period, at which time the latest released version of the Contractor's software shall be installed and validated.

### 1.7 FACTORY TESTING

The Contractor shall assemble the factory test DDC system as specified and shall perform test to demonstrate that the performance of the system satisfies the requirements of this specification. Model numbers of equipment tested shall be identical to those to be delivered to the site. Original copies of data produced, including results of each test procedure during factory testing shall be delivered to the Government at the conclusion of testing, prior to Government approval of the test. The test results documentation shall be arranged so that commands, responses, and data acquired are correlated in a manner which will allow for logical interpretation of the data.

#### 1.7.1 Factory Test Setup

The factory test setup shall include the following:

- a. Central workstation/tester.
- b. Printer.
- c. DDC test set.
- d. Portable workstation/tester.
- e. Communication links of each type and speed including MODEMS.
- f. Dial-up MODEM.
- g. Software.

## PART 2 PRODUCTS

### 2.1 GENERAL EQUIPMENT REQUIREMENTS

Units of the same type of equipment shall be products of a single manufacturer. Each major component of equipment shall have the manufacturer's name and address, and the model and serial number in a conspicuous place. Materials and equipment shall be standard products of a manufacturer regularly engaged in the manufacturing of such products, which are of a similar material, design and workmanship. The standard products shall have been in a satisfactory commercial or industrial use for two years prior to use on this project. The two years' use shall include applications of equipment and materials under similar circumstances and of similar size. The two years' experience shall be satisfactorily completed by a product which has been sold or is offered for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures. Products having less than a two-year field service record will be acceptable if a certified record of satisfactory field operation, for not less than 6,000 hours exclusive of the manufacturer's factory tests, can be shown. The equipment items shall be supported by a service organization. Items of the same type and purpose shall be identical, including equipment, assemblies, parts and components. Automatic temperature controls shall be direct digital controls that will provide the required sequence of operation.

#### 2.1.1 Electrical and Electronic Devices

Electrical, electronic, and electropneumatic devices not located within a DDC panel shall have a NEMA ICS 1 enclosure in accordance with NEMA 250 unless otherwise shown.

#### 2.1.2 Standard Signals

Except for air distribution terminal unit control equipment, the output of all analog transmitters and the analog input and output of all DDC controllers shall be 4-to-20 mA<sub>dc</sub> signals. The signal shall originate from current-sourcing devices and shall be received by current-sinking devices.

#### 2.1.3 Ambient Temperature Limits

DDC panels shall have ambient condition ratings of 1.7 to 49 degrees C and 10 to 95 percent relative humidity, noncondensing. Devices installed outdoors shall operate within limit ratings of minus 37 to plus 66 degrees C. Instrumentation and control elements shall be rated for continuous operation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified or normally encountered for the installed location.

#### 2.1.4 Year 2000 Compliance

All equipment and software shall be Year 2000 compliant and shall be able to accurately process date/time data (including, but not limited to, calculating, comparing, and sequencing) from, into, and between the twentieth and twenty-first centuries, including leap year calculations, when used in accordance with the product documentation provided by the contractor, provided that all products (e.g. hardware, software, firmware) used in combination with other information technology, shall accurately process date/time data if other information technology properly exchanges date/time data with it.

#### 2.2 TUBING

### 2.2.1 Copper

Copper tubing shall conform to ASTM B 88, ASTM B 88M and shall have sweat fittings and valves.

### 2.2.2 Stainless Steel

Stainless steel tubing shall conform to ASTM A 269 and shall have stainless steel compression fittings.

### 2.2.3 Plastic

Plastic tubing shall have barbed fittings and valves. Plastic tubing shall have the burning characteristics of linear low-density polyethylene tubing, shall be self-extinguishing when tested in accordance with ASTM D 635, shall have UL 94 V-2 flammability classification, and shall withstand stress cracking when tested in accordance with ASTM D 1693. Plastic-tubing bundles shall be provided with Mylar barrier and flame-retardant polyethylene jacket.

## 2.3 WIRING

### 2.3.1 Terminal Blocks

Terminal blocks shall be insulated, modular, feed-through, clamp style with recessed captive screw-type clamping mechanism, shall be suitable for rail mounting, and shall have end plates and partition plates for separation or shall have enclosed sides.

### 2.3.2 Control Wiring for 24-Volt Circuits

Control wiring for 24-volt circuits shall be 18 AWG minimum, stranded copper and shall be rated for 300-volt service.

### 2.3.3 Wiring for 120-Volt Circuits

Wiring for 120-volt circuits shall be 18 AWG minimum, stranded copper and shall be rated for 600-volt service.

### 2.3.4 Instrumentation Cable

Instrumentation cable shall be 18 AWG, stranded copper, single- or multiple-twisted, minimum 50 mm lay of twist, 100 percent shielded pairs, and shall have a 300-volt insulation. Each pair shall have a 20 AWG tinned-copper drain wire and individual overall pair insulation. Cables shall have an overall aluminum-polyester or tinned-copper cable-shield tape, overall 20 AWG tinned-copper cable drain wire, and overall cable insulation.

### 2.3.5 Transformers

Step down transformers shall be utilized where control equipment operates at lower than line circuit voltage. Transformers, other than transformers in bridge circuits, shall have primaries wound for the voltage available and secondaries wound for the correct control circuit voltage. Transformer shall be sized so that the connected load is 80 percent of the rated capacity or less. Transformers shall conform to UL 508 and NEMA ST 1.

## 2.4 ACTUATORS

Actuators shall be pneumatic as shown and shall be provided with mounting and connecting hardware. Actuators shall fail to their spring-return positions on signal or power failure. The actuator stroke shall be limited in the direction of power stroke by an adjustable stop. Actuators shall have a visible position indicator. Actuators shall smoothly open or close the devices to which they are applied and shall have a full stroke response time of 90 seconds or less. Electric actuators shall have an oil-immersed gear train. Electric or electronic actuators operating in series shall have an auxiliary actuator driver. Electric or electronic actuators used in sequencing applications shall have an adjustable operating range and start point. Pneumatic actuators shall be rated for 172 kPa operating pressure except for high-pressure cylinder-type actuators.

#### 2.4.1 Valve Actuators

Valve actuators shall be selected to provide a minimum of 125 percent of the motive power necessary to operate the valve over its full range of operation.

#### 2.4.2 Positive Positioners

Positive positioners are required for pneumatic actuators. Each positive positioner shall be a pneumatic relay with a mechanical feedback mechanism and an adjustable operating range and starting point.

### 2.5 AUTOMATIC CONTROL VALVES

Valves shall have stainless-steel stems and stuffing boxes with extended necks to clear the piping insulation. Unless otherwise stated, valves shall have globe style bodies. Valve bodies shall be designed for not less than 862 kPa working pressure or 150 percent of the system operating pressure, whichever is greater. Valve leakage rating shall be 0.01 percent of rated Kv. Unless otherwise specified, bodies for valves 40 mm and smaller shall be brass or bronze, with threaded or union ends; bodies for 50 mm valves shall have threaded ends; and bodies for valves 50 to 80 mm shall be of brass, bronze or iron. Bodies for valves 65 mm and larger shall be provided with flanged-end connections. Valve Kv shall be within 100 to 125 percent of the Kv shown.

#### 2.5.1 Butterfly Valve Assembly

Butterfly valves shall be threaded lug type suitable for dead-end service and modulation to the fully-closed position, with carbon-steel bodies and noncorrosive discs, stainless steel shafts supported by bearings, and EPDM seats suitable for temperatures from minus 29 to plus 121 degrees C. Valves shall have a manual means of operation independent of the actuator. The rated Kv for butterfly valves shall be the value Kv at 70% open (60 degrees open).

#### 2.5.2 Two-Way Valves

Two-way modulating valves shall have equal-percentage characteristics.

#### 2.5.3 Three-Way Valves

Three-way valves shall provide linear flow control with constant total flow throughout full plug travel.

#### 2.5.4 Valves for Steam Service

Bodies for valves 100 mm and larger shall be iron. Internal valve trim shall be Type 316 stainless steel. Valve Kv shall be not less than shown nor greater than the Kv of the manufacturer's next larger size.

### 2.6 DAMPERS

#### 2.6.1 Damper Assembly

A single damper section shall have blades no longer than 1.2 meters and shall be no higher than 1.8 meters. Maximum damper blade width shall be 203 mm. Larger sizes shall be made from a combination of sections. Dampers shall be steel, or other materials where shown. Flat blades shall be made rigid by folding the edges. Blade-operating linkages shall be within the frame so that blade-connecting devices within the same damper section shall not be located directly in the air stream. Damper axles shall be 13 mm minimum, plated steel rods supported in the damper frame by stainless steel or bronze bearings. Blades mounted vertically shall be supported by thrust bearings. Pressure drop through dampers shall not exceed 10 Pa at 5.1 m/s in the wide-open position. Frames shall not be less than 50 mm in width. Dampers shall be tested in accordance with AMCA 500.

#### 2.6.2 Operating Links

Operating links external to dampers, such as crankarms, connecting rods, and line shafting for transmitting motion from damper actuators to dampers, shall withstand a load equal to at least twice the maximum required damper-operating force. Rod lengths shall be adjustable. Links shall be brass, bronze, zinc-coated steel, or stainless steel. Working parts of joints and clevises shall be brass, bronze, or stainless steel. Adjustments of crankarms shall control the open and closed positions of dampers.

#### 2.6.3 Damper Types

Dampers shall be parallel-blade unless butterfly type is shown on the drawings.

##### 2.6.3.1 Outside Air, Return Air, and Relief Air Parallel Blade Dampers

Outside air, return air and relief air dampers shall be provided where shown. Blades shall have interlocking edges and shall be provided with compressible seals at points of contact. The channel frames of the dampers shall be provided with jamb seals to minimize air leakage. Dampers shall not leak in excess of 102 L/s per square meter at 1017 Pa static pressure when closed. Seals shall be suitable for an operating temperature range of minus 40 to plus 94 degrees C. Dampers shall be rated at not less than 10 m/s air velocity.

##### 2.6.3.2 Butterfly Dampers

Butterfly dampers shall be installed where shown on the drawings. Dampers shall consist of a circular blade, mounted to axle within formed flanged frame. Blade shall be 1/4 inch thick minimum with full circumference elastomer type wiper seal retained by seal ring bolted to the blade. The seal shall be field adjustable and replaceable. Damper shaft shall be

continuous, extending through the entire damper diameter and extending beyond the damper bearing a minimum of 6 inches. Leakage through damper shall not exceed in the closed position 0.029 standard cubic feet per minute (SCFM) per inch of blade circumference at a pressure differential of 10 inches of water. Maximum pressure drop across and open damper shall not exceed 0.010 inches of water at design CFM.

#### 2.6.3.3 Mechanical and Electrical Space Ventilation Dampers

Mechanical and electrical space ventilation dampers shall be as shown. Dampers shall not leak in excess of 406 L/s per square meter at 1017 Pa static pressure when closed. Dampers shall be rated at not less than 7.6 m/s air velocity.

#### 2.6.3.4 Smoke Dampers

Smoke-damper and actuator assembly required per NFPA 90A shall meet the Class II leakage requirements of UL 555S. Dampers shall be rated at not less than 10 m/s air velocity.

#### 2.6.4 Damper End Switches

Each end switch shall be a hermetically sealed switch with a trip lever and over-travel mechanism. The switch enclosure shall be suitable for mounting on the duct exterior and shall permit setting the position of the trip lever that actuates the switch. The trip lever shall be aligned with the damper blade.

### 2.7 SMOKE DETECTORS

Duct smoke detectors shall be provided in supply and return air ducts in accordance with NFPA 90A. Duct smoke detectors shall conform to the requirements of UL 268A. Duct smoke detectors shall have perforated sampling tubes extended into the air duct. Detector circuitry shall be mounted in a metallic enclosure exterior to the duct. Detectors shall have manual reset. Detectors shall be rated for air velocities that include air flows between 2.5 and 20 m/s. Detectors shall be powered from the fire alarm control panel (FACP). Detectors shall have two sets of normally open alarm contacts and two sets of normally closed alarm contacts. Detectors shall be connected to the building fire alarm panel for alarm initiation. A remote annunciation lamp and accessible remote reset switch shall be provided for duct detectors that are mounted eight feet or more above the finished floor and for detectors that are not readily visible. Remote lamps and switches as well as the affected fan units shall be properly identified in etched rigid plastic placards.

### 2.8 INSTRUMENTATION

#### 2.8.1 Measurements

Transmitters shall be calibrated to provide the following measurements, over the indicated ranges, for an output of 4 to 20 mAdc:

- a. Conditioned space temperature, from 10 to 30 degrees C .
- b. Duct temperature, from 5 to 60 degrees C .
- c. High-temperature hot-water temperature, from 94 to 260 degrees C .

- d. Chilled-water temperature, from minus 1 to plus 38 degrees C .
- e. Dual-temperature water, from minus 1 to plus 116 degrees C .
- f. Heating hot-water temperature, from 10 to 121 degrees C .
- g. Condenser-water temperature, from minus 1 to plus 55 degrees C .
- h. Outside-air temperature, from minus 35 to plus 55 degrees C .
- i. Relative humidity, 0 to 100 percent for space and duct high-limit applications.
- j. Differential pressure for VAV supply-duct static pressure from 0 to 500 Pa .
- k. Pitot-tube air-flow measurement station and transmitter, from 0 to 25 Pa for flow velocities of 3.5 to 6 m/s , 0 to 60 Pa for velocities of 3.5 to 9 m/s , or 0 to 125 Pa for velocities of 3.5 to 13 m/s .
- l. Electronic air-flow measurement station and transmitter, from 0.6 to 13 m/s .

## 2.8.2 Temperature Instruments

### 2.8.2.1 Resistance Temperature Detectors (RTD)

Temperature sensors shall be 100 ohms 3- or 4-wire RTD. Each RTD shall be platinum with a tolerance of 0.30 degrees C at 0 degrees C with a temperature coefficient of resistance (TCR) of .00385 ohms/ohm/deg C and shall be encapsulated in epoxy, series 300 stainless steel, anodized aluminum, or copper. Each RTD shall be furnished with an RTD transmitter as specified, integrally mounted unless otherwise shown.

### 2.8.2.2 Continuous Averaging RTD

Continuous averaging RTDs shall have a tolerance of plus or minus 0.5 degrees C at the reference temperature, and shall be of sufficient length to ensure that the resistance represents an average over the cross section in which it is installed. The sensing element shall have a bendable copper sheath. Each averaging RTD shall be furnished with an RTD transmitter to match the resistance range of the averaging RTD.

### 2.8.2.3 RTD Transmitter

The RTD transmitter shall match the resistance range of the RTD. The transmitter shall be a two-wire, loop powered device. The transmitter shall produce a linear 4-to-20 mA<sub>dc</sub> output corresponding to the required temperature measurement. The output error shall not exceed 0.1 percent of the calibrated measurement.

## 2.8.3 Relative Humidity Instruments

A relative-humidity instrument for indoor application shall have a measurement range from 0 to 100 percent relative-humidity and be rated for operation at ambient air temperatures within the range of minus 4 to plus 55 degrees C . It shall be capable of being exposed to a condensing air stream (100 percent RH) with no adverse effect to the sensor's calibration or other harm to the instrument. The instrument shall be of the

wall-mounted or duct-mounted type, as required by the application, and shall be provided with any required accessories. Instruments used in duct high-limit applications shall have a bulk polymer resistive sensing element. Duct-mounted instruments shall be provided with a duct probe designed to protect the sensing element from dust accumulation and mechanical damage. The instrument (sensing element and transmitter) shall be a two-wire, loop-powered device and shall have an accuracy of plus or minus three percent of full scale within the range of 20 to 80 percent relative humidity. The instrument shall have a typical long-term stability of 1 percent or less drift per year. The transmitter shall convert the sensing element's output to a linear 4-20 mA<sub>dc</sub> output signal in proportion to the measured relative-humidity value. The transmitter shall include offset and span adjustments.

#### 2.8.4 Electronic Airflow Measurement Stations and Transmitters

##### 2.8.4.1 Stations

Each station shall consist of an array of velocity sensing elements and an air-flow straightener. Air-flow straightener shall be contained in a flanged sheet metal or aluminum casing. The velocity sensing elements shall be of the RTD or thermistor type, producing a linear output. The sensing elements shall be distributed across the duct cross section in the quantity and pattern specified by the published installation instructions of the station manufacturer. The resistance to air flow through the airflow measurement station shall not exceed 20 Pa at an airflow of 10 m/s.

Station construction shall be suitable for operation at airflows of up to 25 m/s over a temperature range of 4 to 49 degrees C , and accuracy shall be plus or minus three percent over a range of 0.6 to 12.5 m/s . In outside air measurement or in low-temperature air delivery applications, the station shall be certified by the manufacturer to be accurate as specified over a temperature range of minus 29 to plus 49 degrees C. In outside air measurement applications, the air flow straightener shall be constructed of 3 mm aluminum honeycomb and the depth of the straightener shall not be less than 40 mm.

##### 2.8.4.2 Transmitters

Each transmitter shall produce a linear, temperature compensated 4-to-20 mA<sub>dc</sub>, output corresponding to the required velocity pressure measurement. The transmitter shall be a two-wire, loop powered device. The output error of the transmitter shall not exceed 0.5 percent of the calibrated measurement.

#### 2.8.5 Pitot Tube Airflow Measurement Stations and Transmitters

##### 2.8.5.1 Stations

Each station shall contain an array of velocity sensing elements and straightening vanes inside a flanged sheet metal casing. The velocity sensing elements shall be of the multiple pitot tube type with averaging manifolds. The sensing elements shall be distributed across the duct cross section in the quantity and pattern specified by the published installation instructions of the station manufacturer. The resistance to air flow through the airflow measurement station shall not exceed 20 Pa at an airflow of 10 m/s. Station construction shall be suitable for operation at airflows of up to 25 m/s over a temperature range of 4 to 49 degrees C , and accuracy shall be plus or minus three percent over a range of 2.5 to 12.5 m/s. This device will not be used if the required velocity

measurement is below 3.5 m/s or for outside airflow measurements.

#### 2.8.5.2 Transmitters

Each transmitter shall produce a linear 4-to-20 mAdc output corresponding to the required velocity pressure measurement. Each transmitter shall have a low range differential pressure sensing element. The transmitter shall be a two-wire, loop powered device. Sensing element accuracy shall be plus or minus one percent of full scale, and overall transmitter accuracy shall be plus or minus 0.25 percent of the calibrated measurement.

#### 2.8.6 Differential Pressure Instruments

The instrument shall be a pressure transmitter with an integral sensing element. The instrument over pressure rating shall be 300 percent of the operating pressure. The sensor/transmitter assembly accuracy shall be plus or minus two percent of full scale. The transmitter shall be a two-wire, loop-powered device. The transmitter shall produce a linear 4-to-20 mAdc output corresponding to the required pressure measurement.

#### 2.8.7 Thermowells

Thermowells shall be Series 300 stainless steel with threaded brass plug and chain, 50 mm lagging neck and extension type well. Inside diameter and insertion length shall be as required for the application.

#### 2.8.8 Sunshields

Sunshields for outside air temperature sensing elements shall prevent the sun from directly striking the temperature sensing elements. The sunshields shall be provided with adequate ventilation so that the sensing element responds to the ambient temperature of the surroundings. The top of each sunshield shall have a galvanized metal rainshield projecting over the face of the sunshield. The sunshields shall be painted white.

#### 2.9 THERMOSTATS

Thermostat ranges shall be selected so that the setpoint is adjustable without tools between plus or minus 5 degrees C of the setpoint shown. Thermostats shall be electronic or electric.

##### 2.9.1 Nonmodulating Room Thermostats

Contacts shall be single-pole double-throw (SPDT), hermetically sealed, and wired to identified terminals. Maximum differential shall be 3 degrees C.

Room thermostats shall be enclosed with separate locking covers (guards).

##### 2.9.2 Microprocessor Based Room Thermostats

Microprocessor based thermostats shall have built-in keypads for scheduling of day and night temperature settings. When out of the scheduling mode, thermostats shall have continuous display of time, with AM and PM indicator, continuous display of day of week, and either continuous display of room temperature with display of temperature setpoint on demand, or continuous display of temperature setpoint with display of room temperature on demand. In the programmable mode, the display shall be used for interrogating time program ON-OFF setpoints for all seven days of the week.

The time program shall allow two separate temperature setback intervals per day. The thermostats shall have a means for temporary and manual override of the program schedule, with automatic program restoration on the

following day. Thermostats shall have a replaceable battery to maintain the timing and maintain the schedule in memory for one year in the event of a power outage. Maximum differential shall be 1 degree C. When used for heat pump applications, the thermostat shall have an emergency heat switch.

#### 2.9.3 Modulating Room Thermostats

Modulating room thermostats shall have either one output signal, two output signals operating in unison, or two output signals operating in sequence, as required for the application. Each thermostat shall have an adjustable throttling range of 2 to 4 degrees C for each output. Room thermostats shall be enclosed with separate locking covers (guards).

#### 2.9.4 Nonmodulating Capillary Thermostats and Aquastats

Each thermostat shall have a capillary length of at least 1500 mm, shall have adjustable direct-reading scales for both setpoint and differential, and shall have a differential adjustable from 3 to 9 degrees C. Aquastats shall be of the strap on type, with 5 degrees C fixed differential.

#### 2.9.5 Deleted Paragraph

#### 2.9.6 Modulating Capillary Thermostats

Each thermostat shall have either one output signal, two output signals operating in unison, or two output signals operating in sequence, as required for the application. Thermostats shall have adjustable throttling ranges of 2 to 4 degrees C for each output.

### 2.10 PRESSURE SWITCHES AND SOLENOID VALVES

#### 2.10.1 Pressure Switches

Each switch shall have an adjustable setpoint with visible setpoint scale. Range shall be as shown. Differential adjustment shall span 20 to 40 percent of the range of the device.

#### 2.10.2 Differential-Pressure Switches

Each switch shall be an adjustable diaphragm-operated device with two SPDT contacts, with taps for sensing lines to be connected to duct pressure fittings designed to sense air pressure. These fittings shall be of the angled-tip type with tips pointing into the air stream. The setpoint shall not be in the upper or lower quarters of the range and the range shall not be more than three times the setpoint. Differential shall be a maximum of 35 Pa at the low end of the range and 85 Pa at the high end of the range.

#### 2.10.3 Pneumatic Electric (PE) Switches

Each switch shall have an adjustable setpoint range of 20 to 140 kPa with a switching differential adjustable from 15 to 35 kPa. The switch action shall be SPDT.

#### 2.10.4 Solenoid-Operated Pneumatic (EP) Valves

Each valve shall have three-port operation: common, normally open, and normally closed. Each valve shall have an outer cast aluminum body and internal parts of brass, bronze, or stainless steel. The air connection

shall be a 10 mm NPT threaded connection. Valves shall be rated for 345 kPa when used in a control system that operates at 172 kPa or less, or 1035 kPa when used in a control system that operates in the range of 172 to 690 kPa.

## 2.11 INDICATING DEVICES

### 2.11.1 Thermometers

Mercury shall not be used in thermometers.

#### 2.11.1.1 Piping System Thermometers

Piping system thermometers shall have brass, malleable iron or aluminum alloy case and frame, clear protective face, permanently stabilized glass tube with indicating-fluid column, white face, black numbers, and a 230 mm scale. Thermometers for piping systems shall have rigid stems with straight, angular, or inclined pattern.

#### 2.11.1.2 Piping System Thermometer Stems

Thermometer stems shall have expansion heads as required to prevent breakage at extreme temperatures. On rigid-stem thermometers, the space between bulb and stem shall be filled with a heat-transfer medium.

#### 2.11.1.3 Nonaveraging Air-Duct Thermometers

Air-duct thermometers shall have perforated stem guards and 45-degree adjustable duct flanges with locking mechanism.

#### 2.11.1.4 Averaging Air-Duct Thermometers

Averaging thermometers shall have a 90 mm (nominal) dial, with black legend on white background, and pointer traveling through a 270-degree arc.

#### 2.11.1.5 Accuracy

Thermometers shall have an accuracy of plus or minus one percent of scale range. Thermometers shall have a range suitable for the application.

### 2.11.2 Pressure Gauges

Gauges shall be 50 mm (nominal) size, back connected, suitable for field or panel mounting as required, shall have black legend on white background, and shall have a pointer traveling through a 270-degree arc. Accuracy shall be plus or minus three percent of scale range. Gauges shall meet requirements of ASME B40.1.

#### 2.11.2.1 Pneumatic Actuator Gauges

Gauges for indicating signal output to pneumatic actuators shall have an outer scale of 21 to 103 kPa in 7 kPa graduations.

#### 2.11.2.2 Air Storage Tank and Filter and Dryer Gauge

Gauges for air storage tanks or for use before and after dirt and oil filters or dryers, shall have a scale of 0 to 1100 kPa with 20 kPa graduations.

### 2.11.2.3 Hydronic System Gauges

Gauges for hydronic system applications shall have ranges and graduations as shown.

### 2.11.3 Low Differential Pressure Gauges

Gauges for low differential pressure measurements shall be a minimum of 90 mm (nominal) size with two sets of pressure taps, and shall have a diaphragm-actuated pointer, white dial with black figures, and pointer zero adjustment. Gauges shall have ranges and graduations as shown. Accuracy shall be plus or minus two percent of scale range.

## 2.12 CONTROL DEVICES AND ACCESSORIES

### 2.12.1 Relays

Control relay contacts shall have utilization category and ratings selected for the application, with a minimum of two sets of contacts (two normally open, two normally closed) enclosed in a dustproof enclosure. Relays shall be rated for a minimum life of one million operations. Operating time shall be 20 milliseconds or less. Relays shall be equipped with coil transient suppression devices to limit transients to 150 percent of rated coil voltage. Time delay relays shall be 2PDT with eight-pin connectors, dust cover, and a matching rail-mounted socket. Adjustable timing range shall be 0 to 5 minutes. Power consumption shall not be greater than three watts.

### 2.12.2 Current to Pneumatic (IP) Transducers

The transducers shall be two-wire current-to-pressure transmitters that convert a 4-to-20 mA<sub>dc</sub> input signal to a 21 to 103 kPa (3 to 15 psig) , or a 103 to 21 kPa (15 to 3 psig) , pneumatic output, with a conversion accuracy of plus or minus two percent of full scale, including linearity and hysteresis. Input impedance shall not exceed 250 ohms. Air consumption shall not be greater than 0.12 L/s.

### 2.12.3 Joule or Watthour Meters

Joule meters shall be in accordance with ANSI C12.1 and have pulse initiators for remote monitoring of Joule consumption. Pulse initiator shall consist of form C contacts with a current rating not to exceed two amperes and voltage not to exceed 500 V, with combinations of VA not to exceed 100 VA, and a life rating of one billion operations. Meter sockets shall be in accordance with ANSI C12.1.

### 2.12.4 Joule or Watthour Meters with Demand Register

Meters shall be in accordance with ANSI C12.1 and shall have pulse initiators for remote monitoring of Joule consumption and instantaneous demand. Pulse initiators shall consist of form C contacts with a current rating not to exceed two amperes and voltage not to exceed 500 V, with combinations of VA not to exceed 100 VA, and a life rating of one billion operations. Meter sockets shall be in accordance with ANSI C12.1

### 2.12.5 Joule or Watthour Transducers

Joule transducers shall have an accuracy of plus or minus 0.25 percent for kW and Joule outputs from full lag to full lead power factor. Input

ranges for kW and Joule transducers shall be selectable without requiring the changing of current or potential transformers. The output shall be 4 to 20 mAdc.

#### 2.12.6 Current Sensing Relays

Current sensing relays shall provide a normally-open contact rated at a minimum of 50 volts peak and 1/2 ampere or 25 VA, noninductive. There shall be a single hole for passage of current carrying conductors. The devices shall be sized for operation at 50 percent rated current based on the connected load. Voltage isolation shall be a minimum of 600 volts.

#### 2.12.7 Power-Line Conditioners (PLC)

Power line conditioners shall be furnished for each DDC panel. The PLCs shall provide both voltage regulation and noise rejection. The PLCs shall be of the ferro-resonant design, with no moving parts and no tap switching, while electrically isolating the secondary from the power-line side. The PLCs shall be sized for 125 percent of the actual connected kVA load. Characteristics of the PLC shall be as follows:

a. At 85 percent load, the output voltage shall not deviate by more than plus or minus one percent of nominal when the input voltage fluctuates between minus 20 percent to plus 10 percent of nominal.

b. During load changes of zero to full load, the output voltage shall not deviate by more than plus or minus three percent of nominal voltage. Full correction of load switching disturbances shall be accomplished within five cycles, and 95 percent correction shall be accomplished within two cycles of the onset of the disturbance.

c. Total harmonic distortion shall not exceed 3-1/2 percent at full load.

#### 2.13 DIRECT DIGITAL CONTROL (DDC) HARDWARE

All functions, constraints, data base parameters, operator developed programs and any other data shall be downloadable from a portable workstation/tester or the central workstation/tester to network control panels, RIU's, universal programmable controllers, and unitary controllers.

Download shall be accomplished through both the primary network and the local DDC portable workstation/tester port.

##### 2.13.1 Network Control Panel

Network control panels shall be microcomputer-based with sufficient memory provided to perform all specified and shown network control panel functions and operations, including spare capacity for all spares and its I/O functions specified. Each network control panel and remote I/O units (RIU) shall have a minimum of 10% of its I/O functions as spare capacity but not less than 2 of each type used in each. The type of spares shall be in the same proportion as the implemented I/O functions on the panel, but in no case shall there be less than two spare points of each type. The panel I/O functions shall be furnished complete, with no changes or additions necessary to support implementation of spare functions. Output relays associated with digital signals shall be considered part of the I/O function, whether physically mounted in the enclosure or separately mounted. Implementation of spare points shall necessitate only providing the additional field sensor or control device, field wiring including

connection to the system, and point definition assignment by the operator using the central workstation/tester or portable workstation/tester. The panel shall contain all necessary I/O functions to connect to field sensors and control panels. I/O function operation shall be fully supervised to detect I/O function failures. Network control panels shall operate in an independent stand-alone mode, which is defined as all network control panel operations performed by the network control panel without any continuing input from other Direct digital controls or portable workstation/tester. The network control panel shall be capable of controlling a mix of at least 32 RIUs, unitary controllers, and universal programmable controllers.

#### 2.13.1.1 Integral Features

The network control panel shall include:

- a. Main power switch.
- b. Power on indicator.
- c. Portable workstation/tester port, connector, and if necessary power supply.
- d. Manufacturers control network port.
- e. On-Off-Auto switches for each DO which controls a device. These switches shall be mounted in the field panel, with the exception of motors, for which the switch shall be mounted at the motor control center. On-Off-Auto switches are not required for DO associated with a status or alarm such as pilot lights. The status of these switches shall be available to the panel for further processing.
- f. Minimum-Maximum-Auto switches, or Auto-Manual switches with manual output override, for each AO. The status of these shall be available to the panel for further processing.
- g. An intrusion detection device, connected as an alarm.

#### 2.13.1.2 Communication Interfaces

The following communication capabilities shall function simultaneously.

- a. Manufacturers Control Network. Manufacturers control network communications interfaces for each data transmission systems (DTS) circuit between network control panels and RIUs, unitary controllers, and universal programmable controllers, shall be provided. Communication interfaces shall be provided between each network control panel and associated I/O functions. The DTS will provide for transmission speeds necessary to comply with performance requirements specified. DTS equipment shall be installed in the network control panel enclosure.
- b. Portable Workstation/Tester Port. A communications port for interfacing to a portable workstation/tester shall be provided. Network control panel workstation/tester port other than RS-232, shall be converted to RS-232, including cabling and power supply, and shall be permanently installed in the panel.
- c. Primary Network Port. The network control panel shall either have a built in primary network Port or be capable of accepting a primary network port expansion card for future networking to a base wide utility

monitoring and control system (UMCS). The primary network port expansion card shall be either Ethernet (IEEE802.3) or ARCNET.

#### 2.13.1.3 Memory and Real Time Clock (RTC) Backup

The network control panel memory and real time clock functions shall continue to operate for a minimum of 72 hours in the event of a power failure. If rechargeable batteries are provided, automatic charging of batteries shall be provided. Whenever a either a permanent workstation/tester or portable workstation/tester is monitoring the network control panel, a low battery alarm message shall be sent to it.

#### 2.13.1.4 Duplex Outlet

A single phase, 120 Vac electrical service outlet for use with test equipment shall be furnished either inside or within 2 meters of the network control panel enclosure.

#### 2.13.1.5 Locking Enclosures

Locking type mounting cabinets with common keying shall be furnished for each network control panel.

#### 2.13.1.6 Failure Mode

Upon failure of the network control panel, either due to failure of the network control panel hardware or of the manufacturers control network, the network control panel shall revert to the failure mode as shown.

a. Manufacturers Control Network Failure: Upon failure of the manufacturers control network, the network control panel shall operate in an independent stand-alone mode.

b. Network Control Panel Hardware Failure: Upon failure of the network control panel hardware, the network control panel shall cease operation and stop communications with other network control panels, RIUs, unitary controllers and universal programmable controllers connected to the affected network control panel. The affected network control panel shall respond to this failure as specified and shown.

#### 2.13.2 RIU

The RIU shall be functionally a part of the network control panel as specified, but may be remotely located from the network control panel and communicate over a dedicated communication circuit. When remotely located, the I/O functions shall be subject to the same requirements as for the network control panel hardware. RIUs shall be used to connect remote inputs and outputs to a network control panel and shall contain all necessary I/O functions to connect to field sensors and control devices. RIU operation shall be fully supervised by the network control panel to detect failures. Each RIU shall have a minimum of 10 % of its I/O functions as spare capacity. The type of spares shall be in the same proportion as the implemented I/O functions on the RIU, but in no case shall there be less than two spare points of each type. The RIU shall be furnished complete, with no changes or additions necessary to support implementation of spare functions. Output relays associated with digital signals shall be considered part of the I/O function, whether physically mounted in the enclosure or separately mounted. Implementation of spare points by others shall require only providing the additional field sensor

or control device, field wiring including connection to the system, and point definition assignment by the operator. The RIU shall either report the status of all connected points on each scan, or report the status of all points which have changed state or value since the previous scan.

#### 2.13.2.1 Integral Features

The RIU shall include:

- a. Main power switch.
- b. Power on indicator.
- c. Portable workstation/tester port, connector, and if necessary power supply.
- d. Manufacturers control network port.
- e. On-Off-Auto switches for each DO which controls a device. These switches shall be mounted in the RIU, with the exception of motors, for which the switch shall be mounted at the motor control center. On-Off-Auto switches are not required for DO associated with a status or alarm such as pilot lights. The status of these switches shall be available to the RIU for further processing.
- f. Minimum-Maximum-Auto switches, or Auto-Manual switches with manual output override, for each AO. The status of these shall be available to the panel for further processing.
- g. An intrusion detection device, connected as an alarm.

#### 2.13.2.2 Duplex Outlet

A single phase, 120 Vac electrical service outlet for use with test equipment shall be furnished either inside or within 2 meters of the RIU.

#### 2.13.2.3 Locking Enclosures

Locking type mounting cabinets with common keying shall be furnished for each RIU.

#### 2.13.2.4 Failure Mode

Upon failure of the RIU, either due to failure of the RIU hardware or of the DTS, the RIU shall revert to the failure mode shown.

#### 2.13.3 Universal Programmable Controller (UPC)

The universal programmable controller shall be a microprocessor based controller designed and programmed to control and monitor systems as shown.

Resident programs shall be contained in reprogrammable nonvolatile memory. Each universal programmable controller shall contain necessary power supplies, transformers, memory, I/O functions and communications interfaces necessary to perform its required functions and to provide control and monitoring of connected equipment and devices. It shall contain all necessary I/O functions to connect to field sensors and controls. I/O operation shall be fully supervised to detect I/O function failures. It shall provide for operation as a device connected to the system via the manufacturers control network.

### 2.13.3.1 Integral Features

The universal programmable controller shall include as a minimum:

- a. Main power switch.
- b. Power on indicator.
- c. Portable workstation/tester port, connector, and if necessary power supply.
- d. Manufacturers control network port.
- e. I/O functions
  - (1) 8 DI
  - (2) 4 DO
  - (3) 8 AI
  - (4) 4 AO
  - (5) 1 PA
- f. On-Off-Auto switches for each DO which controls a device. These switches shall be mounted in the universal programmable controller, with the exception of motors, for which the switch shall be mounted at the motor control center. On-Off-Auto switches are not required for DO associated with a status or alarm such as pilot lights. The status of these switches shall be available to the panel for further processing.
- g. Minimum-Maximum-Auto switches, or Auto-Manual switches with manual output override, for each AO. The status of these shall be available to the panel for further processing.

### 2.13.3.2 Communication Interfaces

The UPC shall have the following communication capabilities which shall function simultaneously.

- a. Manufacturers Control Network. The manufacturers control network communications interface for a data transmission systems (DTS) circuit between the UPC and a network control panels shall be provided. The DTS will provide for transmission speeds necessary to comply with performance requirements specified. DTS equipment shall be installed in the UPC Panel enclosure.
- b. Portable Workstation/Tester Port. A communications port for interfacing to a portable workstation/tester shall be provided. A UPC workstation/tester port other than RS-232, shall be converted to RS-232, including cabling and power supply, and shall be permanently installed in the panel.

### 2.13.3.3 Memory and RTC Backup

The UPC memory and real time clock functions shall continue to operate for a minimum of 72 hours in the event of a power failure. If rechargeable

batteries are provided, automatic charging of batteries shall be provided. Whenever either a permanent workstation/tester or portable workstation/tester is monitoring the network control panel, a low battery alarm message shall be sent to it.

#### 2.13.3.4 Specific Requirements

Each universal programmable controller shall be accessible for purposes of application selection, control parameters, set point adjustment, and monitoring from any DDC controller connected to the same manufacturers control network as the universal programmable controller. This shall be done using a portable workstation/tester connected to a portable workstation/tester port either directly or via modem.

#### 2.13.3.5 Locking Enclosures

Locking type mounting cabinets with common keying shall be furnished for each enclosure.

#### 2.13.3.6 Failure Mode

Upon failure of the universal programmable controller, it shall revert to the failure mode of operation as shown.

#### 2.13.4 Unitary Controller

The unitary controller shall be a microprocessor based, stand-alone, dedicated purpose controller, communicating with the network control panel, designed and programmed to control air distribution system mixing boxes, terminal units, heat pumps, fan coil units, self-contained DX units or VAV boxes as shown. Each unitary controller shall contain resident programs in nonvolatile memory for each specific application implemented. Each unitary controller shall contain necessary power supplies, transformers, memory, I/O functions and communications interfaces necessary to perform its required functions and to provide control and monitoring of connected equipment and devices. It shall contain all necessary I/O functions to connect to field sensors and controls. I/O operation shall be fully supervised to detect I/O function failures and shall provide for operation as a device connected to the network control panel via the manufacturers control network.

##### 2.13.4.1 Integral Features

The unitary controller shall include:

- a. Main power switch.
- b. Power on indicator.
- c. Portable workstation/tester port, connector, and power supply.
- d. Manufacturers control network port.
- e. All I/O functions required to implement the requirements as shown.

f. On-Off-Auto switches for each DO which controls a device. These switches shall be mounted in the field panel, with the exception of motors, for which the switch shall be mounted at the motor control center. On-Off-Auto switches are not required for DO associated with a status or

alarm such as pilot lights. The status of these switches shall be available to the panel for further processing.

g. Minimum-Maximum-Auto switches, or Auto-Manual switches with manual output override, for each AO. The status of these shall be available to the panel for further processing.

#### 2.13.4.2 Communication Interfaces

The unitary controller shall have the following communication capabilities which shall function simultaneously.

a. Manufacturers Control Network. The manufacturers control network communications interface for a data transmission systems (DTS) circuit between the unitary controller and a network control panel shall be provided. The DTS will provide for transmission speeds necessary to comply with performance requirements specified. DTS equipment shall be installed in the unitary control panel enclosure.

b. Portable Workstation/Tester Port. A communications port for interfacing to a portable workstation/tester shall be provided. A unitary controller workstation/tester port other than RS-232, shall be converted to RS-232, including cabling and power supply, and shall be permanently installed in the panel. For unitary controller applications where the controller is not mounted in an enclosure, such as for fan-coil units or VAV terminal units, a portable conversion device for an RS-232 connection to the portable workstation/tester may be provided.

#### 2.13.4.3 Specific Requirements

Unitary controller components for new air distribution terminal units shall be furnished to the air distribution terminal unit manufacturer for factory mounting and calibration. Existing air distribution terminal units shall be controlled by field installed unitary controllers.

a. Accessibility and Interfaces: Each unitary controller shall be accessible for purposes of application selection, control parameters, set point adjustment, and monitoring using a portable workstation/tester connected to the manufacturers control network. They shall also be accessible with a portable workstation/tester connected to the unitary controller portable workstation/tester port.

#### 2.13.4.4 Failure Mode

Upon failure of the unitary controller, it shall revert to the failure mode of operation as shown.

#### 2.13.5 I/O Functions

##### 2.13.5.1 DDC Hardware I/O Functions

I/O Functions shall be provided as part of the DDC system and shall be in accordance with the following:

a. The analog input (AI) function shall monitor each analog input, perform A-to-D conversion, and hold the digital value in a buffer for interrogation. The A-to-D conversion shall have a minimum resolution of 10 bits plus sign. Signal conditioning shall be provided for each analog input. Analog inputs shall be individually calibrated for zero and span, in hardware or in software. The AI shall incorporate common mode noise rejection of 50 dB from 0 to 100 Hz for differential inputs, and normal mode noise rejection of 20 dB at 60 Hz from a source impedance of 10,000 ohms. Input ranges shall be within the range of 4-to-20 mAdc.

b. The analog output (AO) function shall accept digital data, perform D-to-A conversion, and output a signal within the range of 4-to-20 mAdc. D-to-A conversion shall have a minimum resolution of eight bits plus sign. Analog outputs shall be individually calibrated for zero and span. Short circuit protection on voltage outputs and open circuit protection on current outputs shall be provided. An individual gradual switch for manual override of each analog output and means of physically securing access to these switches shall be provided. Each AO shall have a three-position switch for selection of the DDC control signal, no control, or a locally generated control signal for connection to the controlled device. Feedback shall be provided to the system as to the status of the output (manual control or automatic). Switches for pneumatic control outputs shall provide a connection for an externally generated pneumatic signal. All switches shall be either of a key operated design with the same keying system used for other outputs or otherwise suitably protected from unauthorized access .

c. The digital input (DI) function shall accept on-off, open-close, or other change of state (two state data) indications. Isolation and protection against an applied steady-state voltage up to 180 Vac peak shall be provided.

d. The digital output (DO) function shall provide contact closures for momentary and maintained operation of output devices. Closures shall have a minimum duration of 0.1 second. DO relays shall have an initial breakdown voltage between contacts and coil of at least 500 V peak. Electromagnetic interference suppression shall be furnished on all output lines to limit transients to nondamaging levels. Protection against an applied steady-state voltage up to 180 Vac peak shall be provided. Minimum contact rating shall be one ampere at 24 Vac. Key locked HOA switches shall be provided for manual override of each digital output. Feedback shall be provided to the system as to the status of the output (manual control or automatic). Switches shall be common keyed .

e. The pulse accumulator function shall have the same characteristics as the DI. In addition, a buffer shall be provided to totalize pulses and allow for interrogation by the DDC system. The pulse accumulator shall accept rates up to 20 pulses per second. The totalized value shall be reset to zero upon operator's command.

f. Signal conditioning for sensors shall be provided as specified.

g. The binary coded decimal (BCD) function: The BCD function shall have the same characteristics as the DI, except that, in addition, a buffer shall be provided to totalize inputs and allow for interrogation by the network control panel. The BCD function shall have 16-channel optically isolated buffered inputs to read four digit numbers. The BCD function shall accumulate inputs at rates up to 10 inputs per second.

#### 2.13.5.2 Failure Mode

Upon failure of the I/O function, including data transmission failure, logic power supply failure, DDC processor malfunction, software failure, interposing relay power failure, or any other failure which prevents stand alone operation of any DDC normally capable of stand alone operation, connected outputs shall be forced to the failure mode shown.

#### 2.13.6 Portable Workstation/Tester

A portable workstation/tester shall be provided and shall be able to connect to any DDC hardware. The portable workstation/tester shall consist of a portable computer with a nominal 10 inch active color matrix liquid crystal display, capable of displaying up to 256 colors at a minimum resolution of 640 X 480 pixels, an external VGA monitor port, 32 bit microprocessor operating at a minimum of 100 MHZ. The portable workstation/tester shall have, as a minimum, a 1200 MB hard drive, 16 megabytes of memory, integral pointing device, serial and parallel ports, color VGA video port for an external color monitor, 3.5 inch floppy disk drive, modem, PCMCIA type 3 slot, rechargeable battery, battery charger and 120 Vac power supply. It shall include carrying case, extra battery, charger and a compatible network adapter. The workstation/tester shall:

- a. Run DDC diagnostics.
- b. Load all DDC memory resident programs and information, including parameters and constraints.
- c. Display any AI, DI, AO, DO, or PA point in engineering units for analog points or status for digital points.
- d. Control any AO or DO.
- e. Provide an operator interface, contingent on password level, allowing the operator to use full English language words and acronyms, or an object oriented graphical user interface.
- f. Display database parameters.
- g. Modify database parameters.
- h. Accept DDC software and information for subsequent loading into a specific DDC. Provide all necessary software and hardware required to support this function, including an EIA ANSI/EIA/TIA-232-F port.
- i. Disable/enable each DDC.
- j. Perform all workstation functions as specified.

#### 2.14 DDC SOFTWARE

All DDC software described in this specification shall be furnished as part of the complete DDC System.

##### 2.14.1 Operating System

Each DDC shall contain an operating system that controls and schedules that DDC's activities in real time. The DDC shall maintain a point database in

its memory that includes all parameters, constraints, and the latest value or status of all points connected to that DDC. The execution of DDC application programs shall utilize the data in memory resident files. The operating system shall include a real time clock function that maintains the seconds, minutes, hours, date and month, including day of the week. Each DDC real time clock shall be automatically synchronized with the network control panel real time clock at least once per day to plus or minus 10 seconds. When the network control panel is connected to a central workstation/tester, the network control panel RTC shall be updated by the central workstation/tester RTC. The time synchronization shall be accomplished without operator intervention and without requiring system shutdown. The operating system shall allow loading of software, data files data entry, and diagnostics from the central workstation/tester both locally through the central workstation/tester port and remotely through a network control panel and the manufacturers control network.

#### 2.14.1.1 Startup

The DDC shall have startup software that causes automatic commencement of operation without human intervention, including startup of all connected I/O functions. A DDC restart program based on detection of power failure at the DDC shall be included in the DDC software. Upon restoration of power to the DDC, the program shall restart equipment and restore loads to the state at time of power failure, or to the state as commanded by time programs or other overriding programs. The restart program shall include start time delays between successive commands to prevent demand surges or overload trips. The startup software shall initiate operation of self-test diagnostic routines. Upon failure of the DDC, if the database and application software are no longer resident or if the clock cannot be read, the DDC shall not restart and systems shall remain in the failure mode indicated until the necessary repairs are made. If the database and application programs are resident, the DDC shall resume operation after an adjustable time delay of from 0 to 600 seconds. The startup sequence for each DDC shall include a unique time delay setting for each control output when system operation is initiated.

#### 2.14.1.2 Operating Mode

Each DDC shall control and monitor functions as specified, independent of communications with other DDC. This software shall perform all DDC functions and DDC resident application programs as specified using data obtained from I/O functions and based upon the DDC real time clock function. When communications circuits between the DDC are operable, the DDC shall obtain real time clock updates and any required global data values transmitted from other network control panels. The DDC software shall execute commands after performing constraints checks in the DDC. Status and analog values, including alarms and other data shall be transmitted from other network control panels when communications circuits are operable. If communications are not available, each DDC shall function in stand-alone mode and operational data, including the latest status and value of each point and results of calculations, normally transmitted from other network control panels shall be stored for later transmission to the network control panel. Storage for the latest 256 values shall be provided at each network control panel. Each DDC shall accept software downloaded from the network control panel. Constraints shall reside at the DDC.

#### 2.14.1.3 Failure Mode

Upon failure for any reason, each DDC shall perform an orderly shutdown and

force all DDC outputs to a predetermined (failure mode) state, consistent with the failure modes shown and the associated control device.

#### 2.14.2 Functions

The Contractor shall provide software necessary to accomplish the following functions, as appropriate, fully implemented and operational, within each network control panel, RIU, unitary controller and universal programmable controller.

- a. Scanning of inputs.
- b. Control of outputs.
- c. Reporting of analog changes outside a selectable differential.
- d. Reporting of unauthorized digital status.
- e. Reporting of alarms automatically to network control panel.
- f. Reporting of I/O status to network control panel upon request.
- g. Maintenance of real time, updated by the network control panel at least once a day.
- h. Communication with the network control panel.
- i. Execution of DDC resident application programs.
- j. Averaging or filtering of AIs.
- k. Constraints checks (prior to command issuance).
- l. Diagnostics.
- m. Portable workstation/tester operation as specified.
- n. Reset of PA by operator based on time and value.

##### 2.14.2.1 Analog Monitoring

The system shall measure and transmit analog values including calculated analog points. An analog change in value is defined as a change exceeding a preset differential value as specified. The record transmitted for each analog value shall include a readily identifiable flag which indicates the abnormal status of the value when it deviates from operator selectable upper and lower analog limits. Analog values shall be expressed in proper engineering units with sign. Engineering units conversions shall be provided for each measurement. Each engineering units conversion set shall include range, span, and conversion equation. A vocabulary of engineering unit descriptors shall be provided, using at least three alphanumeric characters to identify information in the system. The system shall support 255 different engineering units.

##### 2.14.2.2 Logic (Virtual) Points

Logic (virtual) points shall be software points entered in the point database which are not directly associated with a physical I/O function. Logic (virtual) points shall be analog or digital points created by

calculation from any combination of digital and analog points, or other data having the properties of real points, including alarms, without the associated hardware. Logic (virtual) points shall be defined or calculated and entered into the database by the Contractor. The calculated analog point shall have point identification in the same format as any other analog point. The calculated point shall be used in any program where the real value is not obtainable directly. Constants used in calculations shall be changeable on-line by the operator. Calculated point values shall be current for use by the system within 10 seconds of the time of any input changes.

#### 2.14.2.3 State Variables

If an analog point represents more than two (up to eight) specific states, each state shall be nameable. For example, a level sensor shall be displayed at its measured engineering units plus a state variable with named states usable in programs or for display such as low alarm/low/normal/high/high alarm.

#### 2.14.2.4 Analog Totalization

Any analog point shall be operator assignable to the totalization program. Up to eight analog values shall be totalized within a selectable time period. At the end of the period, the totals shall be stored. Totalization shall then restart from zero for the next time period. The program shall keep track of the peak and total value measured during the current period and for the previous period. The operator shall be able to set or reset each totalized value individually. The time period shall be able to be operator defined, modified or deleted on-line.

#### 2.14.2.5 Energy Totalization

The system shall calculate the heat energy in Btus, for each energy source consumed by the mechanical systems specified, totalize the calculated Btus, the instantaneous rate in Btus per hour, and store totals in thousands of Btus (MBtu). The Btus calculated shall be totalized for an adjustable time period. The time period shall be defined uniquely for each Btu totalization.

#### 2.14.2.6 Trending

Any analog or calculated point shall be operator assignable to the trend program. Up to eight points shall be sampled at individually assigned intervals, selectable between one minute and two hours. A minimum of the most recent 128 samples of each trended point shall be stored. The sample intervals shall be able to be defined, modified, or deleted on-line.

#### 2.14.3 I/O Point Database/Parameter Definition

Each I/O point shall be defined in a database residing in the DDC. The definition shall include all physical parameters associated with each point. Each point shall be defined and entered into the database by the Contractor, including as applicable:

- a. Name.
- b. Device or sensor type (i.e., sensor, control relay, motors).
- c. Point identification number.

- d. Unit.
- e. Building number.
- f. Area.
- g. Island.
- h. DDC number and channel address.
- i. KW (running).
- j. KW (starting).
- k. Sensor range.
- l. Controller range.
- m. Sensor span.
- n. Controller span.
- o. Engineering units conversion (scale factor).
- p. Setpoint (analog).
- q. High reasonableness value (analog).
- r. Low reasonableness value (analog).
- s. High alarm limit differential (return to normal).
- t. Low alarm limit differential (return to normal).
- u. High alarm limit (analog).
- v. Low alarm limit (analog).
- w. Alarm disable time period upon startup or change of setpoint.
- x. Analog change differential (for reporting).
- y. Alarm class and associated primary message text.
- z. High accumulator limit (pulse).
- aa. Status description.
- bb. Run time target.
- cc. Failure mode as specified and shown.
- dd. Constraints as specified.

#### 2.14.4 Alarm Processing

Each DDC shall have alarm processing software for AI, DI, and PA alarms for all real and virtual points connected to that DDC.

#### 2.14.4.1 Digital Alarms Definition

Digital alarms are those abnormal conditions indicated by DIs as specified and shown.

#### 2.14.4.2 Analog Alarms Definition

Analog alarms are those conditions higher or lower than a defined value, as measured by an AI. Analog readings shall be compared to predefined high and low limits, and alarmed each time a value enters or returns from a limit condition. Unique high and low limits shall be assigned to each analog point in the system. Analog alarm limits shall be stored in the DDC database. Each analog alarm limit shall have an associated unique limit differential specifying the amount by which a variable must return into the proper operating range before being annunciated as a return-to-normal-state. All limits and differentials shall be entered on-line by the operator in limits of the measured variable, without interruption or loss of monitoring of the point concerned. The program shall automatically change the high or low limits or both, of any analog point, based on time scheduled operations as specified, allowing for a time interval before the alarm limit becomes effective. In CPA applications, key the limit to a finite deviation traveling with the setpoint. The system shall automatically suppress analog alarm reporting associated with a digital point when that digital point is turned off.

#### 2.14.4.3 Pulse Accumulator Alarms Definition

Pulse accumulator alarms are those conditions calculated from totalized values of accumulator inputs or PA input rates that are outside defined limits as specified and shown. PA totalized values shall be compared to predefined limits and alarmed each time a value enters a limit condition. Unique limits shall be assigned to each PA point in the system. Limits shall be stored in the DDC database.

#### 2.14.5 Constraints

##### 2.14.5.1 Equipment Constraints Definitions

Each control point in the database shall have DDC resident constraints defined and entered by the Contractor, including as applicable:

- a. Maximum starts (cycles) per hour.
- b. Minimum off time.
- c. Minimum on time.
- d. High limit (value in engineering units).
- e. Low limit (value in engineering units).

##### 2.14.5.2 Constraints Checks

Control devices connected to the system shall have the DDC memory resident constraints checked before each command is issued to insure that no equipment damage will result from improper operation. Each command shall be executed by the DDC only after all constraints checks have been passed. Each command point shall have unique constraints assigned. High and low

"reasonableness" values or one differential "rate-of-change" value shall be assigned to each AI. Values outside the reasonableness limits shall be rejected and an alarm message sent to the network control panel or portable workstation/tester. Status changes and analog point values shall be reported to the workstation upon operator request, such as for reports, alphanumeric displays, graphic displays, and application programs. Each individual point shall be capable of being selectively disabled by the operator from a workstation/tester. Disabling a point shall prohibit monitoring and automatic control of that point.

#### 2.14.6 Diagnostics

Each DDC shall have self-test diagnostic routines implemented in firmware. The tests shall include routines that exercise memory. Diagnostic software shall be usable in conjunction with the central workstation/tester and portable workstation/tester. The software shall display messages in English to inform the tester's operator of diagnosed problems.

#### 2.14.7 Summer-Winter Operation Monitoring

The system shall provide software to automatically change the operating parameters, monitoring of alarm limits, and start-stop schedules for each mechanical system from summer to winter and vice-versa. The software shall provide automatic commands to applications programs to coordinate proper summer or winter operation. Change over setpoints shall be operator selectable and settable.

#### 2.14.8 Control Sequences and Control Loops

Sufficient memory shall be provided to implement the requirements specified and shown for each DDC. Specific functions to be implemented are defined in individual system sequences and database tables shown in the drawings, and shall include, as applicable, the following:

a. PI Control: This function shall provide proportional control and proportional plus integral control.

b. Two Position Control: This function shall provide control for a two state device by comparing a set point against a process variable and an established deadband.

c. Floating Point Control: This function shall exercise control when an error signal exceeds a selected deadband, and shall maintain control until the error is within the deadband limits.

d. Signal Selection: This function shall allow the selection of the highest or lowest analog value from a group of analog values as the basis of control. The function shall include the ability to cascade analog values so that large numbers of inputs can be reduced to one or two outputs.

e. Signal Averaging: This function shall allow the mathematical calculation of the average analog value from a group of analog values as the basis of control. The function shall include the ability to "weight" the individual analog values so that the function output can be biased as necessary to achieve proper control.

f. Reset Function: This function shall develop an AO based on up to two AIs and one operator specified reset schedule.

g. Cooling/Heating Operation Program: Software shall be provided to change, either automatically or on operator command, the operating parameters, monitoring of alarm limits, and start-stop schedules for each mechanical system where such a change from cooling to heating and vice versa is meaningful. The software shall provide commands to application programs to coordinate cooling or heating mode operation. Software shall automatically switch facilities from cooling to heating, and vice versa, based on schedules or temperatures. All HVAC equipment and systems shall be assigned to the program.

#### 2.14.9 Command Priorities

A scheme of priority levels shall be provided to prevent interaction of a command of low priority with a command of higher priority. The system shall require the latest highest priority command addressed to a single point to be stored for a period of time longer than the longest time constraint in the on and off states, insuring that the correct command shall be issued when the time constraint is no longer in effect or report the rejected command. Override commands entered by the operator shall have higher priority than those emanating from applications programs.

#### 2.14.10 Resident Application Software

The Contractor shall provide resident applications programs to achieve the sequences of operation, parameters, constraints, and interlocks necessary to provide control of the systems connected to the DDC system. Application programs shall be resident and shall execute in the DDC, and shall coordinate with each other, to insure that no conflicts or contentions remain unresolved. The Contractor shall coordinate the application programs specified with the equipment and controls operation, and other specified requirements. A scheme of priority levels shall be provided to prevent interaction of a command of low priority with a command of higher priority. The system shall require the latest highest priority command addressed to a single point to be stored for a period of time longer than the longest time constraint in the ON and OFF states, insuring that the correct command shall be issued when the time constraint is no longer in effect or the rejected command shall be reported. Override commands entered by the operator shall have higher priority than those emanating from application programs.

##### 2.14.10.1 Program Inputs and Outputs

The Contractor shall select the appropriate program inputs listed for each application program to calculate the required program outputs. Where the specific program inputs are not available, a "default" value or virtual point appropriate for the equipment being controlled and the proposed sequence of operation shall be provided to replace the missing input, thus allowing the application program to operate. AIs to application programs shall have an operator adjustable deadband to preclude short cycling or hunting. Program outputs shall be real analog or digital outputs or logic (virtual) points as required to provide the specified functions. The Contractor shall select the appropriate input and output signals to satisfy the requirements for control of systems as shown.

##### 2.14.10.2 DDC General Conditions

The Contractor shall provide software required to achieve the sequences of operation, parameters, constraints, and interlocks shown. Application software shall be resident in the DDC in addition to any other required

software. In the event of a DDC failure, the controlled equipment shall continue to function in the failure mode shown.

#### 2.14.10.3 Scheduled Start/Stop Program

This program shall start and stop equipment based on a time of day schedule for each day of the week, and on a holiday schedule. To eliminate power surges, an operator adjustable time delay shall be provided between consecutive start commands.

##### a. Program Inputs:

- (1) Day of week/holiday.
- (2) Time of day.
- (3) Cooling and heating high-low alarm limits.
- (4) Cooling and heating start-stop schedules.
- (5) Cooling or heating mode of operation.
- (6) Equipment status.
- (7) Equipment constraints.
- (8) Consecutive start time delay.

##### b. Program Outputs: Start/stop signal.

#### 2.14.10.4 Optimum Start/Stop Program

This program shall start and stop equipment as specified for the scheduled start/stop program, but shall include a sliding schedule based on indoor and outdoor air conditions. The program shall take into account the thermal characteristics of the structure, and indoor and outdoor air conditions, using prediction software to determine the minimum time of HVAC system operation needed to satisfy space environmental requirements at the start of the occupied cycle, and determine the earliest time for stopping equipment at the day's end without exceeding space environmental requirements. An adaptive control algorithm shall be utilized to automatically adjust the constants used in the program.

##### a. Program Inputs:

- (1) Day of week/holiday.
- (2) Time of day.
- (3) Cooling or heating mode of operation.
- (4) Equipment status.
- (5) Cooling and heating building occupancy schedules.
- (6) Space temperature.
- (7) Building heating constant (operator adjustable and automatically optimized).

- (8) Building cooling constant (operator adjustable and automatically optimized).
- (9) OA temperature.
- (10) Required space temperature at occupancy (heating).
- (11) Required space temperature at occupancy (cooling).
- (12) Equipment constraints.
- (13) Cooling and heating high-low alarm limits.

b. Program Outputs: Start/stop signal.

#### 2.14.10.5 Day-Night Setback Program

The software shall limit the rise or drop of space temperature (or specified fluid temperature) during unoccupied hours. Whenever the space temperature (or specified fluid temperature) is above (or below for heating) the operator assigned temperature limit, the system shall be turned on until the temperature is within the assigned temperature limit.

a. Program Inputs:

- (1) Day of week.
- (2) Time of day.
- (3) Cooling or heating mode of operation.
- (4) Cooling and heating occupancy schedules.
- (5) Equipment status.
- (6) Space temperature (or specified fluid temperature).
- (7) Minimum space temperature (or specified fluid temperature) during unoccupied periods.
- (8) Maximum space temperature (or specified fluid temperature) during unoccupied periods.
- (9) Equipment constraints.

b. Program Outputs: Start/stop signal.

#### 2.14.10.6 Ventilation/Recirculation and Flush Programs

The software shall reduce the HVAC system thermal load for two modes of operation and provide for flushing of the building as follows:

a. Ventilation mode: In this mode, the system shall precool the space prior to building occupancy. When the outside air temperature is lower than the space temperature, the outside air damper and exhaust air damper shall open to their maximum positions and the return air damper shall close to its minimum position.

b. Recirculation mode: In this mode, the system shall preheat the space prior to building occupancy. When the outside air temperature is lower than the space temperature, the outside air damper and the exhaust air damper shall close to their minimum positions and the return air damper shall open to its maximum position.

c. Flush mode: The software shall use the HVAC supply system to provide 100% outside air for ventilation purpose and flush building spaces. The network control panel shall modulate the control valves to maintain the air supply temperature setpoints while the flush program is in effect. The flush mode shall be manually initiated and have the highest priority (it shall override all other programs). The outside air damper and the exhaust air damper shall be closed at other times during unoccupied periods, except for economizer operation during day/night setback periods. For systems without mechanical cooling, this program shall, in addition to the above requirements, act as an economizer. The outside, return, and exhaust air dampers shall be modulated to maintain the required mixed air temperature setpoint. When this program is released, the outside and exhaust air dampers shall return to their minimum positions, and the return air damper shall return to its maximum position.

d. Program Inputs:

- (1) Day of week.
- (2) Time of day.
- (3) Cooling or heating mode of operation.
- (4) Equipment status.
- (5) Cooling and heating occupancy schedules.
- (6) OA dry bulb temperature.
- (7) Space temperature.
- (8) Equipment constraints.

e. Program Output: Damper actuator control signal.

#### 2.14.10.7 Heating and Ventilating Unit Program

The software shall control hot water/steam coil valve position to maintain space/supply air temperatures for heating and ventilating units. This program shall be coordinated with the ventilation-recirculation program for damper control and the scheduled or optimum start-stop program for fan control.

a. Program Inputs

- (1) Space temperature.
- (2) Space temperature setpoint.
- (3) Supply air temperature.
- (4) Supply air temperature setpoint.

b. Program Outputs

- (1) Heating or steam coil valve actuator control signal.

- (2) Damper actuator control signal.

#### 2.14.10.8 Air Volume Control Program

The software shall monitor supply and return/exhaust air flow volumes and modulate fan controls to maintain required air flow volumes and/or ratio or fixed differential of supply to return air flows. This program shall be coordinated with the ventilation-recirculation program and the economizer program for damper control and with static pressure control requirements for fan control.

##### a. Program Inputs

- (1) Supply air flow.
- (2) Return/exhaust air flow.
- (3) Required supply air flow - high and low limits.
- (4) Required return/exhaust air flow - high and low limits.
- (5) Volume offset or ratio, as appropriate.

##### b. Program Outputs

- (1) Supply fan volume control.
- (2) Return/exhaust fan volume control.

#### 2.14.10.9 Air Distribution Unitary Controller Software

Software shall be provided for the management and control of the air distribution terminal units. Software shall allow for operator definition of multiple air distribution terminal units as functional groups which may be treated as a single entity; monitoring, alarming and reporting of terminal unit parameters on an individual or group basis; and remote setpoint adjustment on an individual or group basis.

##### a. Functions:

- (1) Volume control in response to temperature.
- (2) Volume flow limits, minimum and maximum.
- (3) Occupied and unoccupied operation with associated temperature and volume limits.
- (4) Temperature setpoint override.

##### b. Program Inputs

- (1) Space temperature.
- (2) Space temperature setpoint.
- (3) Space temperature setpoint limits.
- (4) Supply airflow volume.
- (5) Supply airflow volume high and low limits.

##### c. Program Outputs

- (1) Supply volume control signal.
- (2) Auxiliary fan start/stop signal.
- (3) Supplemental heat control signal.

#### 2.14.10.10 Domestic Hot Water Generator Program

The software shall control the domestic hot water temperature by adjusting the hot water heating control valve.

a. Program Inputs

- (1) Domestic hot water temperature.
- (2) Domestic hot water temperature setpoint.

b. Program Output: Hot water heating control valve actuator control signal.

PART 3 EXECUTION

3.1 GENERAL INSTALLATION CRITERIA

3.1.1 HVAC Control System

The HVAC control system shall be completely installed and ready for operation. Dielectric isolation shall be provided where dissimilar metals are used for connection and support. Penetrations through and mounting holes in the building exterior shall be made watertight. The HVAC control system installation shall provide clearance for control system maintenance by maintaining access space between coils, access space to mixed-air plenums, and other access space required to calibrate, remove, repair, or replace control system devices. The control system installation shall not interfere with the clearance requirements for mechanical and electrical system maintenance.

3.1.2 Software Installation

Software shall be loaded for an operational system, including databases for all points, operational parameters, and system, command, and application software. The Contractor shall provide original and backup copies of source, excluding the general purpose operating systems and utility programs furnished by computer manufacturers and the non-job-specific proprietary code furnished by the system manufacturer, and object modules for software on each type of media utilized, within 30 days of formal Government acceptance. In addition, a copy of individual floppy disks of software for each DDC panel shall be provided.

3.1.3 Device Mounting Criteria

Devices mounted in or on piping or ductwork, on building surfaces, in mechanical/electrical spaces, or in occupied space ceilings shall be installed in accordance with manufacturer's recommendations and as shown. Control devices to be installed in piping and ductwork shall be provided with required gaskets, flanges, thermal compounds, insulation, piping, fittings, and manual valves for shutoff, equalization, purging, and calibration. Strap-on temperature sensing elements shall not be used except as specified.

3.1.4 Wiring Criteria

Wiring external to control panels, including low-voltage wiring, shall be installed in metallic raceways. Nonmetallic-sheathed cables or metallic-armored cables may be installed in areas permitted by NFPA 70. Wiring shall be installed without splices between control devices and DDC panels. Instrumentation grounding shall be installed as necessary to prevent ground loops, noise, and surges from adversely affecting operation of the system. Ground rods installed by the contractor shall be tested as specified in IEEE Std 142. Cables and conductor wires shall be tagged at

both ends, with the identifier shown on the shop drawings. Electrical work shall be as specified in Section 16415A ELECTRICAL WORK, INTERIOR and as shown.

### 3.2 CONTROL SYSTEM INSTALLATION

#### 3.2.1 Damper Actuators

Actuators shall not be mounted in the air stream. Multiple actuators operating a common damper shall be connected to a common drive shaft. Actuators shall be installed so that their action shall seal the damper to the extent required to maintain leakage at or below the specified rate and shall move the blades smoothly.

#### 3.2.2 Local Gauges for Actuators

Pneumatic actuators shall have an accessible and visible receiver gauge installed in the tubing lines at the actuator as shown.

#### 3.2.3 Room Instrument Mounting

Room instruments , such as wall mounted thermostats, shall be mounted 1.5 m above the floor unless otherwise shown. Temperature setpoint devices shall be recess mounted.

#### 3.2.4 Deleted Paragraph

#### 3.2.5 Averaging Temperature Sensing Elements

Sensing elements shall have a total element minimum length equal to 3 m per square meter of duct cross-sectional area.

#### 3.2.6 Foundations and Housekeeping Pads

Foundations and housekeeping pads shall be provided for the HVAC control system air compressors.

#### 3.2.7 Compressed Air Stations

The air compressor assembly shall be mounted on vibration eliminators, in accordance with ASME BPVC SEC VIII D1 for tank clearance. The air line shall be connected to the tank with a flexible pipe connector. Compressed air station specialties shall be installed with required tubing, including condensate tubing to a floor drain.

#### 3.2.8 Duct Static Pressure Sensing Elements and Transmitters

The duct static pressure sensing element and transmitter sensing point shall be located at 75% to 100% of the distance between the first and last air terminal units.

#### 3.2.9 Indication Devices Installed in Piping and Liquid Systems

Gauges in piping systems subject to pulsation shall have snubbers. Gauges for steam service shall have pigtail fittings with cock. Thermometers and temperature sensing elements installed in liquid systems shall be installed in thermowells.

### 3.2.10 Tubing

#### 3.2.10.1 Control System Installation

The control system shall be installed so that pneumatic lines are not exposed to outside air temperatures. All tubes and tube bundles exposed to view shall be installed neatly in lines parallel to the lines of the building. Tubing between panels and actuators in mechanical/electrical spaces shall be routed so that the lines are easily traceable.

#### 3.2.10.2 Pneumatic Lines In Mechanical/Electrical Spaces

In mechanical/electrical spaces, pneumatic lines shall be plastic tubing or copper tubing. Horizontal and vertical runs of plastic tubes or soft copper tubes shall be installed in raceways dedicated to tubing. Dedicated raceways and tubing not installed in raceways shall be supported every 2 m for horizontal runs and every 2.5 m for vertical runs.

#### 3.2.10.3 Pneumatic Lines External To Mechanical/Electrical Spaces

Tubing external to mechanical/electrical spaces, when run in plenum ceilings, shall be soft copper with sweat fittings. Tubing not in plenum spaces shall be soft copper with sweat fittings or shall be plastic tubing in raceways dedicated to tubing. Raceways and tubing not in raceways shall be supported every 2.5 m.

#### 3.2.10.4 Connection to Liquid and Steam Lines

Tubing for connection of sensing elements and transmitters to liquid and steam lines shall be Series 300 stainless steel with stainless-steel compression fittings.

#### 3.2.10.5 Connection to Ductwork

Tubing for connection of sensing elements and transmitters to ductwork shall be plastic tubing.

#### 3.2.10.6 Tubing in Concrete

Tubing in concrete shall be installed in rigid conduit. Tubing in walls containing insulation, fill, or other packing materials shall be installed in raceways dedicated to tubing.

#### 3.2.10.7 Final Connection to Actuators

Final connections to actuators shall be plastic tubing 300 mm long and unsupported at the actuator.

### 3.3 COMMISSIONING PROCEDURES

#### 3.3.1 Evaluations

The Contractor shall make the observations, adjustments, calibrations, measurements, and tests of the control systems, set the time schedule, and make any necessary control system corrections to ensure that the systems function as described in the sequence of operation.

##### 3.3.1.1 Item Check

Signal levels shall be recorded for the extreme positions of each controlled device. An item-by-item check of the sequence of operation requirements shall be performed using Steps 1 through 4 in the specified control system commissioning procedures. Steps 1, 2, and 3 shall be performed with the HVAC system shut down; Step 4 shall be performed after the HVAC systems have been started. External input signals to the DDC system (such as starter auxiliary contacts, and external systems) may be simulated in steps 1, 2, and 3. With each operational mode signal change, DDC system output relay contacts shall be observed to ensure that they function.

#### 3.3.1.2 Weather Dependent Test Procedures

Weather dependent test procedures that cannot be performed by simulation shall be performed in the appropriate climatic season. When simulation is used, the actual results shall be verified in the appropriate season.

#### 3.3.1.3 Two-Point Accuracy Check

A two-point accuracy check of the calibration of each HVAC control system sensing element and transmitter shall be performed by comparing the DDC system readout to the actual value of the variable measured at the sensing element and transmitter or airflow measurement station location. Digital indicating test instruments shall be used, such as digital thermometers, motor-driven psychrometers, and tachometers. The test instruments shall be at least twice as accurate as the specified sensing element-to-DDC system readout accuracy. The calibration of the test instruments shall be traceable to National Institute Of Standards And Technology standards. The first check point shall be with the HVAC system in the shutdown condition, and the second check point shall be with the HVAC system in an operational condition. Calibration checks shall verify that the sensing element-to-DDC system readout accuracies at two points are within the specified product accuracy tolerances. If not, the device shall be recalibrated or replaced and the calibration check repeated.

#### 3.3.1.4 Insertion and Immersion Temperatures

Insertion temperature and immersion temperature sensing elements and transmitter-to-DDC system readout calibration accuracy shall be checked at one physical location along the axis of the sensing element.

#### 3.3.1.5 Averaging Temperature

Averaging temperature sensing element and transmitter-to-DDC system readout calibration accuracy shall be checked every 600 mm along the axis of the sensing element in the proximity of the sensing element, for a maximum of 10 readings. These readings shall then be averaged.

#### 3.3.2 Space Temperature Controlled Perimeter Radiation

The heating medium shall be turned on, and the thermostat temperature setpoint shall be raised. The valve shall open. The thermostat temperature shall be lowered and the valve shall close. The thermostat shall be set at the setpoint shown.

#### 3.3.3 Climate Control Unit CCU-1 & CCU-2 Systems, and Furnace FUR-1C/EF-1C System

Steps for installation shall be as follows:

a. Step 1 - System Inspection: The HVAC system shall be verified in its shutdown condition. The system shall be checked to see that power and main air are available where required, and that the outside air damper, humidifier valve (CCU-1 & 2 only).

b. Step 2 - Calibration Accuracy Check with HVAC System Shutdown: Readings shall be taken with a digital thermometer at each temperature sensing elements location. Each temperature shall be read at the DDC controller, and the thermometer and DDC system display readings logged. The calibration accuracy of the sensing element-to-DDC system readout for outside air, return air, mixed air, and coil discharge temperatures shall be checked. For CCU-1 and CCU-2, a motor-driven psychrometer shall be used to check the wet-bulb and dry-bulb temperatures of the humidifier discharge air, and the psychrometer, and DDC system display readings shall be read and logged.

c. Step 3 - Actuator Range Adjustments: A signal shall be applied to the actuator, through an operator entered value to the DDC system. The proper operation of the actuators and positioners for all dampers and valves shall be visually verified. The signal shall be varied from live zero to full range, and the actuators travel shall be verified from zero stroke to full stroke within the signal range. It shall be verified that all sequenced and parallel operated actuators move from zero stroke to full stroke in the proper direction, and move the connected device in the proper direction from one extreme position to the other. For CCU-1 and CCU-2 Systems pilot lights on control panels, and switches, shall be verified against operation sequences shown.

d. Step 4 - Control System Commissioning:

(1) With the fan ready to start, the control system shall be placed in the enabled, and it shall be verified that supply fan and interlocked exhaust fan starts. It shall be verified that dampers and any associated pilot lights function; and the CCU-1 and CCU-2 steam heating coil valves; multistage DX cooling coils and associated condensing unit stages/hot gas bypass valves for CCU-1, CCU-2, and FUR-1C; modulating gas burner for FUR-1C; and CCU-1 and CCU-2 humidifier valves; are under control, by simulating a change in the humidity and the temperature.

(2) The calibration accuracy check for sensing element-to-DDC system readout for the FUR-1C space temperature shall be performed. The temperature setpoint shall be set as shown. A change shall be simulated in the temperature and it shall be verified that the heating coil valve, FUR-1C gas burner modulating valve, and DX cooling coil and associated condensing unit compressors and hot gas bypass valves, are under control. A similar test shall be performed for the duct mounted temperature sensor and verify the CCU-1 and CCU-2 steam heating coil control valve and DX cooling coil and related condensing unit stages/hot gas bypass are under control.

(3) For CCU-1 and CCU-2, the calibration accuracy check for sensing element-to-DDC system readout for the duct relative humidity shall be performed. The duct relative humidity setpoints shall be set as shown. A change shall be simulated in the duct relative humidity and it shall be verified that the humidifier

valve are under control.

(4) With the HVAC system running, a filter differential pressure switch input signal shall be simulated at the device. It shall be verified that the filter alarm is initiated. The differential pressure switch shall be set at the setpoint.

(5) With the HVAC system running, a freeze trip input signal shall be simulated at the device. HVAC system shutdown shall be verified. It shall be verified that a low temperature alarm is initiated. The freeze trip shall be set at the setpoint. The HVAC system shall be restarted by manual restart and it shall be verified that the alarm returns to normal.

(6) With the HVAC system running, a smoke detector trip input signal shall be simulated at each detector, and control device actions and interlock functions as described in the Sequence of Operation shall be verified. Simulation shall be performed without false-alarming any Life Safety systems. It shall be verified that the HVAC system shuts down and that the smoke detector alarm is initiated. The detectors shall be reset. The HVAC system shall be restarted by manual reset, and it shall be verified that the alarm returns to normal.

### 3.4 BALANCING, COMMISSIONING, AND TESTING

#### 3.4.1 Coordination with HVAC System Balancing

Commissioning of the control system, except for tuning of controllers, shall be performed prior to or simultaneous with HVAC system balancing. The contractor shall tune the HVAC control system after all air system and hydronic system balancing has been completed, minimum damper positions set and a report has been issued.

#### 3.4.2 Control System Calibration, Adjustments, and Commissioning

Control system commissioning shall be performed for each HVAC system, using test plans and procedures previously approved by the Government. The Contractor shall provide all personnel, equipment, instrumentation, and supplies necessary to perform commissioning and testing of the HVAC control system. All instrumentation and controls shall be calibrated and the specified accuracy shall be verified using test equipment with calibration traceable to NIST standards. Wiring shall be tested for continuity and for ground, open, and short circuits. Tubing systems shall be tested for leaks. Mechanical control devices shall be adjusted to operate as specified. HVAC control panels shall be pretested off-site as a functioning assembly ready for field connections, calibration, adjustment, and commissioning of the operational HVAC control system. Control parameters and logic (virtual) points including control loop setpoints, gain constants, and integral constraints, shall be adjusted before the system is placed on line. Communications requirements shall be as indicated. Written notification of any planned commissioning or testing of the HVAC Control systems shall be given to the Government at least 14 calendar days in advance.

#### 3.4.3 Performance Verification Test

The Contractor shall demonstrate compliance of the HVAC control system with

the contract documents. Using test plans and procedures previously approved by the Government, the Contractor shall demonstrate all physical and functional requirements of the project. The performance verification test shall show, step-by-step, the actions and results demonstrating that the control systems perform in accordance with the sequences of operation. The performance verification test shall not be started until after receipt by the Contractor of written permission by the Government, based on Government approval of the Commissioning Report and completion of balancing. The tests shall not be conducted during scheduled seasonal off periods of base heating and cooling systems.

#### 3.4.4 Endurance Test

The endurance test shall be used to demonstrate the specified overall system reliability requirement of the completed system. The endurance test shall not be started until the Government notifies the Contractor in writing that the performance verification test is satisfactorily completed.

The Government may terminate the testing at any time when the system fails to perform as specified. Upon termination of testing by the Government or by the Contractor, the Contractor shall commence an assessment period as described for Phase II. Upon successful completion of the endurance test, the Contractor shall deliver test reports and other documentation as specified to the Government prior to acceptance of the system.

a. Phase I (Testing). The test shall be conducted 24 hours per day, 7 days per week, for 15 consecutive calendar days, including holidays, and the system shall operate as specified. The Contractor shall make no repairs during this phase of testing unless authorized by the Government in writing.

b. Phase II (Assessment). After the conclusion of Phase I, the Contractor shall identify failures, determine causes of failures, repair failures, and deliver a written report to the Government. The report shall explain in detail the nature of each failure, corrective action taken, results of tests performed, and shall recommend the point at which testing should be resumed. After delivering the written report, the Contractor shall convene a test review meeting at the jobsite to present the results and recommendations to the Government. As a part of this test review meeting, the Contractor shall demonstrate that all failures have been corrected by performing appropriate portions of the performance verification test. Based on the Contractor's report and test review meeting, the Government may require that the Phase I test be totally or partially rerun. After the conclusion of any retesting which the Government may require, the Phase II assessment shall be repeated as if Phase I had just been completed.

#### 3.4.5 Posted and Panel Instructions

Posted and Panel Instructions, showing the final installed conditions, shall be provided for each system. The posted instructions shall consist of laminated half-size drawings and shall include the control system schematic, equipment schedule, sequence of operation, wiring diagram, communication network diagram, and valve and damper schedules. The posted instructions shall be permanently affixed, by mechanical means, to a wall near the control panel. Panel instructions shall consist of laminated letter-size sheets and shall include a Routine Maintenance Checklist and as-built configuration check sheets. Panel instructions and one copy of the Operation and Maintenance Manuals, previously described herein, shall be placed inside each control panel or permanently affixed, by mechanical

means, to a wall near the panel.

### 3.5 TRAINING

#### 3.5.1 Training Course Requirements

A training course shall be conducted for 5 operating staff members designated by the Contracting Officer in the maintenance and operation of the system, including specified hardware and software. The training period, for a total of 32 hours of normal working time, shall be conducted within 30 days after successful completion of the performance verification test. The training course shall be conducted at the project site. Audiovisual equipment and 5 sets of all other training materials and supplies shall be provided. A training day is defined as 8 hours of classroom instruction, including two 15 minute breaks and excluding lunchtime, Monday through Friday, during the daytime shift in effect at the training facility.

#### 3.5.2 Training Course Content

For guidance in planning the required instruction, the Contractor shall assume that attendees will have a high school education or equivalent, and are familiar with HVAC systems. The training course shall cover all of the material contained in the Operating and Maintenance Instructions, the layout and location of each HVAC control panel, the layout of one of each type of unitary equipment and the locations of each, the location of each control device external to the panels, the location of the compressed air station, preventive maintenance, troubleshooting, diagnostics, calibration, adjustment, commissioning, tuning, and repair procedures. Typical systems and similar systems may be treated as a group, with instruction on the physical layout of one such system. The results of the performance verification test and the calibration, adjustment and commissioning report shall be presented as benchmarks of HVAC control system performance by which to measure operation and maintenance effectiveness.

-- End of Section --