

AMENDMENT OF SOLICITATION/MODIFICATION OF CONTRACT

1. CONTRACT ID CODE _____ PAGE _____ OF _____ PAGES

2. AMENDMENT/MODIFICATION NO. _____ 3. EFFECTIVE DATE _____ 4. REQUISITION/PURCHASE REQ. NO. _____ 5. PROJECT NO. (If applicable) _____

6. ISSUED BY _____ CODE _____ 7. ADMINISTERED BY (If other than Item 6) _____ CODE _____

8. NAME AND ADDRESS OF CONTRACTOR (No., street, county, State and ZIP Code) _____ (X) 9A. AMENDMENT OF SOLICIATION NO. _____
 9B. DATED (SEE ITEM 11) _____
 10A. MODIFICATION OF CONTRACT/ORDER NO. _____
 10B. DATED (SEE ITEM 11) _____
 CODE _____ FACILITY CODE _____

11. THIS ITEM ONLY APPLIES TO AMENDMENTS OF SOLICITATIONS

The above numbered solicitation is amended as set forth in Item 14. The hour and date specified for receipt of Offers is extended, is not extended. Offers must acknowledge receipt of this amendment prior to the hour and date specified in the solicitation or as amended, by one of the following methods:
 (a) By completing items 8 and 15, and returning _____ copies of the amendment; (b) By acknowledging receipt of this amendment on each copy of the offer submitted; or (c) By separate letter or telegram which includes a reference to the solicitation and amendment numbers. FAILURE OF YOUR ACKNOWLEDGMENT TO BE RECEIVED AT THE PLACE DESIGNATED FOR THE RECEIPT OF OFFERS PRIOR TO THE HOUR AND DATE SPECIFIED MAY RESULT IN REJECTION OF YOUR OFFER. If by virtue of this amendment your desire to change an offer already submitted, such change may be made by telegram or letter, provided each telegram or letter makes reference to the solicitation and this amendment, and is received prior to the opening hour and date specified.

12. ACCOUNTING AND APPROPRIATION DATA (If required) _____

13. THIS ITEM ONLY APPLIES TO MODIFICATION OF CONTRACTS/ORDERS. IT MODIFIES THE CONTRACT/ORDER NO. AS DESCRIBED IN ITEM 14.

CHECK ONE	A. THIS CHANGE ORDER IS ISSUED PURSUANT TO: (Specify authority) THE CHANGES SET FORTH IN ITEM 14 ARE MADE IN THE CONTRACT ORDER NO. IN ITEM 10A.
	B. THE ABOVE NUMBERED CONTRACT/ORDER IS MODIFIED TO REFLECT THE ADMINISTRATIVE CHANGES (such as changes in paying office, appropriation date, etc.) SET FORTH IN ITEM 14, PURSUANT TO THE AUTHORITY OF FAR 43.103(b).
	C. THIS SUPPLEMENTAL AGREEMENT IS ENTERED INTO PURSUANT TO AUTHORITY OF:
	D. OTHER (Specify type of modification and authority)

E. IMPORTANT: Contractor is not, is required to sign this document and return _____ copies to the issuing office.

14. DESCRIPTION OF AMENDMENT/MODIFICATION (Organized by UCF section headings, including solicitation/contract subject matter where feasible.) _____

Except as provided herein, all terms and conditions of the document referenced in Item 9A or 10A, as heretofore changed, remains unchanged and in full force and effect.

15A. NAME AND TITLE OF SIGNER (Type or print) _____	16A. NAME AND TITLE OF CONTRACTING OFFICER (Type or print) _____
15B. CONTRACTOR/OFFEROR _____ (Signature of person authorized to sign)	16B. UNITED STATES OF AMERICA _____ (Signature of Contracting Officer)
15C. DATE SIGNED _____	16C. DATE SIGNED _____

Item 14. Continued.

CHANGES TO PROPOSAL RECEIPT DATE

1. Standard Form 1442, First Page, Item No. 13.A.- In the second line, change the receipt of proposal date from "14 JANUARY 2003" to "22 JANUARY 2003". Receipt of proposal time remains 4 pm local time.

CHANGES TO SPECIFICATIONS

2. New Sections. - Add the following accompanying new section, bearing the notation "ACCOMPANYING AMENDMENT NO. 2 TO SOLICITATION NO. DACA63-03-R-0003:"

15974 BUILDING AUTOMATION & CONTROL SYSTEMS FOR LACKLAND AFB

3. Replacement Sections. - Replace the following sections with the accompanying new sections of the same number and title, bearing the notation "ACCOMPANYING AMENDMENT NO. 2 TO SOLICITATION NO. DACA63-03-R-0003:"

00150 EVALUATION FACTORS FOR AWARD
13930A WET PIPE SPRINKLER SYSTEM, FIRE PROTECTION
15181A CHILLED WATER PIPING AND ACCESSORIES
15400A PLUMBING, GENERAL PURPOSE
15500A DESICCANT COOLING SYSTEMS
15620A LIQUID CHILLERS
15995A COMMISSIONING OF HVAC SYSTEMS

4. New Attachment to Section 08700 - BUILDERS' HARDWARE. - Add the following accompanying new attachment, bearing the notation "AMENDMENT NO. 0002 / DACA63-03-R-0003".

CHANGES TO DRAWINGS

5. Replacement Drawings.- Replace the drawings listed below with the attached new drawings of the same number, bearing the notation "AM #0002":

SN01.cal Seq 101 SN-01 STRUCTURAL NOTES AND DETAILS
SN06.cal Seq 106 SN-06 GRADE BEAM PROFILES
SN07.cal Seq 107 SN-07 GRADE BEAM PROFILES
SN08.cal Seq 108 SN-08 GRADE BEAM PROFILES
SN09.cal Seq 109 SN-09 GRADE BEAM PROFILES
S113.cal Seq 114 S-113 S. WING - FOUNDATION & POST TENSIONING PLANS
S114.cal Seq 115 S-114 S. WING - SECOND FLOOR FRAMING & POST TENSIONING PLANS
S115.cal Seq 116 S-115 S. WING - THIRD FLOOR FRAMING & POST TENSIONING PLANS
S117.cal Seq 118 S-117 E. WING - FOUNDATION & POST TENSIONING PLANS
S118.cal Seq 119 S-118 E. WING - SECOND FLOOR FRAMING & POST TENSIONING PLANS
S119.cal Seq 120 S-119 E. WING - THIRD FLOOR FRAMING & POST TENSIONING PLANS
S121.cal Seq 122 S-121 W. WING - FOUNDATION & POST TENSIONING PLANS
S122.cal Seq 123 S-122 W. WING - SECOND FLOOR FRAMING & POST TENSIONING PLANS
S123.cal Seq 124 S-123 W. WING - THIRD FLOOR FRAMING & POST TENSIONING PLANS
S125.cal Seq 126 S-125 COMMONS - FOUNDATION PLAN

S126.cal Seq 127 S-126 COMMONS - FOUNDATION POST TENSIONING PLAN
S127.cal Seq 128 S-127 COMMONS - SECOND FLOOR FRAMING PLAN
S128.cal Seq 129 S-128 COMMONS - SECOND FLOOR POST TENSIONING PLAN
S129.cal Seq 130 S-129 COMMONS - THIRD FLOOR FRAMING PLAN
S130.cal Seq 131 S-130 COMMONS - THIRD FLOOR POST TENSIONING PLAN
S532.cal Seq 133 S-532 BEAM PROFILES
S533.cal Seq 134 S-533 BEAM PROFILES
S534.cal Seq 135 S-534 BEAM PROFILES
S535.cal Seq 136 S-535 BEAM PROFILES
S536.cal Seq 137 S-536 FOUNDATION DETAILS
S540.cal Seq 141 S-540 PRE-CAST CONCRETE DETAILS
S541.cal Seq 142 S-541 PRE-CAST CONCRETE DETAILS
S542.cal Seq 143 S-542 PRE-CAST CONCRETE DETAILS
S543.cal Seq 144 S-543 PRE-CAST CONCRETE DETAILS
F101.cal Seq 146 F-101 FIRE PROTECTION DETAILS
M001.cal Seq 148 M-001 MECHANICAL SCHEDULES & SYMBOL LEGEND
M002.cal Seq 149 M-002 MECHANICAL SCHEDULES
M105.cal Seq 154 M-105 COMMONS - FIRST FLOOR HVAC PLAN
M106.cal Seq 155 M-106 COMMONS - SECOND FLOOR HVAC PLAN
M107.cal Seq 156 M-107 COMMONS - THIRD FLOOR HVAC PLAN
M108.cal Seq 157 M-108 COMMONS - ATTIC HVAC PLAN
M202.cal Seq 159 M-202 COMMONS - FIRST FLOOR PIPING PLAN
M301.cal Seq 163 M-301 MECHANICAL SECTIONS
M401.cal Seq 164 M-401 ENLARGED PLANS MECHANICAL
M501.cal Seq 165 M-501 MECHANICAL DETAILS
M502.cal Seq 166 M-502 MECHANICAL DETAILS
M601.cal Seq 169 M-601 MECHANICAL PIPING SCHEMATICS
M701.cal Seq 170 M-701 MECHANICAL CONTROLS
M702.cal Seq 171 M-702 MECHANICAL CONTROLS
M703.cal Seq 172 M-703 MECHANICAL CONTROLS
P001.cal Seq 173 P-001 PLUMBING LEGEND-AND GENERAL NOTES
P104.cal Seq 177 P-104 ATTIC PLUMBING PLAN
P105.cal Seq 178 P-105 COMMONS - FIRST FLOOR PLUMBING PLAN
P108.cal Seq 181 P-108 COMMONS - ATTIC PLUMBING PLAN
P402.cal Seq 183 P-402 ENLARGED MECHANICAL ROOM PLANS PLUMBING
P903.cal Seq 187 P-903 PLUMBING SCHEMATICS
E116.cal Seq 203 E-116 COMMONS FIRST FLOOR RECEPTACLE PLAN
E117.cal Seq 204 E-117 COMMONS SECOND FLOOR RECEPTACLE PLAN
E118.cal Seq 205 E-118 COMMONS THIRD FLOOR RECEPTACLE PLAN

END OF AMENDMENT

SECTION 00150 EVALUATION FACTORS FOR AWARD

1.0 BASIS FOR AWARD. The solicitation includes the provision, [FAR 52.0215-0001, CONTRACT AWARD](#). The Government intends to award one (1) contract, based upon initial offers received, without discussion of such offers. Each offer should contain the offeror's best terms. The Government will evaluate price and past performance, which are both equal in importance, and small disadvantaged business utilization that is of less importance to price and past performance. The Government reserves the right to conduct discussions if that is later determined by the Contracting Officer to be necessary. The right is reserved to accept other than the lowest offer and to reject any or all offers. Any award price must be determined to be fair and reasonable.

2.0 PRICE/COST PROPOSAL

2.1 A price analysis will be completed of the offeror's *price/cost* proposal **as submitted on the bidding schedule, Section 00010** to determine price reasonableness. If adequate competition is not obtained, a detailed cost analysis will be used to evaluate for cost realism (allowability, allocability, and reasonableness).

3.0 PAST PERFORMANCE

3.1 For the purpose of evaluating the Contractor Performance Report information submitted hereunder:

3.1.1 Contractor Performance Report data will be evaluated and rated, as it relates to the probability of the offeror successfully accomplishing the proposed effort.

3.1.2 The Government will use the Contractor Performance Report data provided by the offeror (as specified in Section 00120) and data obtained from other sources in addition to these Reports to perform this assessment.

4.0 SMALL DISADVANTAGED BUSINESS UTILIZATION PLANS

4.1 Small Disadvantaged Business (SDB) Utilization Plans applies to all offerors.

4.2 The SDB Utilization Plan will be reviewed based on the following criteria:

- a. The extent to which SDB concerns are specifically identified.
- b. The extent of commitment to use SDB concerns.
- c. The complexity and variety of the work SDB concerns are to perform.
- d. The extent of participation of SDB concerns in terms of the value of the total acquisition.

5.0 SUBCONTRACTING PLAN (applies to Large Businesses only).

The plans will be reviewed for compliance with the requirements of FAR 52.219-9 and scored IAW AFARS 19.7, Appendix DD. If in the event technical and price become more equivalent for two or more large businesses who are being considered for award, the subcontracting plan will then become more significant and may become the determining factor for award.

6.0 EVALUATION OF OPTIONS (JUL 1990)(FAR 52.217-5) Except when it is determined in accordance with FAR 17.206(b) not to be in the Government's best interests, the Government will evaluate offers for award purposes by adding the total price for all options to the total price for the basic requirement. Evaluation of options will not obligate the Government to exercise the option(s).

(END OF SECTION 00150)

SECTION 13930A

WET PIPE SPRINKLER SYSTEM, FIRE PROTECTION

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 135	(2001) Electric-Resistance-Welded Steel Pipe
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 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 563	(2000) Carbon and Alloy Steel Nuts
ASTM A 563M	(2000) Carbon and Alloy Steel Nuts (Metric)
ASTM A 795	(2000) Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Fire Protection Use
ASTM B 62	(1993) Composition Bronze or Ounce Metal Castings
ASTM B 75	(1999) Seamless Copper Tube
ASTM B 75M	(1999) Seamless Copper Tube (Metric)
ASTM B 88	(1999) Seamless Copper Water Tube
ASTM B 88M	(1999) Seamless Copper Water Tube (Metric)
ASTM D 2000	(1999) Rubber Products in Automotive Applications
ASTM F 436	(2000) Hardened Steel Washers

ACCOMPANYING AMENDMENT NO. 2 TO SOLICITATION NO. DACA63-03-R-0003

ASTM F 436M (1993) Hardened Steel Washers (Metric)
ASTM F 442/F 442M (1999) Chlorinated Poly(Vinyl Chloride)
(CPVC) Plastic Pipe (SDR-PR)

AMERICAN SOCIETY OF SANITARY ENGINEERING (ASSE)

ASSE 1015 (1999) Double Check Backflow Prevention
Assembly

AMERICAN WATER WORKS ASSOCIATION(AWWA)

AWWA B300 (1999) Hypochlorites
AWWA B301 (1992; Addenda B301a - 1999) Liquid
Chlorine
AWWA C104 (1995) Cement-Mortar Lining for
Ductile-Iron Pipe and Fittings for Water
AWWA C110 (1998) Ductile-Iron and Gray-Iron Fittings,
3 In. Through 48 In. (75 mm through 1200
mm), for Water and Other Liquids
AWWA C111 (2000) Rubber-Gasket Joints for
Ductile-Iron Pressure Pipe and Fittings
AWWA C151 (1996) Ductile-Iron Pipe, Centrifugally
Cast, for Water or Other Liquids
AWWA C203 (1997; Addenda C203a - 1999) Coal-Tar
Protective Coatings and Linings for Steel
Water Pipelines - Enamel and Tape -
Hot-Applied
AWWA C606 (1997) Grooved and Shouldered Joints
AWWA EWW (1999) Standard Methods for the Examination
of Water and Wastewater
AWWA M20 (1973) Manual: Water Chlorination
Principles and Practices

ASME INTERNATIONAL (ASME)

ASME B16.1 (1998) Cast Iron Pipe Flanges and Flanged
Fittings
ASME B16.11 (1996) Forged Fittings, Socket-Welding and
Threaded
ASME B16.18 (1984; R 1994) Cast Copper Alloy Solder
Joint Pressure Fittings
ASME B16.21 (1992) Nonmetallic Flat Gaskets for Pipe
Flanges
ASME B16.22 (1995; B16.22a1998) Wrought Copper and
Copper Alloy Solder Joint Pressure Fittings

ASME B16.26	(1988) Cast Copper Alloy Fittings for Flared Copper Tubes
ASME B16.3	(1998) Malleable Iron Threaded Fittings
ASME B16.4	(1998) Gray Iron Threaded Fittings
ASME B16.9	(1993) Factory-Made Wrought Steel Buttwelding Fittings
ASME B18.2.1	(1996) Square and Hex Bolts and Screws (Inch Series)
ASME B18.2.2	(1987; R 1993) Square and Hex Nuts (Inch Series)

FACTORY MUTUAL ENGINEERING AND RESEARCH (FM)

FM P7825a	(1998) Approval Guide Fire Protection
FM P7825b	(1998) Approval Guide Electrical Equipment

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

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

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 101	(2000) Life Safety Code
NFPA 13	(1999) Installation of Sprinkler Systems
NFPA 13D	(1996) One- and Two-Family Dwellings and Manufactured Homes Sprinkler Systems
NFPA 13R	(1999) Installation of Sprinkler Systems in Residential Occupancies Up to and Including Four Stories in Height
NFPA 1963	(1998) Fire Hose Connections
NFPA 230	(1999) Fire Protection of Storage
NFPA 24	(1995) Installation of Private Fire Service Mains and Their Appurtenances

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 668	(1995; Rev thru Dec 1998) Hose Valves for Fire Protection Service
UL Bld Mat Dir	(1999) Building Materials Directory
UL Fire Prot Dir	(1999) Fire Protection Equipment Directory

1.2 GENERAL REQUIREMENTS

Wet pipe sprinkler system shall be provided in all areas of the building . The sprinkler system shall provide fire sprinkler protection for the entire area. Except as modified herein, the system shall be designed and installed in accordance with NFPA 13 and NFPA 13R. Pipe sizes which are not indicated on drawings shall be determined by hydraulic calculation. The Contractor shall design any portions of the sprinkler system that are not indicated on the drawings including locating sprinklers, piping and equipment, and size piping and equipment when this information is not indicated on the drawings or is not specified herein. The design of the sprinkler system shall be based on hydraulic calculations, and the other provisions specified herein.

1.2.1 Hydraulic Design

The system shall be hydraulically designed to discharge a minimum density as specified on the drawings over the hydraulically most demanding 280 square meters of floor area. The minimum pipe size for branch lines in gridded systems shall be 32 mm . Hydraulic calculations shall be in accordance with the Area/Density Method of NFPA 13. Water velocity in the piping shall not exceed 6 m/s .

1.2.1.1 Hose Demand

An allowance for exterior hose streams of 950 L/min shall be added to the sprinkler system demand at the point of connection to the existing system.

1.2.1.2 Basis for Calculations

The design of the system shall be based upon a water supply with a static pressure of 434 kPa, and a flow of 116 C/sec at a residual pressure of 400 kPa. Water supply shall be presumed available at the point of connection to existing . Hydraulic calculations shall be based upon the Hazen-Williams formula with a "C" value of 120 for steel piping, 150 for copper tubing, 140 for new cement-lined ductile-iron piping, and 100 for existing underground piping.

1.2.2 Sprinkler Coverage

Sprinklers shall be uniformly spaced on branch lines. In buildings protected by automatic sprinklers, sprinklers shall provide coverage throughout 100 percent of the building. This includes, but is not limited to, telephone rooms, electrical equipment rooms, boiler rooms, switchgear rooms, transformer rooms, and other electrical and mechanical spaces. Coverage per sprinkler shall be in accordance with NFPA 13; as specified in NFPA 13 for extra hazard occupancy but not to exceed 21 square m for light hazard or 12 square m for ordinary hazard occupancies. Exceptions are as follows:

- 1) Facilities that are designed in accordance with NFPA 13R and NFPA 13D.

2) Sprinklers may be omitted from small rooms which are exempted for specific occupancies in accordance with NFPA 101.

1.3 COORDINATION OF TRADES

Piping offsets, fittings, and any other accessories required shall be furnished as required to provide a complete installation and to eliminate interference with other construction. Sprinkler shall be installed over and under ducts, piping and platforms when such equipment can negatively effect or disrupt the sprinkler discharge pattern and coverage.

1.4 DELIVERY AND STORAGE

All equipment delivered and placed in storage shall be housed in a manner to preclude any damage from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Additionally, all pipes shall either be capped or plugged until installed.

1.5 FIELD MEASUREMENTS

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

1.6 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

Sprinkler System Shop Drawings; G .

Three copies of the Sprinkler System Shop Drawings, no later than 21 days prior to the start of sprinkler system installation. The Sprinkler System Shop Drawings shall conform to the requirements established for working plans as prescribed in NFPA 13. Drawings shall include plan and elevation views demonstrating that the equipment will fit the allotted spaces with clearance for installation and maintenance. Each set of drawings shall include the following:

a. Descriptive index of drawings in the submittal with drawings listed in sequence by drawing number. A legend identifying device symbols, nomenclature, and conventions used.

b. Floor plans drawn to a scale not less than 1:100 which clearly show locations of sprinklers, risers, pipe hangers, seismic separation assemblies, sway bracing, inspector's test connections, drains, and other applicable details necessary to clearly describe the proposed arrangement. Each type of fitting used and the locations of bushings, reducing couplings, and welded joints shall be indicated.

c. Actual center-to-center dimensions between sprinklers on

branch lines and between branch lines; from end sprinklers to adjacent walls; from walls to branch lines; from sprinkler feed mains, cross-mains and branch lines to finished floor and roof or ceiling. A detail shall show the dimension from the sprinkler and sprinkler deflector to the ceiling in finished areas.

d. Longitudinal and transverse building sections showing typical branch line and cross-main pipe routing as well as elevation of each typical sprinkler above finished floor.

e. Details of each type of riser assembly; pipe hanger; sway bracing for earthquake protection, and restraint of underground water main at point-of-entry into the building, and electrical devices and interconnecting wiring.

As-Built Shop Drawings; .

As-built shop drawings, at least 14 days after completion of the Final Tests. The Sprinkler System Drawings shall be updated to reflect as-built conditions after all related work is completed and shall be on reproducible full-size mylar film.

SD-03 Product Data

Fire Protection Related Submittals; .

A list of the Fire Protection Related Submittals, no later than 7 days after the approval of the Fire Protection Specialist.

Load Calculations for Sizing Sway Bracing; G .

For systems that are required to be protected against damage from earthquakes, load calculations shall be provided for sizing of sway bracing.

Components and Equipment Data; G.

Manufacturer's catalog data included with the Sprinkler System Drawings for all items specified herein. The data shall be highlighted to show model, size, options, etc., that are intended for consideration. Data shall be adequate to demonstrate compliance with all contract requirements. In addition, a complete equipment list that includes equipment description, model number and quantity shall be provided.

Hydraulic Calculations; G .

Hydraulic calculations, including a drawing showing hydraulic reference points and pipe segments.

Spare Parts; .

Spare parts data shall be included 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.

Preliminary Tests Procedures; G.

Proposed procedures for Preliminary Tests, no later than 14 days prior to the proposed start of the tests.

Final Acceptance Test Procedures; G .

Proposed procedures for Final Acceptance Test, no later than 14 days prior to the proposed start of the tests.

On-site Training Schedule; G .

Proposed On-site Training schedule, at least 14 days prior to the start of related training.

Preliminary Tests; G .

Proposed date and time to begin Preliminary Tests, submitted with the Preliminary Tests Procedures.

Final Acceptance Test; G .

Proposed date and time to begin Final Acceptance Test, submitted with the Final Acceptance Test Procedures. Notification shall be provided at least 14 days prior to the proposed start of the test. Notification shall include a copy of the Contractor's Material & Test Certificates.

Fire Protection Specialist Qualifications; G .

The name and documentation of certification of the proposed Fire Protection Specialists, no later than 14 days after the Notice to Proceed and prior to the submittal of the sprinkler system drawings and hydraulic calculations.

Sprinkler System Installer Qualifications; G .

The name and documentation of certification of the proposed Sprinkler System Installer, concurrent with submittal of the Fire Protection Specialist Qualifications.

SD-06 Test Reports

Preliminary Tests Report; G .

Three copies of the completed Preliminary Tests Reports, no later than 7 days after the completion of the Preliminary Tests. The Preliminary Tests Report shall include both the Contractor's Material and Test Certificate for Underground Piping and the Contractor's Material and Test Certificate for Aboveground Piping. All items in the Preliminary Tests Report shall be signed by the Fire Protection Specialist.

Final Acceptance Test Report; G .

Three copies of the completed Final Acceptance Tests Reports, no later than 7 days after the completion of the Final Acceptance

Tests. All items in the Final Acceptance Report shall be signed by the Fire Protection Specialist.

SD-07 Certificates

Fire Protection Specialist Inspection; G .

Concurrent with the Final Acceptance Test Report, certification by the Fire Protection Specialist that the sprinkler system is installed in accordance with the contract requirements, including signed approval of the Preliminary and Final Acceptance Test Reports.

SD-10 Operation and Maintenance Data

Wet Pipe Sprinkler System; .

Six manuals listing step-by-step procedures required for system startup, operation, shutdown, and routine maintenance, at least 14 days 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.

1.7 HYDRAULIC CALCULATIONS

Hydraulic calculations shall be as outlined in NFPA 13 except that calculations shall be performed by computer using software intended specifically for fire protection system design using the design data shown on the drawings. Software that uses k-factors for typical branch lines is not acceptable. Calculations shall be based on the water supply data shown on the drawings. Calculations shall substantiate that the design area used in the calculations is the most demanding hydraulically. Water supply curves and system requirements shall be plotted on semi-logarithmic graph paper so as to present a summary of the complete hydraulic calculation. A summary sheet listing sprinklers in the design area and their respective hydraulic reference points, elevations, actual discharge pressures and actual flows shall be provided. Elevations of hydraulic reference points (nodes) shall be indicated. Documentation shall identify each pipe individually and the nodes connected thereto. The diameter, length, flow, velocity, friction loss, number and type fittings, total friction loss in the pipe, equivalent pipe length and Hazen-Williams coefficient shall be indicated for each pipe. For gridded systems, calculations shall show peaking of demand area friction loss to verify that the hydraulically most demanding area is being used. Also for gridded systems, a flow diagram indicating the quantity and direction of flows shall be included. A drawing showing hydraulic reference points (nodes) and pipe designations used in the calculations shall be included and shall be independent of shop drawings.

1.8 FIRE PROTECTION SPECIALIST

Work specified in this section shall be performed under the supervision of and certified by the Fire Protection Specialist. The Fire Protection Specialist shall be an individual who is a registered professional engineer and a Full Member of the Society of Fire Protection Engineers or who is

certified as a Level III 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. The Fire Protection Specialist shall be regularly engaged in the design and installation of the type and complexity of system specified in the Contract documents, and shall have served in a similar capacity for at least three systems that have performed in the manner intended for a period of not less than 6 months.

1.9 SPRINKLER SYSTEM INSTALLER QUALIFICATIONS

Work specified in this section shall be performed by the Sprinkler System Installer. The Sprinkler System Installer shall be regularly engaged in the installation of the type and complexity of system specified in the Contract documents, and shall have served in a similar capacity for at least three systems that have performed in the manner intended for a period of not less than 6 months.

1.10 REGULATORY REQUIREMENTS

Compliance with referenced NFPA standards is mandatory. This includes advisory provisions listed in the appendices of such standards, as though the word "shall" had been substituted for the word "should" wherever it appears. In the event of a conflict between specific provisions of this specification and applicable NFPA standards, 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 NAMEPLATES

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

2.3 REQUIREMENTS FOR FIRE PROTECTION SERVICE

Materials and Equipment shall have been tested by Underwriters Laboratories, Inc. and listed in UL Fire Prot Dir or approved by Factory Mutual and listed in FM P7825a and FM P7825b. Where the terms "listed" or "approved" appear in this specification, such shall mean listed in UL Fire Prot Dir or FM P7825a and FM P7825b

2.4 UNDERGROUND PIPING COMPONENTS

2.4.1 Pipe

Piping from a point 150 mm above the floor to a point 1500 mm outside the building wall shall be ductile iron with a rated working pressure of 1034 kPa conforming to AWWA C151, with cement mortar lining conforming to AWWA C104. Piping more than 1500 mm outside the building walls shall comply with Section 02510A WATER DISTRIBUTION SYSTEM.

2.4.2 Fittings and Gaskets

Fittings shall be ductile iron conforming to AWWA C110. Gaskets shall be suitable in design and size for the pipe with which such gaskets are to be used. Gaskets for ductile iron pipe joints shall conform to AWWA C111.

2.4.3 Gate Valve and Indicator Posts

Gate valves for underground installation shall be of the inside screw type with counter-clockwise rotation to open. Where indicating type valves are shown or required, indicating valves shall be gate valves with an approved indicator post of a length to permit the top of the post to be located 900 mm above finished grade. Gate valves and indicator posts shall be listed in UL Fire Prot Dir or FM P7825a and FM P7825b.

2.5 ABOVEGROUND PIPING COMPONENTS

Aboveground piping shall be steel , copper, or plastic.

2.5.1 Steel Piping Components

2.5.1.1 Steel Pipe

Except as modified herein, steel pipe shall be black as permitted by NFPA 13 and shall conform to applicable provisions of ASTM A 795, ASTM A 53/A 53M, or ASTM A 135. Pipe in which threads or grooves are cut shall be Schedule 40 or shall be listed by Underwriters' Laboratories to have a corrosion resistance ratio (CRR) of 1.0 or greater after threads or grooves are cut. Pipe shall be marked with the name of the manufacturer, kind of pipe, and ASTM designation.

2.5.1.2 Fittings for Non-Grooved Steel Pipe

Fittings shall be cast iron conforming to ASME B16.4, steel conforming to ASME B16.9 or ASME B16.11, or malleable iron conforming to ASME B16.3. Galvanized fittings shall be used for piping systems or portions of piping systems utilizing galvanized piping. Fittings into which sprinklers, drop nipples or riser nipples (sprigs) are screwed shall be threaded type. Plain-end fittings with mechanical couplings, fittings that use steel gripping devices to bite into the pipe and segmented welded fittings shall not be used.

2.5.1.3 Grooved Mechanical Joints and Fittings

Joints and fittings shall be designed for not less than 1200 kPa service and shall be the product of the same manufacturer; segmented welded fittings shall not be used. Fitting and coupling houses shall be malleable iron conforming to ASTM A 47/A 47M, Grade 32510; ductile iron conforming to ASTM A 536, Grade 65-45-12. Gasket shall be the flush type that fills the entire cavity between the fitting and the pipe. Nuts and bolts shall be heat-treated steel conforming to ASTM A 183 and shall be cadmium plated or zinc electroplated.

2.5.1.4 Flanges

Flanges shall conform to NFPA 13 and ASME B16.1. Gaskets shall be non-asbestos compressed material in accordance with ASME B16.21, 1.6 mm thick, and full face or self-centering flat ring type.

2.5.1.5 Bolts, Nut, and Washers

Nuts shall be hexagon type conforming to ASME B18.2.2 . Washers shall meet the requirements of ASTM F 436M . Flat circular washers shall be provided under all bolt heads and nuts.

2.5.2 Copper Tube Components

2.5.2.1 Copper Tube

Copper tube shall conform to ASTM B 88M , Types L and M.

2.5.2.2 Copper Fittings and Joints

Cast copper alloy solder-joint pressure fittings shall conform to ASME B16.18 and wrought copper and bronze solder-joint pressure fittings shall conform to ASME B16.22 and ASTM B 75M . Cast copper alloy fittings for flared copper tube shall conform to ASME B16.26 and ASTM B 62. Brass or bronze adapters for brazed tubing 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. Grooved mechanical joints and fittings shall be designed for not less than 862 kPa service and shall be the product of the same manufacturer. Grooved fitting and mechanical coupling housing shall be ductile iron conforming to ASTM A 536. Gaskets for use in grooved joints shall be molded synthetic polymer of pressure responsive design and shall conform to ASTM D 2000 for circulating medium up to 110 degrees C . Grooved joints shall conform to AWWA C606. Coupling nuts and bolts for use in grooved joints shall be steel and shall conform to ASTM A 183.

2.5.3 Plastic Piping Components

2.5.3.1 Plastic Pipe

Plastic pipe shall be chlorinated polyvinyl chloride (CPVC) conforming to ASTM F 442/F 442M, 1207 kPa rating and listed in UL Fire Prot Dir for use in wet pipe sprinkler systems.

2.5.3.2 Plastic Fittings

Plastic fitting shall be chlorinated polyvinyl chloride (CPVC) as listed in UL Fire Prot Dir for use in wet pipe sprinkler systems.

2.5.4 Pipe Hangers

Hangers shall be listed in UL Fire Prot Dir or FM P7825a and FM P7825b and of the type suitable for the application, construction, and pipe type and sized to be supported.

2.5.5 Valves

2.5.5.1 Control Valve and Gate Valve

Manually operated sprinkler control valve and gate valve shall be outside stem and yoke (OS&Y) type and shall be listed in UL Bld Mat Dir or FM P7825a and FM P7825b.

2.5.5.2 Check Valve

Check valve 50 mm and larger shall be listed in UL Bld Mat Dir or FM P7825a and FM P7825b. Check valves 100 mm and larger shall be of the swing type with flanged cast iron body and flanged inspection plate, shall have a clear waterway and shall meet the requirements of MSS SP-71, for Type 3 or 4.

2.5.5.3 Hose Valve

Valve shall comply with UL 668 and shall have a minimum rating of 2070 kPa . Valve shall be non-rising stem, all bronze, 90 degree angle type, with 65 mm American National Standard Fire Hose Screw Thread (NH) male outlet in accordance with NFPA 1963. Hose valve shall be provided with 65 to 40 mm reducer. Hose valves shall be equipped with lugged cap with drip drain, cap gasket and chain. Valve finish shall be rough chrome plated .

2.6 ALARM CHECK VALVE ASSEMBLY

Assembly shall include an alarm check valve, standard trim piping, pressure gauges, bypass, retarding chamber, testing valves, main drain, and other components as required for a fully operational system.

2.7 WATERFLOW ALARM

Electrically operated, exterior-mounted, waterflow alarm bell shall be provided and installed in accordance with NFPA 13. Waterflow alarm bell shall be rated 24 VDC and shall be connected to the Fire Alarm Control Panel(FACP) in accordance with Section [AM002] ~~13850A FIRE DETECTION AND ALARM SYSTEM, DIRECT CURRENT LOOP~~ 13851A FIRE DETECTION AND ALARM SYSTEM, ADDRESSABLE

2.8 ALARM INITIATING AND SUPERVISORY DEVICES

2.8.1 Sprinkler Waterflow Indicator Switch, Vane Type

Switch shall be vane type with a pipe saddle and cast aluminum housing. The electro-mechanical device shall include a flexible, low-density polyethylene paddle conforming to the inside diameter of the fire protection pipe. The device shall sense water movements and be capable of detecting a sustained flow of 38 L/min or greater. The device shall contain a retard device adjustable from 0 to 90 seconds to reduce the possibility of false alarms caused by transient flow surges. The switch shall be tamper resistant and contain two SPDT (Form C) contacts arranged to transfer upon removal of the housing cover, and shall be equipped with a silicone rubber gasket to assure positive water seal and a dustproof cover and gasket to seal the mechanism from dirt and moisture.

2.8.2 Sprinkler Pressure (Waterflow) Alarm Switch

Pressure switch shall include a metal housing with a neoprene diaphragm, SPDT snap action switches and a 15 mm NPT male pipe thread. The switch shall have a maximum service pressure rating of 1207 kPa . There shall be two SPDT (Form C) contacts factory adjusted to operate at 28 to 55 kPa . The switch shall be capable of being mounted in any position in the alarm line trim piping of the alarm check valve.

2.8.3 Valve Supervisory (Tamper) Switch

Switch shall be suitable for mounting to the type of control valve to be

supervised open. The switch shall be tamper resistant and contain one set of SPDT (Form C) contacts arranged to transfer upon removal of the housing cover or closure of the valve of more than two rotations of the valve stem.

2.9 FIRE DEPARTMENT CONNECTION

Fire department connection shall be projecting type with cast brass body, matching wall escutcheon lettered "Auto Spkr" with a polished brass finish.

The connection shall have two inlets with individual self-closing clappers, caps with drip drains and chains. Female inlets shall have 65 mm diameter American National Fire Hose Connection Screw Threads (NH) per NFPA 1963 .

2.10 SPRINKLERS

Sprinklers with internal O-rings shall not be used. Sprinklers shall be used in accordance with their listed coverage limitations. Temperature classification shall be ordinary . Sprinklers in high heat areas including attic spaces or in close proximity to unit heaters shall have temperature classification in accordance with NFPA 13. Extended coverage sprinklers shall not be used.

2.10.1 Concealed Sprinkler

Concealed sprinkler shall be white polyester and shall have a nominal 12.7 mm or 13.5 mm orifice.

2.10.2 Recessed Sprinkler

Upright sprinkler shall be chrome-plated and shall have a nominal 12.7 mm or 13.5 mm orifice.

2.10.3 Flush Sprinkler

Flush sprinkler shall be chrome-plated and shall have a nominal 12.7 mm or 13.5 mm orifice.

2.10.4 Pendent Sprinkler

Pendent sprinkler shall be of the fusible strut or glass bulb type, recessed type with nominal 12.7 mm orifice. Pendent sprinklers shall have a polished chrome finish.

2.10.5 Upright Sprinkler

Upright sprinkler shall be brass and shall have a nominal 12.7 mm or 13.5 mm orifice.

2.10.6 Sidewall Sprinkler

Sidewall sprinkler shall have a nominal 12.7 mm orifice. Sidewall sprinkler shall have a polished chrome finish. Sidewall sprinkler shall be the quick-response type.

2.10.7 Residential Sprinkler

Residential sprinkler shall be the pendent and sidewall type with nominal 12.7 mm orifice. Residential sprinkler shall have a polished chrome finish.

2.11 DISINFECTING MATERIALS

2.11.1 Liquid Chlorine

Liquid chlorine shall conform to AWWA B301.

2.11.2 Hypochlorites

Calcium hypochlorite and sodium hypochlorite shall conform to AWWA B300.

2.12 ACCESSORIES

2.12.1 Sprinkler Cabinet

Spare sprinklers shall be provided in accordance with NFPA 13 and shall be packed in a suitable metal or plastic cabinet. Spare sprinklers shall be representative of, and in proportion to, the number of each type and temperature rating of the sprinklers installed. At least one wrench of each type required shall be provided.

2.12.2 Pendent Sprinkler Escutcheon

Escutcheon shall be one-piece metallic type with a depth of less than 20 mm and suitable for installation on pendent sprinklers. The escutcheon shall have a factory finish that matches the pendent sprinkler heads.

2.12.3 Pipe Escutcheon

Escutcheon shall be polished chromium-plated zinc alloy, or polished chromium-plated copper alloy. Escutcheons shall be either one-piece or split-pattern, held in place by internal spring tension or set screw.

2.12.4 Sprinkler Guard

Guard shall be a steel wire cage designed to encase the sprinkler and protect it from mechanical damage. Guards shall be provided on sprinklers located in equipment rooms with upright heads.

2.12.5 Identification Sign

Valve identification sign shall be minimum 150 mm wide x 50 mm high with enamel baked finish on minimum 1.214 mm steel or 0.6 mm aluminum with red letters on a white background or white letters on red background. Wording of sign shall include, but not be limited to "main drain," "auxiliary drain," "inspector's test," "alarm test," "alarm line," and similar wording as required to identify operational components.

2.13 DOUBLE-CHECK VALVE BACKFLOW PREVENTION ASSEMBLY

Double-check backflow prevention assembly shall comply with ASSE 1015. The assembly shall have a bronze, cast-iron or stainless steel body with flanged ends. The assembly shall include pressure gauge test ports and OS&Y shutoff valves on the inlet and outlet, 2-positive-seating check valve for continuous pressure application, and four test cocks. Assemblies shall be rated for working pressure of 1034 kPa. The maximum pressure loss shall be 40 kPa at a flow rate equal to the sprinkler water demand, at the location of the assembly. A test port for a pressure gauge shall be provided both upstream and downstream of the double check backflow

prevention assembly valves.

PART 3 EXECUTION

3.1 FIRE PROTECTION RELATED SUBMITTALS

The Fire Protection Specialist shall prepare a list of the submittals from the Contract Submittal Register that relate to the successful installation of the sprinkler systems(s). The submittals identified on this list shall be accompanied by a letter of approval signed and dated by the Fire Protection Specialist when submitted to the Government.

3.2 INSTALLATION REQUIREMENTS

The installation shall be in accordance with the applicable provisions of NFPA 13, NFPA 24 and publications referenced therein. Installation of in-rack sprinklers shall comply with applicable provisions of NFPA 230.

3.3 INSPECTION BY FIRE PROTECTION SPECIALIST

The Fire Protection Specialist shall inspect the sprinkler system periodically during the installation to assure that the sprinkler system is being provided and installed in accordance with the contract requirements. The Fire Protection Specialist shall witness the preliminary and final tests, and shall sign the test results. The Fire Protection Specialist, after completion of the system inspections and a successful final test, shall certify in writing that the system has been installed in accordance with the contract requirements. Any discrepancy shall be brought to the attention of the Contracting Officer in writing, no later than three working days after the discrepancy is discovered.

3.4 ABOVEGROUND PIPING INSTALLATION

3.4.1 Protection of Piping Against Earthquake Damage

The system piping shall be protected against damage from earthquakes. Seismic protection shall include flexible and rigid couplings, sway bracing, seismic separation assemblies where piping crosses building seismic separation joints, and other features as required by NFPA 13 for protection of piping against damage from earthquakes.

3.4.2 Piping in Exposed Areas

Exposed piping shall be installed so as not to diminish exit access widths, corridors or equipment access. Exposed horizontal piping, including drain piping, shall be installed to provide maximum headroom.

3.4.3 Piping in Finished Areas

In areas with suspended or dropped ceilings and in areas with concealed spaces above the ceiling, piping shall be concealed above ceilings. Piping shall be inspected, tested and approved before being concealed. Risers and similar vertical runs of piping in finished areas shall be concealed.

3.4.4 Pendent Sprinklers

Drop nipples to pendent sprinklers shall consist of minimum 25 mm pipe with a reducing coupling into which the sprinkler shall be threaded. Hangers shall be provided on arm-overs to drop nipples supplying pendent

sprinklers when the arm-over exceeds 300 mm . Where sprinklers are installed below suspended or dropped ceilings, drop nipples shall be cut such that sprinkler ceiling plates or escutcheons are of a uniform depth throughout the finished space. The outlet of the reducing coupling shall not extend more than 25 mm below the underside of the ceiling. On pendent sprinklers installed below suspended or dropped ceilings, the distance from the sprinkler deflector to the underside of the ceiling shall not exceed 100 mm . Recessed pendent sprinklers shall be installed such that the distance from the sprinkler deflector to the underside of the ceiling shall not exceed the manufacturer's listed range and shall be of uniform depth throughout the finished area.

3.4.4.1 Pendent Sprinkler Locations

Pendent sprinklers in suspended ceilings shall be a minimum of 150 mm from ceiling grid.

3.4.5 Upright Sprinklers

Riser nipples or "sprigs" to upright sprinklers shall contain no fittings between the branch line tee and the reducing coupling at the sprinkler. Riser nipples exceeding 750 mm in length shall be individually supported.

3.4.6 Pipe Joints

Pipe joints shall conform to NFPA 13, except as modified herein. Not more than four threads shall show after joint is made up. Welded joints will be permitted, only if welding operations are performed as required by NFPA 13 at the Contractor's fabrication shop, not at the project construction site.

Flanged joints 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 specification according to pipe material, wall thickness and size. Grooved couplings, fittings and grooving tools shall be products of the same manufacturer. For copper tubing, pipe and groove dimensions shall comply with the tolerances specified by the coupling manufacturer. The diameter of grooves made in the field shall be measured using a "go/no-go" gauge, vernier or dial caliper, narrow-land micrometer, or other method specifically approved by the coupling manufacturer for the intended application. Groove width and dimension of groove from end of pipe shall be measured and recorded for each change in grooving tool setup to verify compliance with coupling manufacturer's tolerances. 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.

3.4.7 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 15 mm (.

3.4.8 Pipe Penetrations

Cutting structural members for passage of pipes or for pipe-hanger

fastenings will not be permitted. Pipes that must penetrate concrete or masonry walls or concrete floors shall be core-drilled and provided with pipe sleeves. Each sleeve shall be Schedule 40 galvanized steel, ductile iron or cast iron pipe and shall extend through its respective wall or floor and be cut flush with each wall surface. Sleeves shall provide required clearance between the pipe and the sleeve per NFPA 13. The space between the sleeve and the pipe shall be firmly packed with mineral wool insulation. Where pipes penetrate fire walls, fire partitions, or floors, pipes shall be fire stopped in accordance with Section 07840A FIRESTOPPING.

In penetrations that are not fire-rated or not a floor penetration, the space between the sleeve and the pipe shall be sealed at both ends with plastic waterproof cement that will dry to a firm but pliable mass or with a mechanically adjustable segmented elastomer seal.

3.4.9 Escutcheons

Escutcheons shall be provided for pipe penetration of ceilings and walls. Escutcheons shall be securely fastened to the pipe at surfaces through which piping passes.

3.4.10 Inspector's Test Connection

Unless otherwise indicated, test connection shall consist of 25 mm pipe connected to the remote branch line ; a test valve located approximately 2 meters above the floor; a smooth bore brass outlet equivalent to the smallest orifice sprinkler used in the system; and a painted metal identification sign affixed to the valve with the words "Inspector's Test."

The discharge orifice shall be located outside the building wall directed so as not to cause damage to adjacent construction or landscaping during full flow discharge.

3.4.11 Drains

Main drain piping shall be provided to discharge at a safe point outside the building . Auxiliary drains shall be provided as indicated and as required by NFPA 13. When the capacity of trapped sections of pipe is less than 11 liters, the auxiliary drain shall consist of a valve not smaller than 15 mm and a plug or nipple and cap. When the capacity of trapped sections of piping is more than 11 liters, the auxiliary drain shall consist of two 25 mm valves and one 50 x 300 mm condensate nipple or equivalent, located in an accessible location. Tie-in drains shall be provided for multiple adjacent trapped branch pipes and shall be a minimum of 25 mm in diameter. Tie-in drain lines shall be pitched a minimum of 15 mm per 3 mm .

3.4.12 Installation of Fire Department Connection

Connection shall be mounted exterior to the building as indicated. The piping between the connection and the check valve shall be provided with an automatic drip in accordance with NFPA 13 and arranged to drain to the outside.

3.4.13 Identification Signs

Signs shall be affixed to each control valve, inspector test valve, main drain, auxiliary drain, test valve, and similar valves as appropriate or as required by NFPA 13. Hydraulic design data nameplates shall be permanently affixed to each sprinkler riser as specified in NFPA 13.

3.5 UNDERGROUND PIPING INSTALLATION

The fire protection water main shall be laid, and joints anchored, in accordance with NFPA 24. Minimum depth of cover shall be 900 mm. The supply line shall terminate inside the building with a flanged piece, the bottom of which shall be set not less than 150 mm above the finished floor. A blind flange shall be installed temporarily on top of the flanged piece to prevent the entrance of foreign matter into the supply line. A concrete thrust block shall be provided at the elbow where the pipe turns up toward the floor. In addition, joints shall be anchored in accordance with NFPA 24 using pipe clamps and steel rods from the elbow to the flange above the floor and from the elbow to a pipe clamp in the horizontal run of pipe. Buried steel components shall be provided with a corrosion protective coating in accordance with AWWA C203. Piping more than 1500 mm outside the building walls shall meet the requirements of Section 02510A WATER DISTRIBUTION SYSTEM.

3.6 EARTHWORK

Earthwork shall be performed in accordance with applicable provisions of Section 02315A EXCAVATION, FILLING AND BACKFILLING FOR BUILDINGS.

3.7 ELECTRICAL WORK

Except as modified herein, electric equipment and wiring shall be in accordance with Section 16415A ELECTRICAL WORK, INTERIOR. Alarm signal wiring connected to the building fire alarm control system shall be in accordance with Section 13851A FIRE DETECTION AND ALARM SYSTEM, ADDRESSABLE. All wiring for supervisory and alarm circuits shall be #14 AWG solid copper installed in metallic tubing or conduit. Wiring color code shall remain uniform throughout the system.

3.8 DISINFECTION

After all system components are installed and hydrostatic test(s) are successfully completed, each portion of the sprinkler system to be disinfected shall be thoroughly flushed with potable water until all entrained dirt and other foreign materials have been removed before introducing chlorinating material. Flushing shall be conducted by removing the flushing fitting of the cross mains and of the grid branch lines, and then back-flushing through the sprinkler main drains. The chlorinating material shall be hypochlorites or liquid chlorine. Water chlorination procedure shall be in accordance with AWWA M20. The chlorinating material shall be fed into the sprinkler piping at a constant rate of 50 parts per million (ppm). A properly adjusted hypochlorite solution injected into the system with a hypochlorinator, or liquid chlorine injected into the system through a solution-fed chlorinator and booster pump shall be used. Chlorination application shall continue until the entire system is filled. The water shall remain in the system for a minimum of 24 hours. Each valve in the system shall be opened and closed several times to ensure its proper disinfection. Following the 24-hour period, no less than 25 ppm chlorine residual shall remain in the system. The system shall then be flushed with clean water until the residual chlorine is reduced to less than one part per million. Samples of water in disinfected containers for bacterial examination will be taken from several system locations which are approved by the Contracting Officer. Samples shall be tested for total coliform organisms (coliform bacteria, fecal coliform, streptococcal, and other bacteria) in accordance with AWWA EWW. The testing method shall be either the multiple-tube fermentation technique or the membrane-filter technique.

The disinfection shall be repeated until tests indicate the absence of coliform organisms (zero mean coliform density per 100 milliliters) in the samples for at least 2 full days. The system will not be accepted until satisfactory bacteriological results have been obtained. After successful completion, verify installation of all sprinklers and plugs and pressure test the system.

3.9 PIPE COLOR CODE MARKING

Color code marking of piping shall be as specified in Section 09900 PAINTS AND COATINGS.

3.10 PRELIMINARY TESTS

The system, including the underground water mains, and the aboveground piping and system components, shall be tested to assure that equipment and components function as intended. The underground and aboveground interior piping systems and attached appurtenances subjected to system working pressure shall be tested in accordance with NFPA 13 and NFPA 24. Upon completion of specified tests, the Contractor shall complete certificates as specified in paragraph SUBMITTALS.

3.10.1 Underground Piping

3.10.1.1 Flushing

Underground piping shall be flushed in accordance with NFPA 24. This includes the requirement to flush the lead-in connection to the fire protection system at a flow rate not less than the calculated maximum water demand rate of the system.

3.10.1.2 Hydrostatic Testing

New underground piping shall be hydrostatically tested in accordance with NFPA 24. The allowable leakage shall be measured at the specified test pressure by pumping from a calibrated container. The amount of leakage at the joints shall not exceed 1.89 liters per hour per 100 gaskets or joints, regardless of pipe diameter.

3.10.2 Aboveground Piping

3.10.2.1 Hydrostatic Testing

Aboveground piping shall be hydrostatically tested in accordance with NFPA 13 at not less than 1400 kPa or 350 kPa in excess of maximum system operating pressure and shall maintain that pressure without loss for 2 hours. There shall be no drop in gauge pressure or visible leakage when the system is subjected to the hydrostatic test. The test pressure shall be read from a gauge located at the low elevation point of the system or portion being tested.

3.10.2.2 Backflow Prevention Assembly Forward Flow Test

Each backflow prevention assembly shall be tested at system flow demand, including all applicable hose streams, as specified in NFPA 13. The Contractor shall provide all equipment and instruments necessary to conduct a complete forward flow test, including 65 mm diameter hoses, playpipe nozzles, calibrated pressure gauges, and pitot tube gauge. The Contractor shall provide all necessary supports to safely secure hoses and nozzles

during the test. At the system demand flow, the pressure readings and pressure drop (friction) across the assembly shall be recorded. A metal placard shall be provided on the backflow prevention assembly that lists the pressure readings both upstream and downstream of the assembly, total pressure drop, and the system test flow rate. The pressure drop shall be compared to the manufacturer's data.

3.10.3 Testing of Alarm Devices

Each alarm switch shall be tested by flowing water through the inspector's test connection. Each water-operated alarm devices shall be tested to verify proper operation.

3.10.4 Main Drain Flow Test

Following flushing of the underground piping, a main drain test shall be made to verify the adequacy of the water supply. Static and residual pressures shall be recorded on the certificate specified in paragraph SUBMITTALS. In addition, a main drain test shall be conducted each time after a main control valve is shut and opened.

3.11 FINAL ACCEPTANCE TEST

Final Acceptance Test shall begin only when the Preliminary Test Report has been approved. The Fire Protection Specialist shall conduct the Final Acceptance Test and shall provide a complete demonstration of the operation of the system. This shall include operation of control valves and flowing of inspector's test connections to verify operation of associated waterflow alarm switches. After operation of control valves has been completed, the main drain test shall be repeated to assure that control valves are in the open position. In addition, the representative shall have available copies of as-built drawings and certificates of tests previously conducted. The installation shall not be considered accepted until identified discrepancies have been corrected and test documentation is properly completed and received.

3.12 ON-SITE TRAINING

The Fire Protection Specialist shall conduct a training course for operating and maintenance personnel as designated by the Contracting Officer. Training shall be provided for a period of 4 hours of normal working time and shall start after the system is functionally complete but prior to the Preliminary Tests and Final Acceptance Test. The On-Site Training shall cover all of the items contained in the approved Operating and Maintenance Instructions.

-- End of Section --

SECTION 15181A

CHILLED WATER PIPING AND ACCESSORIES

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 Z21.22 (1999) Relief Valves and Automatic Gas Shutoff Devices for Hot Water Supply Systems

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 106 (1999e1) Seamless Carbon Steel Pipe for High-Temperature Service

ASTM A 182/A 182M (2001) Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service

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 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 653/A 653M (2000) Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

ASTM A 733 (1999) Welded and Seamless Carbon Steel and Austenitic Stainless Steel Pipe Nipples

ASTM B 117 (1997) Operating Salt Spray (Fog) Apparatus

ASTM B 32 (1996) Solder Metal

ASTM B 62 (1993) Composition Bronze or Ounce Metal Castings

ASTM B 75 (1999) Seamless Copper Tube

ASTM B 75M (1999) Seamless Copper Tube (Metric)

ASTM B 813 (2000) Liquid and Paste Fluxes for Soldering Applications of Copper and Copper Alloy Tube

ASTM B 88 (1999) Seamless Copper Water Tube

ASTM B 88M (1999) Seamless Copper Water Tube (Metric)

ASTM D 1384 (1997a) Corrosion Test for Engine Coolants in Glassware

ASTM D 2000 (1999) Rubber Products in Automotive Applications

ASTM D 3308 (1997) PTFE Resin Skived Tape

ASTM D 520 (2000) Zinc Dust Pigment

ASTM D 596 (1991; R 1995) Reporting Results of Analysis of Water

ASTM E 84 (2000a) Surface Burning Characteristics of Building Materials

ASTM F 1007 (1986; R 1996) Pipe-Line Expansion Joints of the Packed Slip Type for Marine Application

ASTM F 1120 (1987; R 1998) Circular Metallic Bellows Type Expansion Joints for Piping Applications

ASTM F 1199 (1988; R 1998) Cast (All Temperature and Pressures) and Welded Pipe Line Strainers (150 psig and 150 degrees F Maximum)

AMERICAN SOCIETY OF SANITARY ENGINEERING (ASSE)

ASSE 1003 (1995) Water Pressure Reducing Valves for Domestic Water Supply Systems

ASSE 1017 (1986) Temperature Actuated Mixing Valves for Primary Domestic use

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

AWS Brazing Hdbk (1991) Brazing Handbook

AWS D1.1 (2000) Structural Welding Code - Steel

AWS Z49.1 (1999) Safety in Welding and Cutting

ASME INTERNATIONAL (ASME)

ASME B1.20.1	(1983; R 1992) Pipe Threads, General Purpose (Inch)
ASME B16.11	(1996) Forged Fittings, Socket-Welding and Threaded
ASME B16.18	(1984; R 1994) Cast Copper Alloy Solder Joint Pressure Fittings
ASME B16.21	(1992) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.22	(1995; B16.22a1998) Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.26	(1988) Cast Copper Alloy Fittings for Flared Copper Tubes
ASME B16.3	(1998) Malleable Iron Threaded Fittings
ASME B16.39	(1998) Malleable Iron Threaded Pipe Unions Classes 150, 250, and 300
ASME B16.5	(1996; B16.5a) Pipe Flanges and Flanged Fittings NPS 1/2 thru NPS 24
ASME B16.9	(1993) Factory-Made Wrought Steel Buttwelding Fittings
ASME B31.1	(1998) Power Piping
ASME B31.9	(1996) Building Services Piping
ASME B40.1	(1991) Gauges - Pressure Indicating Dial Type - Elastic Element
ASME BPVC SEC IX	(1998) Boiler and Pressure Vessel Code; Section IX, Welding and Brazing Qualifications
ASME BPVC SEC VIII D1	(1998) Boiler and Pressure Vessel Code; Section VIII, Pressure Vessels Division 1 - Basic Coverage

EXPANSION JOINT MANUFACTURERS ASSOCIATION (EJMA)

EJMA Stds	(1998; 7th Edition) EJMA Standards
-----------	------------------------------------

HYDRAULIC INSTITUTE (HI)

HI 1.1-1.5	(1994) Centrifugal Pumps
------------	--------------------------

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-67	(1995) Butterfly Valves
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-78	(1998) Cast Iron Plug Valves, Flanged and Threaded Ends
MSS SP-80	(1997) Bronze Gate, Globe, Angle and Check Valves
MSS SP-85	(1994) Cast Iron Globe & Angle Valves, Flanged and Threaded Ends

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(1997) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA MG 1	(1998) Motors and Generators
NEMA MG 2	(1989) Safety Standard for Construction and Guide for Selection, Installation, and Use of Electric Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 90A	(1999) Installation of Air Conditioning and Ventilating Systems
----------	---

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-50541	(Basic) Valves, Tank Float, Angle and Globe Pattern (Inch-Pound)
---------------	--

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

Piping System

Drawings, at least 5 weeks prior to beginning construction, provided in adequate detail to demonstrate compliance with contract requirements. Drawings shall consist of:

- a. Piping layouts which identify all valves and fittings.
- b. Plans and elevations which identify clearances required for maintenance and operation.

SD-03 Product Data

Piping System

Manufacturer's standard catalog data, at least 5 weeks prior to the purchase or installation of a particular component, highlighted to show material, size, options, performance charts and curves, etc. in adequate detail to demonstrate compliance with contract requirements. Data shall include manufacturer's recommended installation instructions and procedures. Data shall be provided for the following components as a minimum:

- a. Piping and Fittings
- b. Valves and Accessories
- c. Expansion Joints
- d. Pumps
- e. Expansion Tanks
- f. Air Separator Tanks
- g. Pipe Hangers, Inserts, and Supports

Water Treatment Systems

Six complete copies, at least 5 weeks prior to the purchase of the water treatment system, of the proposed water treatment plan including a layout, control scheme, a list of existing make-up water conditions including the items listed in paragraph "Water Analysis", a list of chemicals, the proportion of chemicals to be added, the final treated water conditions, and a description of environmental concerns for handling the chemicals.

Spare Parts

Spare parts data for each different item of equipment specified, after approval of detail drawings and not 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, a recommended spare parts list for 1 year of operation, and a list of the parts recommended by the manufacturer

to be replaced on a routine basis.

Qualifications

Six copies of qualified procedures, and list of names and identification symbols of qualified welders and welding operators, prior to non-factory welding operations.

Field Tests

A schedule, at least 2 weeks prior to the start of related testing, for each test. The schedules shall identify the proposed date, time, and location for each test.

Demonstrations

A schedule, at least 2 weeks prior to the date of the proposed training course, which identifies the date, time, and location for the training.

Verification of Dimensions

A letter, at least 2 weeks prior to beginning construction, including the date the site was visited, conformation of existing conditions, and any discrepancies found.

SD-06 Test Reports

Field Tests

Six copies of the report shall be provided in bound 216 x 279 mm (8 1/2 x 11 inch) booklets. Reports shall document all phases of the tests performed. The report shall include initial test summaries, all repairs/adjustments made, and the final test results.

One-Year Inspection

Six copies of an inspection report, at the completion of one year of service, in bound 216 x 279 (8 1/2 x 11 inch) inch booklets. The report shall identify the condition of each cooling tower and condenser. The report shall also include a comparison of the condition of the cooling tower and condenser with the manufacturer's recommended operating conditions. The report shall identify all actions taken by the Contractor and manufacturer to correct deficiencies during the first year of service.

SD-07 Certificates

Service Organization

A certified list of qualified permanent service organizations, which includes their addresses and qualifications, for support of the equipment. The service organizations shall be reasonably convenient to the equipment installation and be able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

SD-10 Operation and Maintenance Data

Operation Manuals

Six complete copies of an operation manual in bound 216 x 279 (8 1/2 x 11 inch) booklets listing step-by-step procedures required for system startup, operation, abnormal shutdown, emergency shutdown, and normal shutdown at least 4 weeks prior to the first training course. The booklets shall include the manufacturer's name, model number, and parts list. The manuals shall include the manufacturer's name, model number, service manual, and a brief description of all equipment and their basic operating features.

Maintenance Manuals

Six complete copies of maintenance manual in bound 216 x 279 (8 1/2 x 11 inch) booklets listing routine maintenance procedures, possible breakdowns and repairs, and a trouble shooting guide. The manuals shall include piping layouts and simplified wiring and control diagrams of the system as installed.

Water Treatment Systems

Six complete copies of operating and maintenance manuals for the step-by-step water treatment procedures. The manuals shall include testing procedures used in determining water quality.

1.3 QUALIFICATIONS

Piping shall be welded in accordance with the qualified procedures using performance qualified welders and welding operators. Procedures and welders shall be qualified in accordance with ASME BPVC SEC IX. Welding procedures qualified by others, and welders and welding operators qualified by another employer may be accepted as permitted by ASME B31.1. The Contracting Officer shall be notified 24 hours in advance of tests and the tests shall be performed at the work site if practical. The welder or welding operator shall apply the personally assigned symbol near each weld made, as a permanent record. Structural members shall be welded in accordance with Section 05090A WELDING, STRUCTURAL.

1.4 SAFETY REQUIREMENTS

Exposed moving parts, parts that produce high operating temperature, parts which may be electrically energized, and parts that may be a hazard to operating personnel shall be insulated, fully enclosed, guarded, or fitted with other types of safety devices. Safety devices shall be installed so that proper operation of equipment is not impaired. Welding and cutting safety requirements shall be in accordance with AWS Z49.1.

1.5 DELIVERY, STORAGE, AND HANDLING

Stored items shall be protected from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Proper protection and care of all material both before and during installation shall be the Contractor's responsibility. Any materials found to be damaged shall be replaced at the Contractor's expense. During installation, piping and similar openings shall be capped to keep out dirt and other foreign matter.

1.6 PROJECT/SITE CONDITIONS

1.6.1 Verification of Dimensions

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

1.6.2 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 plumbing, fire protection, electrical, structural and finish conditions that would affect the work to be performed and shall arrange such work accordingly, furnishing required offsets, fittings, and accessories to meet such conditions.

PART 2 PRODUCTS

2.1 STANDARD COMMERCIAL PRODUCTS

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 satisfactory commercial or industrial use for 2 years prior to bid opening. The 2 year use shall include applications of equipment and materials under similar circumstances and of similar size. The 2 years experience shall be satisfactorily completed by a product which has been sold or is offered for sale on the commercial market through advertisements, manufacturer's catalogs, or brochures. Products having less than a 2 year field service record shall 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. Products shall be supported by a service organization. System components shall be environmentally suitable for the indicated locations.

2.2 NAMEPLATES

Major equipment including pumps, pump motors, expansion tanks, and air separator tanks shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the item of equipment. Plates shall be durable and legible throughout equipment life and made of stainless steel. Plates shall be fixed in prominent locations with nonferrous screws or bolts.

2.3 ELECTRICAL WORK

Electrical equipment, motors, motor efficiencies, and wiring shall be in accordance with Section 16415A ELECTRICAL WORK, INTERIOR. Electrical motor driven equipment specified shall be provided complete with motors, motor starters, and controls. Electrical characteristics shall be as shown, and unless otherwise indicated, all motors of 746 kW (1 hp) and above with open, dripproof, totally enclosed, or explosion proof fan cooled enclosures, shall be high efficiency type. Field wiring shall be in accordance with manufacturer's instructions. Each motor shall conform to NEMA MG 1 and NEMA MG 2 and be of sufficient size to drive the equipment at the specified capacity without exceeding the nameplate rating of the motor.

Motors shall be continuous duty with the enclosure specified. Motor starters shall be provided complete with thermal overload protection and other appurtenances necessary for the motor control indicated. Motors shall be furnished with a magnetic across-the-line or reduced voltage type starter as required by the manufacturer. Motor duty requirements shall allow for maximum frequency start-stop operation and minimum encountered interval between start and stop. Motors shall be sized for the applicable loads. Motor torque shall be capable of accelerating the connected load within 20 seconds with 80 percent of the rated voltage maintained at motor

terminals during one starting period. Motor bearings shall be fitted with grease supply fittings and grease relief to outside of enclosure. Manual or automatic control and protective or signal devices required for the operation specified and any control wiring required for controls and devices specified, but not shown, shall be provided.

2.4 PIPING SYSTEM

System design, component selection, and system installation, including pressure containing parts and material, shall be based upon a minimum service pressure of 862 kPa at 66 degrees C ; minimum ANSI Class 125. Chilled and condenser water piping shall be steel pipe with the exception that piping 100 mm and smaller may be copper tubing.

2.5 STEEL PIPE

Steel pipe shall conform to ASTM A 53/A 53M, Schedule 40, Type E or S, Grades A or B. Type F pipe shall not be used.

2.5.1 Fittings and End Connections (Joints)

Fittings and end connections shall be as defined herein, except as identified elsewhere. Piping and fittings 25 mm (1 inch) and smaller shall have threaded connections. Piping and fittings larger than 25 mm (1 inch) and smaller than 80 mm (3 inches) shall have either threaded, grooved, or welded connections. Piping and fittings 80 mm (3 inches) and larger shall have grooved, welded, or flanged connections. Rigid grooved mechanical connections may only be used in serviceable aboveground locations where the temperature of the circulating medium does not exceed 110 degrees C . Flexible grooved connections shall be used only as a flexible connector with grooved pipe system. Unless otherwise specified, grooved piping components shall meet the corresponding criteria specified for the similar welded, flanged, or threaded component specified herein. The manufacturer of each fitting shall be permanently identified on the body of the fitting in accordance with MSS SP-25.

2.5.1.1 Threaded Connections

Threaded valves and pipe connections shall conform to ASME B1.20.1. Threaded fitting shall conform to ASME B16.3. Threaded unions shall conform to ASME B16.39. Threaded pipe nipples shall conform to ASTM A 733.

2.5.1.2 Flanged Connections

Flanges shall conform to ASTM A 182/A 182M and ASME B16.5, Class 150. Gaskets shall be nonasbestos compressed material in accordance with ASME B16.21, 1.59 mm (1/16 inch) thickness, full face or self-centering flat ring type. These gaskets shall contain aramid fibers bonded with styrene butadiene rubber (SBR) or nitrile butadiene rubber (NBR). Bolts, nuts, and bolt patterns shall conform to ASME B16.5. Bolts shall be high or intermediate strength material conforming to ASTM A 193/A 193M.

2.5.1.3 Welded Connections

Welded valves and pipe connections (both butt-welds and socket-welds types) shall conform to ASME B31.9. Butt-welded fittings shall conform to ASME B16.9. Socket-welded fittings shall conform to ASME B16.11. Welded fittings shall be identified with the appropriate grade and marking symbol.

2.5.1.4 Grooved Mechanical Connections

Fitting and coupling houses shall be malleable iron conforming to ASTM A 47/A 47M, Grade 32510; ductile iron conforming to ASTM A 536, Grade 65-45-12; or steel conforming ASTM A 106, Grade B or ASTM A 53/A 53M. Gaskets shall be molded synthetic rubber with central cavity, pressure responsive configuration and shall conform to ASTM D 2000 Grade No. 2CA615A15B44F17Z for circulating medium up to 110 degrees C (230 degrees F) or Grade No. M3BA610A15B44Z for circulating medium up to 93 degrees C (200 degrees F) . Grooved mechanical connections shall conform to AWWA C606. Coupling nuts and bolts shall be steel and shall conform to ASTM A 183. Pipe connections and fittings shall be the product of the same manufacturer.

2.5.1.5 Dielectric Waterways and Flanges

Dielectric waterways shall have a water impervious insulation barrier capable of limiting galvanic current to 1 percent of short circuit current in a corresponding bimetallic joint. When dry, insulation barrier shall be able to withstand a 600-volt breakdown test. Dielectric waterways shall be constructed of galvanized steel and have threaded end connections to match connecting piping. Dielectric waterways shall be suitable for the required operating pressures and temperatures. Dielectric flanges shall provide the same pressure ratings as standard flanges and provide complete electrical isolation between connecting pipe and/or equipment as described herein for dielectric waterways.

2.6 COPPER PIPE

Copper pipe shall conform to ASTM B 88M , Type K or L.

2.6.1 Fittings and End Connections (Joints)

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. Cast copper alloy fittings for flared copper tube shall conform to ASME B16.26 and ASTM B 62. Brass or bronze adapters for brazed tubing 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.

2.6.1.1 Grooved Mechanical Connections

Grooved mechanical joints and fittings shall be designed for not less than 862 kPa service and shall be the product of the same manufacturer. Grooved fitting and mechanical coupling housing shall be ductile iron conforming to ASTM A 536. Gaskets for use in grooved joints shall be molded synthetic polymer of pressure responsive design and shall conform to ASTM D 2000 for circulating medium up to 110 degrees C . Grooved joints shall conform to AWWA C606. Coupling nuts and bolts for use in grooved joints shall be steel and shall conform to ASTM A 183. Pipe connections and fittings shall be the product of the same manufacturer.

2.6.2 Solder

Solder shall conform to ASTM B 32, grade Sb5, tin-antimony alloy for service pressures up to 1034 kPa . Solder flux shall be liquid or paste form, non-corrosive and conform to ASTM B 813.

2.6.3 Brazing Filler Metal

Filler metal shall conform to AWS A5.8, Type BAg-5 with AWS Type 3 flux, except Type BCuP-5 or BCuP-6 may be used for brazing copper-to-copper joints.

2.7 VALVES

Valves shall meet the material, fabrication and operating requirements of ASME B31.1. Chain operators shall be provided for valves located 3 m or higher above the floor. Valves in sizes larger than 25 mm (1 inch) and used on steel pipe systems, may be provided with rigid grooved mechanical joint ends. Such grooved end valves shall be subject to the same requirements as rigid grooved mechanical joints and fittings and, shall be provided by the same manufacturer as the grooved pipe joint and fitting system.

2.7.1 Gate Valve

Gate valves 65 mm (2-1/2 inches) and smaller shall conform to MSS SP-80 and shall be bronze with rising stem and threaded, soldered, or flanged ends. Gate valves 80 mm (3 inches) and larger shall conform to MSS SP-70, Type I, II, Class 125, Design OF and shall be cast iron with bronze trim, outside screw and yoke, and flanged or threaded ends.

2.7.2 Globe and Angle Valve

Globe and angle valves 65 mm (2-1/2 inches) and smaller shall conform to MSS SP-80 and shall be bronze with threaded, soldered, or flanged ends. Globe and angle valves 80 mm (3 inches) and larger shall conform to MSS SP-85 and shall be cast iron with bronze trim and flanged or threaded ends.

2.7.3 Check Valve

Check valves 65 mm (2-1/2 inches) and smaller shall conform to MSS SP-80 and shall be bronze with threaded, soldered, or flanged ends. Check valves 80 mm (3 inches) and larger shall conform to MSS SP-71, Type I, II, III, or IV, Class 125 or 150 and shall be cast iron with bronze trim and flanged or threaded ends.

2.7.4 Butterfly Valve

Butterfly valves shall be in accordance with MSS SP-67, Type 1 and shall be either the wafer or lug type. Valves shall be bubble tight at 1,000 kPa. Valve bodies shall be cast iron, malleable iron, or steel. Valves smaller than 200 mm (8 inches) shall have throttling handles with a minimum of seven locking positions. Valves 200 mm (8 inches) 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.

2.7.5 Plug Valve

Plug valves 50 mm (2 inches) and larger shall conform to MSS SP-78, have flanged or threaded ends, and have cast iron bodies with bronze trim. Valves 50 mm (2 inches) and smaller shall be bronze with NPT connections for black steel pipe and brazed connections for copper tubing. Valve shall be lubricated, non-lubricated, or tetrafluoroethylene resin-coated type. Valve shall be resilient, double seated, trunnion mounted with tapered lift

plug capable of 2-way shutoff. Valve shall operate from fully open to fully closed by rotation of the handwheel to lift and turn the plug. Valve shall have weatherproof operators with mechanical position indicators. Valves 200 mm (8 inches) or larger shall be provided with manual gear operators with position indicators.

2.7.6 Ball Valve

Ball valves 15 mm (1/2 inch) and larger shall conform to MSS SP-72 or MSS SP-110 and shall be ductile iron or bronze with threaded, soldered, or flanged ends. Valves 200 mm (8 inches) or larger shall be provided with manual gear operators with position indicators.

2.7.7 Drain Valves

Valves shall be the gate valve type which are in accordance with MSS SP-80. Valve shall be manually-operated, 20 mm pipe size and above with a threaded end connection. Valve shall be provided with a water hose nipple adapter.

2.7.8 Air Vents

Manually-operated general service type air vents shall be brass or bronze valves which are furnished with threaded plugs or caps. Air vents on water coils shall have not less than 3 mm threaded end connections. Air vents on water mains shall have not less than 20 mm threaded end connections. Air vents on all other applications shall have not less than 15 mm threaded end connections.

2.8 PIPING ACCESSORIES

2.8.1 Strainer

Strainer shall be in accordance with ASTM F 1199, except as modified herein. Strainer shall be the cleanable, basket or "Y" type, the same size as the pipeline. Strainer bodies shall be fabricated of cast iron with bottoms drilled, and tapped. The bodies shall have arrows clearly cast on the sides indicating the direction of flow. Strainer shall be equipped with removable cover and sediment screen. The screen shall be made of minimum 0.8 mm (22 gauge) monel, with small perforations numbering not less than 60 per square centimeter (400 per square inch) 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.

2.8.2 Combination Strainer and Suction Diffuser

Unit shall consist of an angle type body with removable strainer basket and straightening vanes, a suction pipe support, and a blowdown outlet. Strainer shall be in accordance with ASTM F 1199, except as modified herein. Unit body shall have arrows clearly cast on the sides indicating the direction of flow. Strainer screen shall be made of minimum 0.8 mm (22 gauge) monel, with small perforations numbering not less than 60 per square centimeter (400 per square inch) to provide a net free area through the basket of at least 3.30 times that of the entering pipe. Flow shall be into the screen and out through the perforations.

2.8.3 Flexible Pipe Connectors

Flexible pipe connectors shall be designed for 862 kPa (125 psig) or 1034

kPa (150 psig) service as appropriate for the static head plus the system head, and 110 degrees C, for grooved end flexible connectors. The flexible section shall be constructed of rubber, tetrafluoroethylene resin, or corrosion-resisting steel, bronze, monel, or galvanized steel. The flexible section shall be suitable for intended service with end connections to match adjacent piping. Flanged assemblies shall be equipped with limit bolts to restrict maximum travel to the manufacturer's standard limits. Unless otherwise indicated, the length of the flexible connectors shall be as recommended by the manufacturer for the service intended. Internal sleeves or liners, compatible with circulating medium, shall be provided when recommended by the manufacturer. Covers to protect the bellows shall be provided where indicated.

2.8.4 Pressure and Vacuum Gauges

Gauges shall conform to ASME B40.1 and shall be provided with throttling type needle valve or a pulsation dampener and shut-off valve. Gauge shall be a minimum of 85 mm in diameter with a range from 0 kPa (0 psig) to approximately 1.5 times the maximum system working pressure. Each gauge range shall be selected so that at normal operating pressure, the needle is within the middle-third of the range.

2.8.5 Temperature Gauges

Temperature gauges shall be the industrial duty type and be provided for the required temperature range. Gauges shall have Celsius scale in 1 degree graduations scale (black numbers) on a white face. The pointer shall be adjustable. Rigid stem type temperature gauges shall be provided in thermal wells located within 1.5 m of the finished floor. Universal adjustable angle type or remote element type temperature gauges shall be provided in thermal wells located 1.5 to 2.1 m above the finished floor. Remote element type temperature gauges shall be provided in thermal wells located 2.1 m above the finished floor.

2.8.5.1 Stem Cased-Glass

Stem cased-glass case shall be polished stainless steel or cast aluminum, 229 mm (9 inches) long, with clear acrylic lens, and non-mercury filled glass tube with indicating-fluid column.

2.8.5.2 Bimetallic Dial

Bimetallic dial type case shall be not less than 89 mm (3-1/2 inches), stainless steel, and shall be hermetically sealed with clear acrylic lens. Bimetallic element shall be silicone dampened and unit fitted with external calibrator adjustment. Accuracy shall be one percent of dial range.

2.8.5.3 Liquid-, Solid-, and Vapor-Filled Dial

Liquid-, solid-, and vapor-filled dial type cases shall be not less than 89 mm (3-1/2 inches), stainless steel or cast aluminum with clear acrylic lens. Fill shall be nonmercury, suitable for encountered cross-ambients, and connecting capillary tubing shall be double-braided bronze.

2.8.5.4 Thermal Well

Thermal well shall be identical size, 15 or 20 mm (1/2 or 3/4 inch) NPT connection, brass or stainless steel. Where test wells are indicated, provide captive plug-fitted type 15 mm (1/2 inch) NPT connection suitable

for use with either engraved stem or standard separable socket thermometer or thermostat. Mercury shall not be used in thermometers. Extended neck thermal wells shall be of sufficient length to clear insulation thickness by 25 mm .

2.8.6 Pipe Hangers, Inserts, and Supports

Pipe hangers, inserts, guides, and supports shall conform to MSS SP-58 and MSS SP-69.

2.8.7 Escutcheons

Escutcheons shall be chromium-plated iron or chromium-plated brass, either one piece or split pattern, held in place by internal spring tension or set screws.

2.9 PUMPS

Pumps shall be the electrically driven, non-overloading, centrifugal type which conform to HI 1.1-1.5. Pump capacity, efficiency, motor size, and impeller type shall be as indicated on the drawings. Pumps shall be selected at or within 5 percent of peak efficiency. Pump curve shall rise continuously from maximum capacity to shutoff. Pump motor shall conform to NEMA MG 1, be open , and have sufficient wattage (horsepower) for the service required. Pump motor shall be equipped with an across-the-line magnetic controller in a NEMA 250, Type 1 enclosure with "START-STOP" switch in the cover.

2.9.1 Construction

Shaft seal shall be mechanical-seal or stuffing-box type. Impeller shall be statically and dynamically balanced. Each pump casing shall be designed to withstand the discharge head specified plus the static head on system plus 50 percent of the total, but not less than 862 kPa (125 psig) . Pump casing and bearing housing shall be close grained cast iron. High points in the casing shall be provided with manual air vents; low points shall be provided with drain plugs. Impeller, impeller wearing rings, glands, casing wear rings, and shaft sleeve shall be bronze. Shaft shall be carbon or alloy steel, turned and ground. Bearings shall be ball-bearings, roller-bearings, or oil-lubricated bronze-sleeve type bearings, and be efficiently sealed or isolated to prevent loss of oil or entrance of dirt or water. Pump and motor shall be mounted on a common cast iron base having lipped edges and tapped drainage openings or structural steel base with lipped edges and drain pan and tapped drainage openings. Pump shall be provided with shaft coupling guard. Pump motor shall have the required capacity to prevent overloading with pump operating at any point on its characteristic curve. Pump speed shall not exceed 3,600 rpm, except where the pump head is less than 180 kPa , the pump speed shall not exceed 1,750 rpm. Pump shall be accessible for servicing without disturbing piping connections.

2.9.2 Mechanical Shaft Seals

Seals shall be single, inside mounted, end-face-elastomer bellows type with stainless steel spring, brass or stainless steel seal head, carbon rotating face, and tungsten carbide or ceramic sealing face. Glands shall be bronze and of the water-flush design to provide lubrication flush across the face of the seal. Bypass line from pump discharge to flush connection in gland shall be provided, with filter or cyclone separator in line.

2.10 EXPANSION TANKS

Tank shall be welded steel, constructed, tested and stamped in accordance with ASME BPVC SEC VIII D1 for a working pressure of 862 kPa and precharged to the minimum operating pressure. Tank shall have a replaceable diaphragm and be the captive air type. Tanks shall accommodate expanded water of the system generated within the normal operating temperature range, limiting this pressure increase at all components in the system to the maximum allowable pressure at those components. Each tank air chamber shall be fitted with a drain, fill, an air charging valve, and system connections. Tank shall be supported by steel legs or bases for vertical installation or steel saddles for horizontal installations. The only air in the system shall be the permanent sealed-in air cushion contained within the expansion tank.

2.11 AIR SEPARATOR TANKS

External air separation tank shall have an internal design suitable for creating the required vortex and subsequent air separation. Tank shall be steel, constructed, tested, and stamped in accordance with ASME BPVC SEC VIII D1 for a working pressure of 862 kPa. Tank shall have tangential inlets and outlets connections, threaded for 50 mm and smaller and flanged for sizes 65 mm and larger. Air released from a tank shall be vented as indicated. Tank shall be provided with a blow-down connection.

2.12 WATER TREATMENT SYSTEMS

When water treatment is specified, the use of chemical-treatment products containing hexavalent chromium (Cr) is prohibited.

2.12.1 Water Analysis

Conditions of make-up water to be supplied to the condenser and chilled water systems are to be reported in accordance with ASTM D 596 as follows:

Date of Sample	_____	
Temperature	_____	degrees C.
Silica (SiO ₂)	_____	ppm (mg/l)
Insoluble	_____	ppm (mg/l)
Iron and Aluminum Oxides	_____	ppm (mg/l)
Calcium (Ca)	_____	ppm (mg/l)
Magnesium (Mg)	_____	ppm (mg/l)
Sodium and Potassium (Na and K)	_____	ppm (mg/l)
Carbonate (HCO ₃)	_____	ppm (mg/l)
Sulfate (SO ₄)	_____	ppm (mg/l)
Chloride (Cl)	_____	ppm (mg/l)
Nitrate (NO ₃)	_____	ppm (mg/l)
Turbidity	_____	unit
pH	_____	
Residual Chlorine	_____	ppm (mg/l)
Total Alkalinity	_____	epm (meq/l)
Non-Carbonate Hardness	_____	epm (meq/l)
Total Hardness	_____	epm (meq/l)
Dissolved Solids	_____	ppm (mg/l)
Fluorine	_____	ppm (mg/l)
Conductivity	_____	micrmho/cm

2.12.2 Chilled Water

Water to be used in the chilled water systems shall be treated to maintain the conditions recommended by this specification as well as the recommendations from the manufacturers. Chemicals shall meet all required federal, state, and local environmental regulations for the treatment of evaporator coils and direct discharge to the sanitary sewer.

2.12.3 Water Treatment Services

The services of a company regularly engaged in the treatment of chilled water systems shall be used to determine the correct chemicals required, the concentrations required, and the water treatment equipment sizes and flow rates required. The company shall maintain the chemical treatment and provide all chemicals required for the chilled water systems for a period of 1 year from the date of occupancy. The chemical treatment and services provided over the 1 year period shall meet the requirements of this specification as well as the recommendations from the manufacturers of the condenser and evaporator coils. Acid treatment and proprietary chemicals shall not be used.

2.12.4 Chilled Water System

A shot feeder shall be provided on the chilled water piping as indicated. Size and capacity of feeder shall be based on local requirements and water analysis. The feeder shall be furnished with an air vent, gauge glass, funnel, valves, fittings, and piping.

2.13 FABRICATION

2.13.1 Factory Coating

Unless otherwise specified, equipment and component items, when fabricated from ferrous metal, shall be factory finished with the manufacturer's standard finish, except that items located outside of buildings shall have weather resistant finishes that will withstand 125 hours exposure to the salt spray test specified in ASTM B 117 using a 5 percent sodium chloride solution. Immediately after completion of the test, the specimen shall show no signs of blistering, wrinkling, cracking, or loss of adhesion and no sign of rust creepage beyond 3 mm on either side of the scratch mark. Cut edges of galvanized surfaces where hot-dip galvanized sheet steel is used shall be coated with a zinc-rich coating conforming to ASTM D 520, Type I.

2.13.2 Factory Applied Insulation

Factory insulated items installed outdoors are not required to be fire-rated. As a minimum, factory insulated items installed indoors shall have a flame spread index no higher than 75 and a smoke developed index no higher than 150. Factory insulated items (no jacket) installed indoors and which are located in air plenums, in ceiling spaces, and in attic spaces shall have a flame spread index no higher than 25 and a smoke developed index no higher than 50. Flame spread and smoke developed indexes shall be determined by ASTM E 84. Insulation shall be tested in the same density and installed thickness as the material to be used in the actual construction. Material supplied by a manufacturer with a jacket shall be tested as a composite material. Jackets, facings, and adhesives shall have a flame spread index no higher than 25 and a smoke developed index no higher than 50 when tested in accordance with ASTM E 84.

2.14 SUPPLEMENTAL COMPONENTS/SERVICES

2.14.1 Drain and Make-Up Water Piping

Piping and backflow preventers shall comply with the requirements of Section 15400A PLUMBING, GENERAL PURPOSE. Drains which connect to sanitary sewer system shall be connected by means of an indirect waste.

2.14.2 Field Applied Insulation

Field applied insulation shall be provided and installed in accordance with Section 15080A THERMAL INSULATION FOR MECHANICAL SYSTEMS.

PART 3 EXECUTION

3.1 INSTALLATION

Pipe and fitting installation shall conform to the requirements of ASME B31.1. Pipe shall be cut accurately to measurements established at the jobsite, and worked into place without springing or forcing, completely clearing all windows, doors, and other openings. Cutting or other weakening of the building structure to facilitate piping installation will not be permitted without written approval. Pipe or tubing shall be cut square, shall have burrs removed by reaming, and shall permit free expansion and contraction without causing damage to the building structure, pipe, joints, or hangers.

3.1.1 Directional Changes

Changes in direction shall be made with fittings, except that bending of pipe 100 mm (4 inches) and smaller will be permitted, provided a pipe bender is used and wide weep bends are formed. Mitering or notching pipe or other similar construction to form elbows or tees will not be permitted.

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.

3.1.2 Functional Requirements

Horizontal supply mains shall pitch down in the direction of flow as indicated. The grade shall not be less than 2 mm in 1 m. Reducing fittings shall be used for changes in pipe sizes. Open ends of pipelines and equipment shall be capped or plugged during installation to keep dirt or other foreign materials out of the system. Pipe not otherwise specified shall be uncoated. Connections to appliances shall be made with malleable iron unions for steel pipe 65 mm (2-1/2 inches) or less in diameter, and with flanges for pipe 80 mm (3 inches) and above in diameter. Connections between ferrous and copper piping shall be electrically isolated from each other with dielectric waterways or flanges. Piping located in air plenums shall conform to NFPA 90A requirements. Pipe and fittings installed in inaccessible conduits or trenches under concrete floor slabs shall be welded. Equipment and piping arrangements shall fit into space allotted and allow adequate acceptable clearances for installation, replacement, entry, servicing, and maintenance. Electric isolation fittings shall be provided between dissimilar metals.

3.1.3 Fittings and End Connections

3.1.3.1 Threaded Connections

Threaded connections shall be made with tapered threads and made tight with PTFE tape complying with ASTM D 3308 or equivalent thread-joint compound applied to the male threads only. Not more than three threads shall show after the joint is made.

3.1.3.2 Brazed Connections

Brazing shall be performed in accordance with AWS Brazing Hdbk, except as modified herein. During brazing, the pipe and fittings shall be filled with a pressure regulated inert gas, such as nitrogen, to prevent the formation of scale. Before brazing copper joints, both the outside of the tube and the inside of the fitting shall be cleaned with a wire fitting brush until the entire joint surface is bright and clean. Brazing flux shall not be used. Surplus brazing material shall be removed at all joints. Steel tubing joints shall be made in accordance with the manufacturer's recommendations. Piping shall be supported prior to brazing and not be sprung or forced.

3.1.3.3 Welded Connections

Branch connections shall be made with welding tees or forged welding branch outlets. Pipe shall be thoroughly cleaned of all scale and foreign matter before the piping is assembled. During welding, the pipe and fittings shall be filled with an inert gas, such as nitrogen, to prevent the formation of scale. Beveling, alignment, heat treatment, and inspection of weld shall conform to ASME B31.1. Weld defects shall be removed and rewelded at no additional cost to the Government. Electrodes shall be stored and dried in accordance with AWS D1.1 or as recommended by the manufacturer. Electrodes that have been wetted or that have lost any of their coating shall not be used.

3.1.3.4 Grooved Mechanical Connections

Grooves shall be prepared in accordance with the coupling manufacturer's instructions. Pipe and groove dimensions shall comply with the tolerances specified by the coupling manufacturer. The diameter of grooves made in the field shall be measured using a "go/no-go" gauge, vernier or dial caliper, or narrow-land micrometer, or other method specifically approved by the coupling manufacturer for the intended application. Groove width and dimension of groove from end of pipe shall be measured and recorded for each change in grooving tool setup to verify compliance with coupling manufacturer's tolerances. 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.

3.1.3.5 Flared Connections

When flared connections are used, a suitable lubricant shall be used between the back of the flare and the nut in order to avoid tearing the flare while tightening the nut.

3.1.3.6 Flanges and Unions

Except where copper tubing is used, union or flanged 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. Flanged joints shall be assembled square end tight with matched flanges, gaskets, and bolts. Gaskets shall be

suitable for the intended application.

3.1.4 Valves

Isolation gate or ball valves shall be installed on each side of each piece of equipment, at the midpoint of all looped mains, and at any other points indicated or required for draining, isolating, or sectionalizing purpose. Isolation valves may be omitted where balancing cocks are installed to provide both balancing and isolation functions. Each valve except check valves shall be identified. Valves in horizontal lines shall be installed with stems horizontal or above.

3.1.5 Air Vents

Air vents shall be provided at all high points, on all water coils, and where indicated to ensure adequate venting of the piping system.

3.1.6 Drains

Drains shall be provided at all low points and where indicated to ensure complete drainage of the piping. Drains shall be accessible, and shall consist of nipples and caps or plugged tees unless otherwise indicated.

3.1.7 Flexible Pipe Connectors

Connectors shall be attached to components in strict 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 flexible pipe connector manufacturer and shall be provided at the intervals recommended.

3.1.8 Temperature Gauges

Temperature gauges shall be located on coolant supply and return piping at each heat exchanger, on condenser water piping entering and leaving a condenser, at each automatic temperature control device without an integral thermometer, and where indicated or required for proper operation of equipment. Thermal wells for insertion thermometers and thermostats shall extend beyond thermal insulation surface not less than 25 mm .

3.1.9 Pipe Hangers, Inserts, and Supports

Pipe hangers, inserts, and supports shall conform to MSS SP-58 and MSS SP-69, except as modified herein. Pipe hanger types 5, 12, and 26 shall not be used. Hangers used to support piping 50 mm (2 inches) and larger shall be fabricated to permit adequate adjustment after erection while still supporting the load. 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.

3.1.9.1 Hangers

Type 3 shall not be used on insulated piping. Type 24 may be used only on trapeze hanger systems or on fabricated frames.

3.1.9.2 Inserts

Type 18 inserts shall be secured to concrete forms before concrete is placed. Continuous inserts which allow more adjustments may be used if

they otherwise meet the requirements for Type 18 inserts.

3.1.9.3 C-Clamps

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.

3.1.9.4 Angle Attachments

Type 20 attachments used on angles and channels shall be furnished with an added malleable-iron heel plate or adapter.

3.1.9.5 Saddles and Shields

Where Type 39 saddle or Type 40 shield are permitted for a particular pipe attachment application, the Type 39 saddle, connected to the pipe, shall be used on all pipe 100 mm (4 inches) and larger when the temperature of the medium is 16 degrees C or higher. Type 40 shields shall be used on all piping less than 100 mm (4 inches) and all piping 100 mm (4 inches) and larger carrying medium less than 16 degrees C. A high density insulation insert of cellular glass shall be used under the Type 40 shield for piping 50 mm (2 inches) and larger.

3.1.9.6 Horizontal Pipe Supports

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 1.5 m apart at valves. Pipe hanger loads suspended from steel joist with hanger loads between panel points in excess of 23 kg shall have the excess hanger loads suspended from panel points.

3.1.9.7 Vertical Pipe Supports

Vertical pipe shall be supported at each floor, except at slab-on-grade, and at intervals of not more than 4.5 m, not more than 2.4 m from end of risers, and at vent terminations.

3.1.9.8 Pipe Guides

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.

3.1.9.9 Steel Slides

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 shall be used. On piping under 100 mm (4 inches), a Type 40 protection shield may be attached to the pipe or insulation and freely rest on a steel slide plate.

3.1.9.10 High Temperature Guides with Cradles

Where there are high system temperatures and welding to piping is not desirable, then 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.

3.1.9.11 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 members shall not exceed the hanger and support spacing required for an individual pipe in the multiple pipe run.

3.1.9.12 Seismic Requirements

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

3.1.9.13 Structural Attachments

Attachment to building structure concrete and masonry shall be by cast-in concrete inserts, built-in anchors, or masonry anchor devices. Inserts and anchors shall be applied with a safety factor not less than 5. Supports shall not be attached to metal decking. Masonry anchors for overhead applications shall be constructed of ferrous materials only. Structural steel brackets required to support piping, headers, and equipment, but not shown, shall be provided under this section. Material used for support shall be as specified under Section 05120A STRUCTURAL STEEL.

3.1.10 Pipe Alignment Guides

Pipe alignment guides shall be provided where indicated for expansion loops, offsets, and bends and as recommended by the manufacturer for expansion joints, not to exceed 1.5 m on each side of each expansion joint, and in lines 100 mm (4 inches) or smaller not more than 600 mm on each side of the joint.

3.1.11 Pipe 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. Where pipe and conduit penetrations of vapor barrier sealed surfaces occur, these items shall be anchored immediately adjacent to each penetrated surface, to provide essentially zero movement within penetration seal. Detailed drawings of pipe anchors shall be submitted for approval before installation.

3.1.12 Building Surface Penetrations

Sleeves shall not be installed in structural members except where indicated or approved. Sleeves in nonload bearing surfaces shall be galvanized sheet

metal, conforming to ASTM A 653/A 653M, Coating Class G-90, 1.0 mm (20 gauge) . Sleeves in load bearing surfaces shall be uncoated carbon steel pipe, conforming to ASTM A 53/A 53M, Standard weight. Sealants shall be applied to moisture and oil-free surfaces and elastomers to not less than 13 mm depth. Sleeves shall not be installed in structural members.

3.1.12.1 General Service Areas

Each sleeve shall extend through its respective wall, floor, or roof, and shall be cut flush with each surface. Pipes passing through concrete or masonry wall or concrete floors or roofs shall be provided with pipe sleeves fitted into place at the time of construction. Sleeves shall be of such size as to provide a minimum of 6.35 mm all-around clearance between bare pipe and sleeves or between jacketed-insulation and sleeves. Except in pipe chases or interior walls, the annular space between pipe and sleeve or between jacket over-insulation and sleeve shall be sealed in accordance with Section 07900A JOINT SEALING.

3.1.12.2 Waterproof Penetrations

Pipes passing through roof or floor waterproofing membrane shall be installed through a 5.17 kg/sq. m. (17 ounce) copper sleeve, or a 0.81 mm (0.032 inch) thick aluminum sleeve, each within an integral skirt or flange. Flashing sleeve shall be suitably formed, and skirt or flange shall extend not less than 200 mm from the pipe and be set over the roof or floor membrane in a troweled coating of bituminous cement. The flashing sleeve shall extend up the pipe a minimum of 50 mm above the roof or floor penetration. The annular space between the flashing sleeve and the bare pipe or between the flashing sleeve and the metal-jacket-covered insulation shall be sealed as indicated. Penetrations shall be sealed by either one of the following methods.

- a. Waterproofing Clamping Flange: Pipes up to and including 250 mm in diameter passing through roof or floor waterproofing membrane may be installed through a cast iron sleeve with caulking recess, anchor lugs, flashing clamp device, and pressure ring with brass bolts. Waterproofing membrane shall be clamped into place and sealant shall be placed in the caulking recess.
- b. Modular Mechanical Type Sealing Assembly: In lieu of a waterproofing clamping flange, a modular mechanical type sealing assembly may be installed. Seals shall consist of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe/conduit and sleeve with corrosion protected carbon steel bolts, nuts, and pressure plates. Links shall be loosely assembled with bolts to form a continuous rubber belt around the pipe with a pressure plate under each bolt head and each nut. After the seal assembly is properly positioned in the sleeve, tightening of the bolt shall cause the rubber sealing elements to expand and provide a watertight seal between the pipe/conduit and sleeve. Each seal assembly shall be sized as recommended by the manufacturer to fit the pipe/conduit and sleeve involved. The Contractor electing to use the modular mechanical type seals shall provide sleeves of the proper diameters.

3.1.12.3 Fire-Rated Penetrations

Penetration of fire-rated walls, partitions, and floors shall be sealed as

specified in Section 07840A FIRESTOPPING.

3.1.12.4 Escutcheons

Finished surfaces where exposed piping, bare or insulated, pass through floors, walls, or ceilings, except in boiler, utility, or equipment rooms, shall be provided with escutcheons. Where sleeves project slightly from floors, special deep-type escutcheons shall be used. Escutcheon shall be secured to pipe or pipe covering.

3.1.13 Pumps

Support, anchor, and guide so that no strains are imposed on pump by weight or thermal movement of piping. Air vents on pump casings shall be provided. Drain outlets on pump bases shall be piped to the nearest floor or other acceptable drains, with necessary clean-out tees.

3.1.14 Access Panels

Access panels shall be provided for all concealed valves, vents, controls, 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.

3.1.15 Field Applied Insulation

Field installed insulation shall be as specified in Section 15080A THERMAL INSULATION FOR MECHANICAL SYSTEMS, except as defined differently herein.

3.1.16 Field Painting

Painting required for surfaces not otherwise specified, and finish painting of items only primed at the factory are specified in Section 09900 [AM0002] PAINTS AND COATINGS~~PAINTING, GENERAL~~.

3.1.16.1 Color Coding

Color coding for piping identification is specified in Section 09900 PAINTING, GENERAL.

3.2 CLEANING AND ADJUSTING

Pipes shall be cleaned free of scale and thoroughly flushed of all foreign matter. A temporary bypass shall be provided for all water coils to prevent flushing water from passing through coils. Strainers and valves shall be thoroughly cleaned. Prior to testing and balancing, air shall be removed from all water systems by operating the air vents. Temporary measures, such as piping the overflow from vents to a collecting vessel shall be taken to avoid water damage during the venting process. Air vents shall be plugged or capped after the system has been vented. Control valves and other miscellaneous equipment requiring adjustment shall be adjusted to setting indicated or directed.

3.3 FIELD TESTS

Tests shall be conducted in the presence of the Contracting Officer. Water and electricity required for the tests will be furnished by the Government. Any material, equipment, instruments, and personnel required for the test

shall be provided by the Contractor. The services of a qualified technician shall be provided as required to perform all tests and procedures indicated herein. Field tests shall be coordinated with Section 15990A TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS.

3.3.1 Hydrostatic Tests

Following the cleaning procedures defined above, all chilled and condenser water piping systems shall be hydrostatically tested as defined herein. Unless otherwise agreed by the Contracting Officer, water (or glycol solution) shall be the test medium.

3.3.1.1 Equipment and Component Isolation

Prior to testing, equipment and components that cannot withstand the test pressure shall be properly isolated.

3.3.1.2 Tests

Piping shall be hydrostatically tested at a pressure equal to 150 percent of the total system operating pressure for period of time sufficient to inspect every joint in the system and in no case less than 2 hours. Test pressure shall be monitored by a calibrated, test pressure gauge. Leaks shall be repaired and piping retested until test is successful. No loss of pressure shall be allowed. Leaks shall be repaired by rewelding or replacing pipe or fittings. Caulking of joints will not be permitted. Concealed and insulated piping shall be tested in place before concealing.

3.3.2 Backflow Prevention Assemblies Tests

Backflow prevention assemblies shall be tested in accordance with Section 15400A PLUMBING, GENERAL PURPOSE.

3.4 DEMONSTRATIONS

Contractor shall conduct a training course for the operating staff as designated by the Contracting Officer. The training period shall consist of a total 16 hours of normal working time and start after the system is functionally completed but prior to final acceptance tests. The field posted instructions shall cover all of the items contained in the approved operation and maintenance manuals as well as demonstrations of routine maintenance operations.

3.5 ONE-YEAR INSPECTION

At the conclusion of the one year period, each connecting liquid chiller condenser shall be inspected for problems due to corrosion, scale, and biological growth. If the equipment is found not to conform to the manufacturers recommended conditions, and the water treatment company recommendations have been followed; the water treatment company shall provide all chemicals and labor for cleaning or repairing the equipment as required by the manufacturer's recommendations.

-- End of Section --

SECTION 15400A

PLUMBING, GENERAL PURPOSE

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 1010 (1994) Self-Contained, Mechanically Refrigerated Drinking-Water Coolers
- ARI 700 (1999) Specifications for Fluorocarbon and Other Refrigerants

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

- ANSI Z21.10.1 (1998; Z21.10.1a; Z21.10.1b; Z21.10.1c) Gas Water Heaters Vol. I, Storage Water Heaters with Input Ratings of 75,000 Btu Per Hour or Less
- ANSI Z21.10.3 (1998) Gas Water Heaters Vol.III, Storage Water Heaters With Input Ratings Above 75,000 Btu Per Hour, Circulating and Instantaneous Water Heaters
- ANSI Z21.22 (1999) Relief Valves and Automatic Gas Shutoff Devices for Hot Water Supply Systems
- ANSI Z21.56 (1994; Z21.56a) Gas-Fired Pool Heaters
- ANSI Z358.1 (1998) Emergency Eyewash and Shower Equipment

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

- ASTM A 105/A 105M (2001) Carbon Steel Forgings for Piping Applications
- 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 47/A 47M (1999) Ferritic Malleable Iron Castings
- ASTM A 515/A 515M (1989; R 1997) Pressure Vessel Plates, Carbon Steel, for Intermediate- and Higher-Temperature Service

ASTM A 516/A 516M	(1990; R 1996) Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service
ASTM A 518/A 518M	(1999) Corrosion-Resistant High-Silicon 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 733	(1999) Welded and Seamless Carbon Steel and Austenitic Stainless Steel Pipe Nipples
ASTM A 74	(1998) Cast Iron Soil Pipe and Fittings
ASTM A 888	(1998e1) Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications
ASTM B 111	(1998) Copper and Copper-Alloy Seamless Condenser Tubes and Ferrule Stock
ASTM B 111M	(1998) Copper and Copper-Alloy Seamless Condenser Tubes and Ferrule Stock (Metric)
ASTM B 117	(1997) Operating Salt Spray (Fog) Apparatus
ASTM B 152	(1997a) Copper Sheet, Strip, Plate, and Rolled Bar
ASTM B 152M	(1997a) Copper Sheet, Strip, Plate, and Rolled Bar (Metric)
ASTM B 306	(1999) Copper Drainage Tube (DWV)
ASTM B 32	(1996) Solder Metal
ASTM B 370	(1998) Copper Sheet and Strip for Building Construction
ASTM B 42	(1998) Seamless Copper Pipe, Standard Sizes
ASTM B 43	(1998) Seamless Red Brass Pipe, Standard Sizes
ASTM B 584	(2000a) Copper Alloy Sand Castings for General Applications
ASTM B 75	(1999) Seamless Copper Tube
ASTM B 75M	(1999) Seamless Copper Tube (Metric)
ASTM B 813	(2000) Liquid and Paste Fluxes for Soldering Applications 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	(1999) Seamless Copper Water Tube
ASTM B 88M	(1999) Seamless Copper Water Tube (Metric)
ASTM C 1053	(2000) Borosilicate Glass Pipe and Fittings for Drain, Waste, and Vent (DWV) Applications
ASTM C 564	(1997) Rubber Gaskets for Cast Iron Soil Pipe and Fittings
ASTM C 920	(1998) Elastomeric Joint Sealants
ASTM D 1004	(1994; Rev. A) Initial Tear Resistance of Plastic Film and Sheeting
ASTM D 1248	(2000) Polyethylene Plastics Molding and Extrusion Materials
ASTM D 1785	(1999) Poly(Vinyl Chloride)(PVC) Plastic Pipe, Schedules 40, 80, and 120
ASTM D 2000	(1999) Rubber Products in Automotive Applications
ASTM D 2235	(1996a) Solvent Cement for Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe and Fittings
ASTM D 2239	(1999) Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter
ASTM D 2241	(2000) Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)
ASTM D 2447	(1999) Polyethylene (PE) Plastic Pipe, Schedules 40 and 80, Based on Outside Diameter
ASTM D 2464	(1999) Threaded Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D 2466	(1999) Poly(Vinyl Chloride)(PVC) Plastic Pipe Fittings, Schedule 40
ASTM D 2467	(1999) Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D 2485	(1991; R 1996) Evaluating Coatings for High Temperature Service
ASTM D 2564	(1996a) Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems
ASTM D 2657	(1997) Heat Fusion Joining Polyolefin Pipe

and Fittings

ASTM D 2661	(1997a) Acrylonitrile-Butadiene-Styrene (ABS) Schedule 40 Plastic Drain, Waste, and Vent Pipe and Fittings
ASTM D 2665	(2000) Poly(Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings
ASTM D 2672	(1996a) Joints for IPS PVC Pipe Using Solvent Cement
ASTM D 2683	(1998) Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing
ASTM D 2737	(1999) Polyethylene (PE) Plastic Tubing
ASTM D 2822	(1991; R 1997e) Asphalt Roof Cement
ASTM D 2846/D 2846M	(1999) Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Hot- and Cold-Water Distribution Systems
ASTM D 2855	(1996) Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings
ASTM D 2996	(1995) Filament-Wound "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe
ASTM D 3035	(1995) Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter
ASTM D 3122	(1995) Solvent Cements for Styrene-Rubber (SR) Plastic Pipe and Fittings
ASTM D 3138	(1995) Solvent Cements for Transition Joints Between Acrylonitrile-Butadiene-Styrene (ABS) and Poly(Vinyl Chloride) (PVC) Non-Pressure Piping Components
ASTM D 3139	(1998) Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals
ASTM D 3212	(1996a) Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
ASTM D 3261	(1997) Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing
ASTM D 3308	(1997) PTFE Resin Skived Tape
ASTM D 3311	(1994) Drain, Waste, and Vent (DWV) Plastic Fittings Patterns
ASTM D 4060	(1995) Abrasion Resistance of Organic

Coatings by the Taber Abraser

ASTM D 4101	(2000) Propylene Plastic Injection and Extrusion Materials
ASTM D 4551	(1996) Poly(Vinyl Chloride) (PVC) Plastic Flexible Concealed Water-Containment Membrane
ASTM D 638	(1999) Tensile Properties of Plastics
ASTM D 638M	(1998) Tensile Properties of Plastics (Metric)(Withdrawn 1998; no replacement)
ASTM E 1	(1998) ASTM Thermometers
ASTM E 96	(2000) Water Vapor Transmission of Materials
ASTM F 1290	(1998a) Electrofusion Joining Polyolefin Pipe and Fittings
ASTM F 1760	(1997) Coextruded Poly(Vinyl Chloride) (PVC) Non-Pressure Plastic Pipe Having Reprocessed-Recycled Content
ASTM F 409	(1999a) Thermoplastic Accessible and Replaceable Plastic Tube and Tubular Fittings
ASTM F 437	(1999) Threaded Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80
ASTM F 438	(1999) Socket-Type Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40
ASTM F 439	(1999) Socket-Type Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80
ASTM F 441/F 441M	(1999) Chlorinated Poly(Vinyl Chloride).(CPVC) Plastic Pipe, Schedules 40 and 80
ASTM F 442/F 442M	(1999) Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe (SDR-PR)
ASTM F 477	(1999) Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F 493	(1997) Solvent Cements for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe and Fittings
ASTM F 628	(2000) Acrylonitrile-Butadiene-Styrene (ABS) Schedule 40 Plastic Drain, Waste, and Vent Pipe with a Cellular Core

ACCOMPANYING AMENDMENT NO. 2 TO SOLICITATION NO. DACA63-03-R-0003

ASTM F 877 (2001) Crosslinked Polyethylene (PEX)
Plastic Hot- and Cold- Water Distribution
Systems

ASTM F 891 (2000) Coextruded Poly (Vinyl chloride)
(PVC) Plastic Pipe with a Cellular Core

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING
ENGINEERS (ASHRAE)

ASHRAE 34 (1997) Number Designation and Safety
Classification of Refrigerants

ASHRAE 90.1 (1989; 90.1b; 90.1c; 90.1d; 90.1e; 90.1g;
90.1i; 90.1l-1995; 90.1m-1995; 90.1n-1997)
Energy Efficient Design of New Buildings
Except Low-Rise Residential Buildings

AMERICAN SOCIETY OF SANITARY ENGINEERING (ASSE)

ASSE 1001 (1990) Pipe Applied Atmospheric Type Vacuum
Breakers

ASSE 1002 (1986) Water Closet Flush Tank Ball Cocks

ASSE 1003 (1995) Water Pressure Reducing Valves for
Domestic Water Supply Systems

ASSE 1005 (1986) Water Heater Drain Valves - 3/4-Inch
Iron Pipe Size

ASSE 1006 (1989) Residential Use (Household)
Dishwashers

ASSE 1011 (1995) Hose Connection Vacuum Breakers

ASSE 1012 (1995) Backflow Preventers with
Intermediate Atmospheric Vent

ASSE 1013 (1999) Reduced Pressure Principle Backflow
Preventers

ASSE 1018 (1986) Trap Seal Primer Valves Water Supply
Fed

ASSE 1020 (1998) Pressure Vacuum Breaker Assembly
(Recommended for Outdoor Usage)

ASSE 1037 (1990; Rev thru Mar 1990) Pressurized
Flushing Devices (Flushometers) for
Plumbing Fixtures

AMERICAN WATER WORKS ASSOCIATION(AWWA)

AWWA B300 (1999) Hypochlorites

AWWA B301 (1992; Addenda B301a - 1999) Liquid
Chlorine

AWWA C105 (1999) Polyethylene Encasement for Ductile-Iron Pipe Systems

AWWA C203 (1997; Addenda C203a - 1999) Coal-Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel and Tape - Hot-Applied

AWWA C606 (1997) Grooved and Shouldered Joints

AWWA C700 (1995) Cold-Water Meters - Displacement Type, Bronze Main Case

AWWA C701 (1988) Cold-Water Meters - Turbine Type, for Customer Service

AWWA D100 (1996) Welded Steel Tanks for Water Storage

AWWA EWW (1999) Standard Methods for the Examination of Water and Wastewater

AWWA M20 (1973) Manual: Water Chlorination Principles and Practices

AMERICAN WELDING SOCIETY (AWS)

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

AWS B2.2 (1991) Brazing Procedure and Performance Qualification

ASME INTERNATIONAL (ASME)

ASME A112.1.2 (1991; R 1998) Air Gaps in Plumbing Systems

ASME A112.14.1 (1975; R 1998) Backwater Valves

ASME A112.18.1M (1996) Plumbing Fixture Fittings

ASME A112.19.1M (1994; R 1999) Enameled Cast Iron Plumbing Fixtures

ASME A112.19.2M (1998) Vitreous China Plumbing Fixtures

ASME A112.19.3M (1987; R 1996) Stainless Steel Plumbing Fixtures (Designed for Residential Use)

ASME A112.19.4M (1994; Errata Nov 1996) Porcelain Enameled Formed Steel Plumbing Fixtures

ASME A112.21.1M (1991; R 1998) Floor Drains

ASME A112.21.2M (1983) Roof Drains

ASME A112.36.2M (1991; R 1998) Cleanouts

ASME A112.6.1M (1997) Supports for Off-the-Floor Plumbing Fixtures for Public Use

ASME B1.20.1	(1983; R 1992) Pipe Threads, General Purpose (Inch)
ASME B16.12	(1998) Cast Iron Threaded Drainage Fittings
ASME B16.15	(1985; R 1994) Cast Bronze Threaded Fittings Classes 125 and 250
ASME B16.18	(1984; R 1994) Cast Copper Alloy Solder Joint Pressure Fittings
ASME B16.21	(1992) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.22	(1995; B16.22a1998) Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.23	(1992; Errata Jan 1994) Cast Copper Alloy Solder Joint Drainage Fittings - DWV
ASME B16.24	(1991; R 1998) Cast Copper Alloy Pipe Flanges, Class 150, 300, 400, 600, 900, 1500, and 2500, and Flanged Fittings, Class 150 and 300
ASME B16.29	(1994) Wrought Copper and Wrought Copper Alloy Solder Joint Drainage Fittings - DWV
ASME B16.3	(1998) Malleable Iron Threaded Fittings
ASME B16.34	(1997) Valves - Flanged, Threaded, and Welding End
ASME B16.39	(1998) Malleable Iron Threaded Pipe Unions Classes 150, 250, and 300
ASME B16.4	(1998) Gray Iron Threaded Fittings
ASME B16.5	(1996; B16.5a) Pipe Flanges and Flanged Fittings NPS 1/2 thru NPS 24
ASME B31.1	(1998) Power Piping
ASME B31.5	(1992; B31.5a1994) Refrigeration Piping
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
ASME BPVC SEC IX	(1998) Boiler and Pressure Vessel Code; Section IX, Welding and Brazing Qualifications
ASME CSD-1	(1998) Controls and Safety Devices for Automatically Fired Boilers

CAST IRON SOIL PIPE INSTITUTE (CISPI)

CISPI 301 (1997) Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications

CISPI 310 (1997) Coupling for Use in Connection with Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications

CISPI HSN-85 (1985) Neoprene Rubber Gaskets for Hub and Spigot Cast Iron Soil Pipe and Fittings

COPPER DEVELOPMENT ASSOCIATION (CDA)

CDA Tube Handbook (1995) Copper Tube Handbook

FOUNDATION FOR CROSS-CONNECTION CONTROL AND HYDRAULIC RESEARCH (FCCCHR)

FCCCHR-CCC (1993) Manual of Cross-Connection Control

HYDRAULIC INSTITUTE (HI)

HI 1.1-1.5 (1994) Centrifugal Pumps

INTERNATIONAL ASSOCIATION OF PLUMBING AND MECHANICAL OFFICIALS (IAPMO)

IAPMO Z124.1 (1995) Plastic Bathtub Units

IAPMO Z124.3 (1995) Plastic Lavatories

IAPMO Z124.5 (1997) Plastic Toilet (Water Closets) Seats

IAPMO Z124.9 (1994) Plastic Urinal Fixtures

INTERNATIONAL CODE COUNCIL (ICC)

CABO A117.1 (1998) Accessible and Usable Buildings and Facilities

ICC Plumbing Code (2000) International Plumbing Code (IPA)

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-44 (1996) Steel Pipe line Flanges

MSS SP-58 (1993) Pipe Hangers and Supports -

Materials, Design and Manufacture

MSS SP-67	(1995) Butterfly Valves
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-73	(1991; R 1996) Brazing Joints for Copper and Copper Alloy Pressure Fittings
MSS SP-78	(1998) Cast Iron Plug Valves, Flanged and Threaded Ends
MSS SP-80	(1997) Bronze Gate, Globe, Angle and Check Valves
MSS SP-83	(1995) Class 3000 Steel Pipe Unions Socket-Welding and Threaded
MSS SP-85	(1994) Cast Iron Globe & Angle Valves, Flanged and Threaded Ends

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(1997) Enclosures for Electrical Equipment (1000 Volts Maximum)
----------	--

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 31	(2001) Installation of Oil Burning Equipment
NFPA 54	(1999) National Fuel Gas Code
NFPA 90A	(1999) Installation of Air Conditioning and Ventilating Systems

NSF INTERNATIONAL (NSF)

NSF 14	(1999) Plastics Piping Components and Related Materials
NSF 3	(1996) Commercial Spray-Type Dishwashing and Glasswashing Machines
NSF 5	(1992) Water Heaters, Hot Water Supply Boilers, and Heat Recovery Equipment
NSF 61	(1999) Drinking Water System Components - Health Effects (Sections 1-9)

PLASTIC PIPE AND FITTINGS ASSOCIATION (PPFA)

PPFA-01 (1998) Plastic Pipe in Fire Resistive Construction

PLUMBING AND DRAINAGE INSTITUTE (PDI)

PDI G 101 (1996) Testing and Rating Procedure for Grease Interceptors with Appendix of Sizing and Installation Data

PDI WH 201 (1992) Water Hammer Arresters

PLUMBING-HEATING-COOLING CONTRACTORS NATIONAL ASSOCIATION (NAPHCC)

NAPHCC Plumbing Code (1996) National Standard Plumbing Code

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE J 1508 (1997) Hose Clamps

THE SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC SP 5 (1994) White Metal Blast Cleaning

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-240 (Rev A; Canc. Notice 1) Shower Head, Ball Joint

CID A-A-50012 (Basic) Garbage Disposal Machine, Commercial

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

10 CFR 430 Energy Conservation Program for Consumer Products

21 CFR 175 Indirect Food Additives: Adhesives and Components of Coatings

PL 93-523 (1974; Amended 1986) Safe Drinking Water Act

UNDERWRITERS LABORATORIES (UL)

UL 174 (1996; Rev thru Oct 1999) Household Electric Storage Tank Water Heaters

UL 430 (1994; Rev thru Nov 1996) Waste Disposers

UL 732 (1995; Rev thru Jan 1999) Oil-Fired Storage Tank Water Heaters

UL 749 (1997; Rev thru Feb 1999) Household Dishwashers

UL 921 (1996) Commercial Electric Dishwashers

1.2 STANDARD PRODUCTS

Specified materials and equipment shall be standard products of a manufacturer regularly engaged in the manufacture of such products. Specified equipment shall essentially duplicate equipment that has performed satisfactorily at least two years prior to bid opening.

1.3 ELECTRICAL WORK

Motors, motor controllers and motor efficiencies shall conform to the requirements of Section 16415A ELECTRICAL WORK, INTERIOR. Electrical motor-driven equipment specified herein shall be provided complete with motors. Equipment shall be rated at 60 Hz, single phase, ac unless otherwise indicated. Where a motor controller is not provided in a motor-control center on the electrical drawings, a motor controller shall be as indicated. Motor controllers shall be provided complete with properly sized thermal-overload protection in each ungrounded conductor, auxiliary contact, and other equipment, at the specified capacity, and including an allowable service factor.

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:

SD-02 Shop Drawings

Plumbing System.

Detail drawings consisting of illustrations, schedules, performance charts, instructions, brochures, diagrams, and other information to illustrate the requirements and operations of each system. Detail drawings for the complete plumbing system including piping layouts and locations of connections; dimensions for roughing-in, foundation, and support points; schematic diagrams and wiring diagrams or connection and interconnection diagrams. Detail drawings shall indicate clearances required for maintenance and operation. Where piping and equipment are to be supported other than as indicated, details shall include loadings and proposed support methods. Mechanical drawing plans, elevations, views, and details, shall be drawn to scale.

Electrical Schematics.

Complete electrical schematic lineless or full line interconnection and connection diagram for each piece of mechanical equipment having more than one automatic or manual electrical control device.

SD-03 Product Data

Welding.

A copy of qualified procedures and a list of names and identification symbols of qualified welders and welding operators.

Plumbing Fixture Schedule; G.

Catalog cuts of specified plumbing fixtures valves and related piping system and system location where installed.

Vibration-Absorbing Features; G.

Details of vibration-absorbing features, including arrangement, foundation plan, dimensions and specifications.

Plumbing System; .

Diagrams, instructions, and other sheets proposed for posting. Manufacturer's recommendations for the installation of bell and spigot and hubless joints for cast iron soil pipe.

SD-06 Test Reports

Tests, Flushing and Disinfection.

Test reports in booklet form showing all field tests performed to adjust each component and all field tests performed to prove compliance with the specified performance criteria, completion and testing of the installed system. Each test report shall indicate the final position of controls.

Backflow Prevention Assembly Tests..

Certification of proper operation shall be as accomplished in accordance with state regulations by an individual certified by the state to perform such tests. If no state requirement exists, the Contractor shall have the manufacturer's representative test the device, to ensure the unit is properly installed and performing as intended. The Contractor shall provide written documentation of the tests performed and signed by the individual performing the tests.

SD-07 Certificates

Materials and Equipment

Where materials or equipment are specified to comply with requirements of AGA, ASME, or NSF proof of such compliance shall be included. The label or listing of the specified agency will be acceptable evidence. In lieu of the label or listing, a written certificate may be submitted from an approved, nationally recognized testing organization equipped to perform such services, stating that the items have been tested and conform to the requirements and testing methods of the specified agency. Where equipment is specified to conform to requirements of the ASME Boiler and Pressure Vessel Code, the design, fabrication, and installation shall conform to the code.

Bolts.

Written certification by the bolt manufacturer that the bolts furnished comply with the specified requirements. The certification shall include illustrations of product-required 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

Plumbing System.

Six copies of the operation manual outlining the step-by-step procedures required for system startup, operation and shutdown. The manual shall include the manufacturer's name, model number, service manual, parts list, and brief description of all equipment and their basic operating features. Six copies of the maintenance manual listing routine maintenance procedures, possible breakdowns and repairs. The manual shall include piping and equipment layout and simplified wiring and control diagrams of the system as installed.

1.5 PERFORMANCE REQUIREMENTS

1.5.1 Welding

Piping shall be welded in accordance with qualified procedures using performance-qualified welders and welding operators. Procedures and welders shall be qualified in accordance with ASME BPVC SEC IX. Welding procedures qualified by others, and welders and welding operators qualified by another employer, may be accepted as permitted by ASME B31.1. The Contracting Officer shall be notified 24 hours in advance of tests, and the tests shall be performed at the work site if practicable. Welders or welding operators shall apply their assigned symbols near each weld they make as a permanent record. Structural members shall be welded in accordance with Section 05090A WELDING, STRUCTURAL.

1.6 REGULATORY REQUIREMENTS

Plumbing work shall be in accordance with ICC Plumbing Code.

1.7 PROJECT/SITE CONDITIONS

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

PART 2 PRODUCTS

2.1 MATERIALS

Materials for various services shall be in accordance with TABLES I and II. Pipe schedules shall be selected based on service requirements. Pipe fittings shall be compatible with the applicable pipe materials. Plastic pipe, fittings, and solvent cement shall meet NSF 14 and shall be NSF listed for the service intended. Plastic pipe, fittings, and solvent cement used for potable hot and cold water service shall bear the NSF seal "NSF-PW." Polypropylene pipe and fittings shall conform to dimensional requirements of Schedule 40, Iron Pipe size. Pipe threads (except dry seal) shall conform to ASME B1.20.1. Grooved pipe couplings and fittings shall be from the same manufacturer. Material or equipment containing lead shall not be used in any potable water system. In line devices such as water meters, building valves, check valves, meter stops, valves, fittings and back flow preventers shall comply with PL 93-523 and NSF 61, Section 8. End point devices such as drinking water fountains, lavatory faucets, kitchen and bar faucets, residential ice makers, supply stops and end point control valves used to dispense water for drinking must meet the

requirements of NSF 61, Section 9. Hubless cast-iron soil pipe shall not be installed underground, under concrete floor slabs, or in crawl spaces below kitchen floors. Plastic pipe shall not be installed in air plenums. Plastic pipe shall not be installed in a pressure piping system in buildings greater than three stories including any basement levels.

2.1.1 Pipe Joint Materials

Grooved pipe and hubless cast-iron soil pipe shall not be used under ground. Joints and gasket materials shall conform to the following:

- a. Coupling for Cast-Iron Pipe: for hub and spigot type ASTM A 74, AWWA C606. For hubless type: CISPI 310
- b. Coupling for Steel Pipe: AWWA C606.
- c. Couplings for Grooved Pipe: Malleable Iron ASTM A 47/A 47M, Grade 32510. Copper ASTM A 536.
- d. Flange Gaskets: Gaskets shall be made of non-asbestos material in accordance with ASME B16.21. Gaskets shall be flat, 1.6 mm (1/16 inch) thick, and contain Aramid fibers bonded with Styrene Butadiene Rubber (SBR) or Nitro Butadiene Rubber (NBR). Gaskets shall be the full face or self centering flat ring type. Gaskets used for hydrocarbon service shall be bonded with NBR.
- e. Neoprene Gaskets for Hub and Cast-Iron Pipe and Fittings: CISPI HSN-85.
- f. Brazing Material: Brazing material shall conform to AWS A5.8, BCuP-5.
- g. 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.
- h. Solder Material: Solder metal shall conform to ASTM B 32.
- i. Solder Flux: Flux shall be liquid form, non-corrosive, and conform to ASTM B 813, Standard Test 1.
- j. PTFE Tape: PTFE Tape, for use with Threaded Metal or Plastic Pipe, ASTM D 3308.
- k. Rubber Gaskets for Cast-Iron Soil-Pipe and Fittings (hub and spigot type and hubless type): ASTM C 564.
- l. Rubber Gaskets for Grooved Pipe: ASTM D 2000, maximum temperature 110 degrees C (230 degrees F).
- m. Flexible Elastomeric Seals: ASTM D 3139, ASTM D 3212 or ASTM F 477.
- n. Bolts and Nuts for Grooved Pipe Couplings: Heat-treated carbon steel, ASTM A 183.
- o. Solvent Cement for Transition Joints between ABS and PVC Nonpressure Piping Components: ASTM D 3138.

- p. Plastic Solvent Cement for ABS Plastic Pipe: ASTM D 2235.
- q. Plastic Solvent Cement for PVC Plastic Pipe: ASTM D 2564 and ASTM D 2855.
- r. Plastic Solvent Cement for CPVC Plastic Pipe: ASTM F 493.
- s. Flanged fittings including flanges, bolts, nuts, bolt patterns, etc., shall be in accordance with ASME B16.5 class 150 and shall have the manufacturer's trademark affixed in accordance with MSS SP-25. Flange material shall conform to ASTM A 105/A 105M. 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.
- t. Plastic Solvent Cement for Styrene Rubber Plastic Pipe: ASTM D 3122.

2.1.1.2 Miscellaneous Materials

Miscellaneous materials shall conform to the following:

- a. Water Hammer Arrester: PDI WH 201.
- b. Copper, Sheet and Strip for Building Construction: ASTM B 370.
- c. Asphalt Roof Cement: ASTM D 2822.
- d. Hose Clamps: SAE J 1508.
- e. Supports for Off-The-Floor Plumbing Fixtures: ASME A112.6.1M.
- f. Metallic Cleanouts: ASME A112.36.2M.
- g. Plumbing Fixture Setting Compound: A preformed flexible ring seal molded from hydrocarbon wax material. The seal material shall be nonvolatile nonasphaltic and contain germicide and provide watertight, gastight, odorproof and verminproof properties.
- h. Coal-Tar Protective Coatings and Linings for Steel Water Pipelines:
AWWA C203.
- i. Hypochlorites: AWWA B300.
- j. Liquid Chlorine: AWWA B301.
- k. Polyethylene Encasement for Ductile-Iron Piping: AWWA C105.
- l. Gauges - Pressure and Vacuum Indicating Dial Type - Elastic Element: ASME B40.1.
- m. Thermometers: ASTM E 1. Mercury shall not be used in thermometers.

2.1.1.3 Pipe Insulation Material

Insulation shall be as specified in Section 15080A THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.2 PIPE HANGERS, INSERTS, AND SUPPORTS

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

2.3 VALVES

Valves shall be provided on supplies to equipment and fixtures. Valves 65 mm (2-1/2 inches) and smaller shall be bronze with threaded bodies for pipe and solder-type connections for tubing. Valves 80 mm (3 inches) and larger shall have flanged iron bodies and bronze trim. Pressure ratings shall be based upon the application. Grooved end valves may be provided if the manufacturer certifies that the valves meet the performance requirements of applicable MSS standard. Valves shall conform to the following standards:

Description	Standard
Butterfly Valves	MSS SP-67
Cast-Iron Gate Valves, Flanged and Threaded Ends	MSS SP-70
Cast-Iron Swing Check Valves, Flanged and Threaded Ends	MSS SP-71
Ball Valves with Flanged Butt-Welding Ends for General Service	MSS SP-72
Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends	MSS SP-110
Cast-Iron Plug Valves, Flanged and Threaded Ends	MSS SP-78
Bronze Gate, Globe, Angle, and Check Valves	MSS SP-80
Steel Valves, Socket Welding and Threaded Ends	ASME B16.34
Cast-Iron Globe and Angle Valves, Flanged and Threaded Ends	MSS SP-85
Water Pressure Reducing Valves	ASSE 1003
Water Heater Drain Valves	ASSE 1005
Trap Seal Primer Valves	ASSE 1018
Temperature and Pressure Relief Valves for Hot Water Supply Systems	ANSI Z21.22
Temperature and Pressure Relief Valves for Automatically Fired Hot Water Boilers	ASME CSD-1 Safety Code No., Part CW, Article 5

2.3.1 Wall Faucets

Wall faucets with vacuum-breaker backflow preventer shall be brass with 20 mm (3/4 inch) male inlet threads, hexagon shoulder, and 20 mm (3/4 inch)

hose connection. Faucet handle shall be securely attached to stem.

2.3.2 Wall Hydrants

Wall hydrants with vacuum-breaker backflow preventer shall have a nickel-brass or nickel-bronze wall plate or flange with nozzle and detachable key handle. A brass or bronze operating rod shall be provided within a galvanized iron casing of sufficient length to extend through the wall so that the valve is inside the building, and the portion of the hydrant between the outlet and valve is self-draining. A brass or bronze valve with coupling and union elbow having metal-to-metal seat shall be provided. Valve rod and seat washer shall be removable through the face of the hydrant. The hydrant shall have 20 mm (3/4 inch) exposed hose thread on spout and 20 mm (3/4 inch) male pipe thread on inlet.

2.3.3 Relief Valves

Water heaters and hot water storage tanks shall have a combination pressure and temperature (P&T) relief valve. The pressure relief element of a P&T relief valve shall have adequate capacity to prevent excessive pressure buildup in the system when the system is operating at the maximum rate of heat input. The temperature element of a P&T relief valve shall have a relieving capacity which is at least equal to the total input of the heaters when operating at their maximum capacity. Relief valves shall be rated according to ANSI Z21.22. Relief valves for systems where the maximum rate of heat input is less than 59 kW (200,000 Btuh) shall have 20 mm (3/4 inch) minimum inlets, and 20 mm (3/4 inch) outlets. Relief valves for systems where the maximum rate of heat input is greater than 59 kW (200,000 Btuh) shall have 25 mm (1 inch) minimum inlets, and 25 mm (1 inch) outlets. The discharge pipe from the relief valve shall be the size of the valve outlet.

2.3.4 Thermostatic Mixing Valves

Mixing valves, thermostatic type, pressure-balanced or combination thermostatic and pressure-balanced shall be line size and shall be constructed with rough or finish bodies either with or without plating. Each valve shall be constructed to control the mixing of hot and cold water and to deliver water at a desired temperature regardless of pressure or input temperature changes. The control element shall be of an approved type. The body shall be of heavy cast bronze, and interior parts shall be brass, bronze, corrosion-resisting steel or copper. The valve shall be equipped with necessary stops, check valves, unions, and sediment strainers on the inlets. Mixing valves shall maintain water temperature within 2 degrees C of any setting.

2.4 FIXTURES

Fixtures shall be water conservation type, in accordance with ICC Plumbing Code. Fixtures for use by the physically handicapped shall be in accordance with CABO A117.1. Vitreous china, nonabsorbent, hard-burned, and vitrified throughout the body shall be provided. Porcelain enameled ware shall have specially selected, clear white, acid-resisting enamel coating evenly applied on surfaces. No fixture will be accepted that shows cracks, crazes, blisters, thin spots, or other flaws. Fixtures shall be equipped with appurtenances such as traps, faucets, stop valves, and drain fittings. Each fixture and piece of equipment requiring connections to the drainage system, except grease interceptors, shall be equipped with a trap. Brass expansion or toggle bolts capped with acorn nuts shall be provided

for supports, and polished chromium-plated pipe, valves, and fittings shall be provided where exposed to view. Fixtures with the supply discharge below the rim shall be equipped with backflow preventers. Internal parts of flush and/or flushometer valves, shower mixing valves, shower head face plates, pop-up stoppers of lavatory waste drains, and pop-up stoppers and overflow tees and shoes of bathtub waste drains may contain acetal resin, fluorocarbon, nylon, acrylonitrile-butadiene-styrene (ABS) or other plastic material, if the material has provided satisfactory service under actual commercial or industrial operating conditions for not less than 2 years. Plastic in contact with hot water shall be suitable for 82 degrees C (180 degrees F) water temperature. Plumbing fixtures shall be as indicated in paragraph PLUMBING FIXTURE SCHEDULE.

2.4.1 Lavatories

Vitreous china lavatories shall be provided with two integral molded lugs on the back-underside of the fixture and drilled for bolting to the wall in a manner similar to the hanger plate.

2.5 BACKFLOW PREVENTERS

Backflow preventers shall be approved and listed by the Foundation For Cross-Connection Control & Hydraulic Research. Reduced pressure principle assemblies, double check valve assemblies, atmospheric (nonpressure) type vacuum breakers, and pressure type vacuum breakers shall be tested, approved, and listed in accordance with FCCCHR-CCC. Backflow preventers with intermediate atmospheric vent shall conform to ASSE 1012. Reduced pressure principle backflow preventers shall conform to ASSE 1013. Hose connection vacuum breakers shall conform to ASSE 1011. Pipe applied atmospheric type vacuum breakers shall conform to ASSE 1001. Pressure vacuum breaker assembly shall conform to ASSE 1020. Air gaps in plumbing systems shall conform to ASME A112.1.2.

2.6 DRAINS

2.6.1 ~~[AM002]Floor and Shower Drains (FD-1)~~

Floor and shower drains shall consist of a galvanized body, integral seepage pan, and adjustable perforated or slotted chromium-plated bronze, nickel-bronze, or nickel-brass strainer, consisting of grate and threaded collar. Floor drains shall be cast iron except where metallic waterproofing membrane is installed. Drains shall be of double drainage pattern for embedding in the floor construction. The seepage pan shall have weep holes or channels for drainage to the drainpipe. The strainer shall be adjustable to floor thickness. A clamping device for attaching flashing or waterproofing membrane to the seepage pan without damaging the flashing or waterproofing membrane shall be provided when required. Drains shall be provided with threaded connection. Between the drain outlet and waste pipe, a neoprene rubber gasket conforming to ASTM C 564 may be installed, provided that the drain is specifically designed for the rubber gasket compression type joint. Floor and shower drains shall conform to ASME A112.21.1M.

~~[AM002]~~

~~2.6.1.1 Metallic Shower Pan Drains~~

~~Where metallic shower pan membrane is installed, polyethylene drain with corrosion resistant screws securing the clamping device shall be provided. Polyethylene drains shall have fittings to adapt drain to waste piping.~~

~~Polyethylene for floor drains shall conform to ASTM D 1248. Drains shall have separate cast iron "P" trap, circular body, seepage pan, and strainer, unless otherwise indicated.~~

~~2.6.1.2 Drains and Backwater Valves~~

~~Drains and backwater valves installed in connection with waterproofed floors or shower pans shall be equipped with bolted type device to securely clamp flashing.~~

~~2.6.2 Area Drains~~

~~Area drains shall be plain pattern with polished stainless steel perforated or slotted grate and bottom outlet. The drain shall be circular or square with a 300 mm (12 inch) nominal overall width or diameter and 250 mm (10 inch) nominal overall depth. Drains shall be cast iron with manufacturer's standard coating. Grate shall be easily lifted out for cleaning. Outlet shall be suitable for inside caulked connection to drain pipe. Drains shall conform to ASME A112.21.1M.~~

~~2.6.3 Floor Sinks~~

~~Floor sinks shall be square, with 300 mm (12 inch) nominal overall width or diameter and 250 mm (10 inch) nominal overall depth. Floor sink shall have an acid resistant enamel interior finish with cast iron body, aluminum sediment bucket, and perforated grate of cast iron in industrial areas and stainless steel in finished areas. The outlet pipe size shall be as indicated or of the same size as the connecting pipe.~~

2.6.2 Floor Drains (FD-2)

Floor and shower drains shall consist of a galvanized body, integral seepage pan, and adjustable perforated or slotted chromium-plated bronze, nickel-bronze, or nickel-brass strainer, consisting of grate and threaded collar. Floor drains shall be cast iron except where metallic waterproofing membrane is installed. Drains shall be of double drainage pattern for embedding in the floor construction. The seepage pan shall have weep holes or channels for drainage to the drainpipe. The strainer shall be adjustable to floor thickness. A clamping device for attaching flashing or waterproofing membrane to the seepage pan without damaging the flashing or waterproofing membrane shall be provided when required. Drains shall be provided with threaded connection. Between the drain outlet and waste pipe, a neoprene rubber gasket conforming to ASTM C 564 may be installed, provided that the drain is specifically designed for the rubber gasket compression type joint. Floor and shower drains shall conform to ASME A112.21.1M.

2.6.3 Boiler Room Drain (FD-3)

Boiler room drains shall have combined drain and trap, hinged grate, removable bucket, and threaded brass cleanout with brass backwater valve. The removable galvanized cast iron sediment bucket shall have rounded corners to eliminate fouling and shall be equipped with hand grips. Drain shall have a minimum water seal of 100 mm (inches). The grate area shall be not less than 0.065 meters (100 square inches).

2.7 SHOWER PAN

Shower pan may be copper, or nonmetallic material.

2.7.1 Sheet Copper

Sheet copper shall be 4.9 kg per square meter (16 ounce) weight.

2.7.2 Plasticized Polyvinyl Chloride Shower Pan Material

Material shall be sheet form. The material shall be 1.016 mm (0.040 inch) minimum thickness of plasticized polyvinyl chloride or chlorinated polyethylene and shall be in accordance with ASTM D 4551.

2.7.3 Nonplasticized Polyvinyl Chloride (PVC) Shower Pan Material

Material shall consist of a plastic waterproofing membrane in sheet form. The material shall be 1.016 mm (0.040 inch) minimum thickness of nonplasticized PVC and shall have the following minimum properties:

a. ASTM D 638M or :

Ultimate Tensile Strength:	1.79 MPa (2600 psi)
Ultimate Elongation:	398 percent
100 Percent Modulus:	3.07 MPa (445 psi)

b. ASTM D 1004:

Tear Strength:	53 kilonewtons per meter (300 pounds per inch)
----------------	--

c. ASTM E 96:

Permeance:	0.46 ng per Pa per second per square meter (0.008 perms)
------------	--

d. Other Properties:

Specific Gravity:	1.29
PVC Solvent:	Weldable
Cold Crack:	minus 47 degrees C (-53 degrees F)
Dimensional stability, 100 degrees C (212 minus 2.5 percent degrees F)	
Hardness, Shore A:	89

2.8 TRAPS

Unless otherwise specified, traps shall be plastic per ASTM F 409 or copper-alloy adjustable tube type with slip joint inlet and swivel. Traps shall be without a cleanout. Tubes shall be copper alloy with walls not less than 0.813 mm (0.032 inch) thick within commercial tolerances, except on the outside of bends where the thickness may be reduced slightly in manufacture by usual commercial methods. Inlets shall have rubber washer and copper alloy nuts for slip joints above the discharge level. Swivel joints shall be below the discharge level and shall be of metal-to-metal or metal-to-plastic type as required for the application. Nuts shall have flats for wrench grip. Outlets shall have internal pipe thread, except that when required for the application, the outlets shall have sockets for solder-joint connections. The depth of the water seal shall be not less than 50 mm (2 inches). The interior diameter shall be not more than 3.2 mm (1/8 inch) over or under the nominal size, and interior surfaces shall be reasonably smooth throughout. A copper alloy "P" trap assembly

consisting of an adjustable "P" trap and threaded trap wall nipple with cast brass wall flange shall be provided for lavatories. The assembly shall be a standard manufactured unit and may have a rubber-gasketed swivel joint.

2.9 [AM002] OIL SEPARATOR

The oil separator shall have a fabricated steel body with an acid resistant interior coating. The cover shall be of non-skid construction and secured with a gasket for an airtight seal. The unit shall have a bronze cleanout plug and visible double wall trap seal. The unit shall contain a removable combination pressure equalizing flow diffusing baffle and sediment bucket, a horizontal baffle, oil draw-off port, and vent connections. Furnish unit complete with a flow control fitting, backwater valve, and integral storage tank. The unit shall have capacities as listed on the drawings.

2.10 WATER HEATERS

Water heater types and capacities shall be as indicated. Each water heater shall have replaceable anodes. Each primary water heater shall have controls with an adjustable range that includes 32 to 71 degrees C (90 to 160 degrees F). Each gas-fired water heater and booster water heater shall have controls with an adjustable range that includes 49 to 82 degrees C (120 to 180 degrees F). Hot water systems utilizing recirculation systems shall be tied into building off-hour controls. The thermal efficiencies and standby heat losses shall conform to TABLE III for each type of water heater specified. The only exception is that storage water heaters and hot water storage tanks having more than 2000 liters storage capacity need not meet the standard loss requirement if the tank surface area is insulated to R-12.5 and if a standing light is not used. Plastic materials polyetherimide (PEI) and polyethersulfone (PES) are forbidden to be used for vent piping of combustion gases. A factory pre-charged expansion tank shall be installed on the cold water supply to each water heater. Expansion tanks shall be specifically designed for use on potable water systems and shall be rated for 93 degrees C water temperature and 1034 kPa working pressure. The expansion tank size and acceptance volume shall be as indicated.

2.10.1 Automatic Storage Type

Heaters shall be complete with control system, and shall have ASME rated combination pressure and temperature relief valve. A phenolic resin coating shall be provided.

2.10.2 Phenolic Resin Coatings

The phenolic resin coating shall be applied at either the coil or coating manufacturer's factory. The coil shall be chemically cleaned to remove any scale if present and to etch the metal surface. The exposed exterior surface of the coil shall be abrasively cleaned to white metal blast in accordance with SSPC SP 5. The coating shall be a product specifically intended for use on the material the water heating coils are made of and shall be acceptable for use in potable water systems. Steel, copper, copper alloy, or stainless steel coatings shall be capable of withstanding temperatures up to 204 degrees C (400 degrees F) dry bulb; and meet the requirements of 21 CFR 175. The entire exterior surface of each coil shall be coated with three component phenolic resin coating system. The system shall consist of the following: wash primer, pigmented base coat, and the clear top coat. Immediate and final cure times and temperatures shall be

as recommended by the coating manufacturer.

2.10.2.1 Wash Primer

The wash primer shall be composed of a combination of polyvinyl butyral and a heat hardening phenolic resin. The weight per liter (gallon) shall be between 0.8388 kg per liter (7.0 lbs. per gallon) minimum and 0.8867 kg per liter (7.4 lbs. per gallon) maximum.

2.10.2.2 Pigmented Base Coat

The pigmented baking phenolic base coat shall consist of heat hardening phenolic resins, suitable pigments of the earth type, and softening agents, and shall not contain drying oils or cellulose material. The weight per liter (gallon) shall be between 1.2 kg per liter (10.3 lbs per gallon) minimum and 1.3 kg per liter (10.7 lbs per gallon) maximum. The non-volatile solids content shall be between 60 percent minimum and 64 percent maximum by weight.

2.10.2.3 Clear Top Coat

The clear non-pigmented baking phenolic top coat shall have a weight per liter (gallon) of between 1.0 kg per liter (8.65 lbs per gallon) minimum and 1.1 kg per liter (8.95 lbs per gallon) maximum. The non-volatile solids content shall be between 48 percent minimum and 52 percent maximum by weight.

2.10.2.4 Certificate of Compliance

A certificate of compliance shall be submitted by the coating manufacturer that documents successful use of coating system under service conditions indicated on the drawings for a minimum of 2 years at three different locations, and that the coating material and application comply with the testing procedures outlined.

2.10.2.5 Test Panels

Steel test panel substrate shall be 0.607 mm (24 gauge) in thickness. The panels shall be coated with one coat wash primer, then pigmented baking phenolic to a dry film thickness of 0.10 to 0.15 mm, then clear baking phenolic to a total dry film thickness of 0.13 to 0.18 mm. The panels shall then be subjected to the tests specified below:

- a. Heat Test: Test panel shall be minimum 70 x 150 mm in size. A coated test panel shall show no cracking, flaking, or other failure after the panel has been tested in accordance with ASTM D 2485, with a furnace temperature of 204 degrees C (400 degrees F).
- b. Abrasion Test: A coated test panel shall show no more than a 40 milligram loss when tested in accordance with ASTM D 4060, utilizing a Tabor Abraser CS-17F wheel with a 1000 g weight for 1000 cycles.
- c. Corrosion Test: A coated test panel shall show no corrosion after being subjected to a 500 hour salt spray test in accordance with ASTM B 117.

2.11 HOT-WATER STORAGE TANKS

Hot-water storage tanks shall be constructed by one manufacturer, ASME stamped for the working pressure, and shall have the National Board (ASME) registration. The tank shall be cement-lined or glass-lined steel type in accordance with AWWA D100. The heat loss shall conform to TABLE III as determined by the requirements of ASHRAE 90.1. Each tank shall be equipped with a thermometer, conforming to ASTM E 1, Type I, Class 3, Range C, style and form as required for the installation, and with 175 mm (7 inch) scale.

Thermometer shall have a separable socket suitable for a 20 mm (3/4 inch) tapped opening. Tanks shall be equipped with a pressure gauge 155 mm (6 inch) minimum diameter face. Insulation shall be as specified in Section 15080A THERMAL INSULATION FOR MECHANICAL SYSTEMS. Storage tank capacity shall be as shown.

2.12 PUMPS

2.12.1 {AM002} Sump Pumps

Sump pumps shall be close coupled FM listed submersible type. The pump body shall be cast iron construction with a corrosion resistant powder coated epoxy finish. The motor shall be oil filled, Class B, insulated, NEMA B design, FM listed for Class I, Division I and Group C and D environments, and include an integral thermal overload switch, heavy duty, permanently lubricated ball bearings with a stainless steel shaft. The seals shall be suitable for use with 32AW (25-ft) power cord. The power cord shall be SO type capable of continued exposure to the pumped liquid, sized in accordance with the National Electric Code. Each conductor in the cord shall be individually sealed to eliminate wicking of the liquids.

2.12.2 Circulating Pumps

Domestic hot water circulating pumps shall be electrically driven, single-stage, centrifugal, with mechanical seals, suitable for the intended service. Pump capacities, efficiencies, motor sizes, speeds, and impeller types shall be as shown. Pump and motor shall be close-coupled with an overhung impeller, or supported by the piping on which it is installed. The shaft shall be one-piece, heat-treated, corrosion-resisting steel with impeller and smooth-surfaced housing of bronze. Motor shall be totally enclosed, fan-cooled and shall have sufficient wattage (horsepower) for the service required. Pump shall conform to HI 1.1-1.5. Each pump motor shall be equipped with an across-the-line magnetic controller in a NEMA 250, Type 1 enclosure with "START-STOP" switch in cover. Pump motors smaller than 746 W (Fractional horsepower pump motors) shall have integral thermal overload protection in accordance with Section 16415A ELECTRICAL WORK, INTERIOR. Guards shall shield exposed moving parts.

2.12.3 Flexible Connectors

Flexible connectors shall be provided at the suction and discharge of each pump that is 1 hp or larger. Connectors shall be constructed of neoprene, rubber, or braided bronze, with Class 150 standard flanges. Flexible connectors shall be line size and suitable for the pressure and temperature of the intended service.

PART 3 EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

Piping located in air plenums shall conform to NFPA 90A requirements. Plastic pipe shall not be installed in air plenums. Piping located in

shafts that constitute air ducts or that enclose air ducts shall be noncombustible in accordance with NFPA 90A. Installation of plastic pipe where in compliance with NFPA may be installed in accordance with PPFA-01. The plumbing system shall be installed complete with necessary fixtures, fittings, traps, valves, and accessories. Water and drainage piping shall be extended 1.5 m outside the building, unless otherwise indicated. A gate valve and drain shall be installed on the water service line inside the building approximately 150 mm above the floor from point of entry. Piping shall be connected to the exterior service lines or capped or plugged if the exterior service is not in place. Sewer and water pipes shall be laid in separate trenches, except when otherwise shown. Exterior underground utilities shall be at least 300 mm below the average local frost depth or as indicated on the drawings. If trenches are closed or the pipes are otherwise covered before being connected to the service lines, the location of the end of each plumbing utility shall be marked with a stake or other acceptable means. Valves shall be installed with control no lower than the valve body.

3.1.1 Water Pipe, Fittings, and Connections

3.1.1.1 Utilities

The piping shall be extended to fixtures, outlets, and equipment. The hot-water and cold-water piping system shall be arranged and installed to permit draining. The supply line to each item of equipment or fixture, except faucets, flush valves, or other control valves which are supplied with integral stops, shall be equipped with a shutoff valve to enable isolation of the item for repair and maintenance without interfering with operation of other equipment or fixtures. Supply piping to fixtures, faucets, hydrants, shower heads, and flushing devices shall be anchored to prevent movement.

3.1.1.2 Cutting and Repairing

The work shall be carefully laid out in advance, and unnecessary cutting of construction shall be avoided. Damage to building, piping, wiring, or equipment as a result of cutting shall be repaired by mechanics skilled in the trade involved.

3.1.1.3 Protection of Fixtures, Materials, and Equipment

Pipe openings shall be closed with caps or plugs during installation. Fixtures and equipment shall be tightly covered and protected against dirt, water, chemicals, and mechanical injury. Upon completion of the work, the fixtures, materials, and equipment shall be thoroughly cleaned, adjusted, and operated. Safety guards shall be provided for exposed rotating equipment.

3.1.1.4 Mains, Branches, and Runouts

Piping shall be installed as indicated. Pipe shall be accurately cut and worked into place without springing or forcing. Structural portions of the building shall not be weakened. Aboveground piping shall run parallel with the lines of the building, unless otherwise indicated. Branch pipes from service lines may be taken from top, bottom, or side of main, using crossover fittings required by structural or installation conditions. Supply pipes, valves, and fittings shall be kept a sufficient distance from other work and other services to permit not less than 12 mm between finished covering on the different services. Bare and insulated water

lines shall not bear directly against building structural elements so as to transmit sound to the structure or to prevent flexible movement of the lines. Water pipe shall not be buried in or under floors unless specifically indicated or approved. Changes in pipe sizes shall be made with reducing fittings. Use of bushings will not be permitted except for use in situations in which standard factory fabricated components are furnished to accommodate specific accepted installation practice. Change in direction shall be made with fittings, except that bending of pipe 100 mm (4 inches) and smaller will be permitted, provided a pipe bender is used and wide sweep bends are formed. The center-line radius of bends shall be not less than six diameters of the pipe. Bent pipe showing kinks, wrinkles, flattening, or other malformations will not be acceptable.

3.1.1.5 Pipe Drains

Pipe drains indicated shall consist of 20 mm (3/4 inch) hose bibb with renewable seat and full port ball valve ahead of hose bibb. At other low points, 20 mm (3/4 inch) brass plugs or caps shall be provided. Disconnection of the supply piping at the fixture is an acceptable drain.

3.1.1.6 Expansion and Contraction of Piping

Allowance shall be made throughout for expansion and contraction of water pipe. Each hot-water and hot-water circulation riser shall have expansion loops or other provisions such as offsets, changes in direction, etc., where indicated and/or required. Risers shall be securely anchored as required or where indicated to force expansion to loops. Branch connections from risers shall be made with ample swing or offset to avoid undue strain on fittings or short pipe lengths. Horizontal runs of pipe over 15 m in length shall be anchored to the wall or the supporting construction about midway on the run to force expansion, evenly divided, toward the ends. Sufficient flexibility shall be provided on branch runouts from mains and risers to provide for expansion and contraction of piping. Flexibility shall be provided by installing one or more turns in the line so that piping will spring enough to allow for expansion without straining. If mechanical grooved pipe coupling systems are provided, the deviation from design requirements for expansion and contraction may be allowed pending approval of Contracting Officer.

3.1.1.7 Thrust Restraint

Plugs, caps, tees, valves and bends deflecting 11.25 degrees or more, either vertically or horizontally, in waterlines 100 mm in diameter or larger shall be provided with thrust blocks, where indicated, to prevent movement. Thrust blocking shall be concrete of a mix not leaner than: 1 cement, 2-1/2 sand, 5 gravel; and having a compressive strength of not less than 14 MPa after 28 days. Blocking shall be placed between solid ground and the fitting to be anchored. Unless otherwise indicated or directed, the base and thrust bearing sides of the thrust block shall be poured against undisturbed earth. The side of the thrust block not subject to thrust shall be poured against forms. The area of bearing will be as shown. Blocking shall be placed so that the joints of the fitting are accessible for repair. Steel rods and clamps, protected by galvanizing or by coating with bituminous paint, shall be used to anchor vertical down bends into gravity thrust blocks.

3.1.1.8 Commercial-Type Water Hammer Arresters

Commercial-type water hammer arresters shall be provided on hot- and

cold-water supplies and shall be located as generally indicated, with precise location and sizing to be in accordance with PDI WH 201. Water hammer arresters, where concealed, shall be accessible by means of access doors or removable panels. Commercial-type water hammer arresters shall conform to PDI WH 201. Vertical capped pipe columns will not be permitted.

3.1.2 Joints

Installation of pipe and fittings shall be made in accordance with the manufacturer's recommendations. Mitering of joints for elbows and notching of straight runs of pipe for tees will not be permitted. Joints shall be made up with fittings of compatible material and made for the specific purpose intended.

3.1.2.1 Threaded

Threaded joints shall have American Standard taper pipe threads conforming to ASME B1.20.1. Only male pipe threads shall be coated with graphite or with an approved graphite compound, or with an inert filler and oil, or shall have a polytetrafluoroethylene tape applied.

3.1.2.2 Mechanical Couplings

Grooved mechanical joints shall be prepared according to the coupling manufacturer's instructions. Pipe and groove dimensions shall comply with the tolerances specified by the coupling manufacturer. The diameter of grooves made in the field shall be measured using a "go/no-go" gauge, vernier or dial caliper, or narrow-land micrometer. Groove width and dimension of groove from end of the pipe shall be measured and recorded for each change in grooving tool setup to verify compliance with coupling manufacturer's tolerances. 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.

3.1.2.3 Unions and Flanges

Unions, flanges and mechanical couplings shall not be concealed in walls, ceilings, or partitions. Unions shall be used on pipe sizes 65 mm (2-1/2 inches) and smaller; flanges shall be used on pipe sizes 80 mm (3 inches) and larger.

3.1.2.4 Grooved Mechanical Joints

Grooves shall be prepared according to the coupling manufacturer's instructions. Grooved fittings, couplings, and grooving tools shall be products of the same manufacturer. Pipe and groove dimensions shall comply with the tolerances specified by the coupling manufacturer. The diameter of grooves made in the field shall be measured using a "go/no-go" gauge, vernier or dial caliper, narrow-land micrometer, or other method specifically approved by the coupling manufacturer for the intended application. Groove width and dimension of groove from end of pipe shall be measured and recorded for each change in grooving tool setup to verify compliance with coupling manufacturer's tolerances. Grooved joints shall not be used in concealed locations.

3.1.2.5 Cast Iron Soil, Waste and Vent Pipe

Bell and spigot compression and hubless gasketed clamp joints for soil, waste and vent piping shall be installed per the manufacturer's

recommendations.

3.1.2.6 Copper Tube and Pipe

The tube or fittings shall not be annealed when making connections.

- a. Brazed. Brazed joints shall be made in conformance with AWS B2.2, MSS SP-73, and CDA Tube Handbook with flux and are acceptable for all pipe sizes. Copper to copper joints shall include the use of copper-phosphorus or copper-phosphorus-silver brazing metal without flux. Brazing of dissimilar metals (copper to bronze or brass) shall include the use of flux with either a copper-phosphorus, copper-phosphorus-silver or a silver brazing filler metal.
- b. Soldered. Soldered joints shall be made with flux and are only acceptable for piping 50 mm (2 inches) and smaller. Soldered joints shall conform to ASME B31.5 and CDA Tube Handbook. Soldered joints shall not be used in compressed air piping between the air compressor and the receiver.
- c. Copper Tube Extracted Joint. An extracted mechanical joint may be made in copper tube. Joint shall be produced with an appropriate tool by drilling a pilot hole and drawing out the tube surface to form a collar having a minimum height of three times the thickness of the tube wall. To prevent the branch tube from being inserted beyond the depth of the extracted joint, dimpled depth stops shall be provided. Branch tube shall be notched for proper penetration into fitting to assure a free flow joint. Extracted joints shall be brazed in accordance with NAPHCC Plumbing Code using B-cup series filler metal in accordance with MSS SP-73. Soldered extracted joints will not be permitted.

3.1.2.7 Plastic Pipe

Acrylonitrile-Butadiene-Styrene (ABS) pipe shall have joints made with solvent cement. PVC and CPVC pipe shall have joints made with solvent cement elastomeric, threading, (threading of Schedule 80 Pipe is allowed only where required for disconnection and inspection; threading of Schedule 40 Pipe is not allowed), or mated flanged.

3.1.3 Dissimilar Pipe Materials

Connections between ferrous and non-ferrous copper water pipe shall be made with dielectric unions or flange waterways. 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. Connecting joints between plastic and metallic pipe shall be made with transition fitting for the specific purpose.

3.1.4 Corrosion Protection for Buried Pipe and Fittings

3.1.4.1 Cast Iron and Ductile Iron

Pressure pipe shall have protective coating, a cathodic protection system, and joint bonding. Pipe, fittings, and joints shall have a protective coating. The protective coating shall be completely encasing polyethylene

tube or sheet in accordance with AWWA C105. Joints and fittings shall be cleaned, coated with primer, and wrapped with tape. The pipe shall be cleaned, coated, and wrapped prior to pipe tightness testing. Joints and fittings shall be cleaned, coated, and wrapped after pipe tightness testing. Tape shall conform to AWWA C203 and shall be applied with a 50 percent overlap. Primer shall be as recommended by the tape manufacturer.

3.1.4.2 Steel

Steel pipe, joints, and fittings shall be cleaned, coated with primer, and wrapped with tape. Pipe shall be cleaned, coated, and wrapped prior to pipe tightness testing. Joints and fittings shall be cleaned, coated, and wrapped after pipe tightness testing. Tape shall conform to AWWA C203 and shall be applied with a 50 percent overlap. Primer shall be as recommended by the tape manufacturer.

3.1.5 Pipe Sleeves and Flashing

Pipe sleeves shall be furnished and set in their proper and permanent location.

3.1.5.1 Sleeve Requirements

Pipes 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. Sleeves are not required for supply, drainage, waste and vent pipe passing through concrete slab on grade, except where penetrating a membrane waterproof floor. A modular mechanical type sealing assembly may be installed in lieu of a waterproofing clamping flange and caulking and sealing of annular space between pipe and sleeve. The seals shall consist of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe and sleeve using galvanized steel bolts, nuts, and pressure plates. The links shall be loosely assembled with bolts to form a continuous rubber belt around the pipe with a pressure plate under each bolt head and each nut. After the seal assembly is properly positioned in the sleeve, tightening of the bolt shall cause the rubber sealing elements to expand and provide a watertight seal between the pipe and the sleeve. Each seal assembly shall be sized as recommended by the manufacturer to fit the pipe and sleeve 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 floor, or roof, and shall be cut flush with each surface, except for special circumstances. Pipe sleeves passing through floors in wet areas such as mechanical equipment rooms, lavatories, kitchens, and other plumbing fixture areas shall extend a minimum of 100 mm above the finished floor. Unless otherwise indicated, sleeves shall be of a size to provide a minimum of 6 mm (1/4 inch) clearance between bare pipe or insulation and inside of sleeve or between insulation and inside of sleeve. Sleeves in bearing walls and concrete slab on grade floors shall be steel pipe or cast-iron pipe. Sleeves in nonbearing walls or ceilings may be steel pipe, cast-iron pipe, galvanized sheet metal with lock-type longitudinal seam, or plastic. Except as otherwise specified, the annular space between pipe and sleeve, or between jacket over insulation and sleeve, shall be sealed as indicated with sealants conforming to ASTM C 920 and with a primer, backstop material and surface preparation as specified in Section 07900A JOINT SEALING. The annular space between pipe and sleeve, between bare insulation and sleeve or between jacket over insulation and sleeve shall not be sealed for interior walls which are not designated as fire rated. Sleeves through below-grade walls in contact

with earth shall be recessed 12 mm (1/2 inch) from wall surfaces on both sides. Annular space between pipe and sleeve shall be filled with backing material and sealants in the joint between the pipe and masonry wall as specified above. Sealant selected for the earth side of the wall shall be compatible with dampproofing/waterproofing materials that are to be applied over the joint sealant. Pipe sleeves in fire-rated walls shall conform to the requirements in Section 07840A FIRESTOPPING.

3.1.5.2 Flashing Requirements

Pipes passing through roof shall be installed through a 4.9 kg per square meter (16 ounce) copper flashing, each within an integral skirt or flange.

Flashing shall be suitably formed, and the skirt or flange shall extend not less than 200 mm from the pipe and shall be set over the roof or floor membrane in a solid coating of bituminous cement. The flashing shall extend up the pipe a minimum of 250 mm. For cleanouts, the flashing shall be turned down into the hub and caulked after placing the ferrule. Pipes passing through pitched roofs shall be flashed, using lead or copper flashing, with an adjustable integral flange of adequate size to extend not less than 200 mm from the pipe in all directions and lapped into the roofing to provide a watertight seal. The annular space between the flashing and the bare pipe or between the flashing and the metal-jacket-covered insulation shall be sealed as indicated. Flashing for dry vents shall be turned down into the pipe to form a waterproof joint. Pipes, up to and including 250 mm (10 inches) in diameter, passing through roof or floor waterproofing membrane may be installed through a cast-iron sleeve with caulking recess, anchor lugs, flashing-clamp device, and pressure ring with brass bolts. Flashing shield shall be fitted into the sleeve clamping device. Pipes passing through wall waterproofing membrane shall be sleeved as described above. A waterproofing clamping flange shall be installed.

3.1.5.3 Waterproofing

Waterproofing at floor-mounted water closets shall be accomplished by forming a flashing guard from soft-tempered sheet copper. The center of the sheet shall be perforated and turned down approximately 40 mm to fit between the outside diameter of the drainpipe and the inside diameter of the cast-iron or steel pipe sleeve. The turned-down portion of the flashing guard shall be embedded in sealant to a depth of approximately 40 mm; then the sealant shall be finished off flush to floor level between the flashing guard and drainpipe. The flashing guard of sheet copper shall extend not less than 200 mm from the drainpipe and shall be lapped between the floor membrane in a solid coating of bituminous cement. If cast-iron water closet floor flanges are used, the space between the pipe sleeve and drainpipe shall be sealed with sealant and the flashing guard shall be upturned approximately 40 mm to fit the outside diameter of the drainpipe and the inside diameter of the water closet floor flange. The upturned portion of the sheet fitted into the floor flange shall be sealed.

3.1.5.4 Optional Counterflashing

Instead of turning the flashing down into a dry vent pipe, or caulking and sealing the annular space between the pipe and flashing or metal-jacket-covered insulation and flashing, counterflashing may be accomplished by utilizing the following:

- a. A standard roof coupling for threaded pipe up to 150 mm (6 inches) in diameter.

- b. A tack-welded or banded-metal rain shield around the pipe.

3.1.5.5 Pipe Penetrations of Slab on Grade Floors

Where pipes, fixture drains, floor drains, cleanouts or similar items penetrate slab on grade floors, except at penetrations of floors with waterproofing membrane as specified in paragraphs Flashing Requirements and Waterproofing, a groove 6 to 13 mm wide by 6 to 10 mm deep shall be formed around the pipe, fitting or drain. The groove shall be filled with a sealant as specified in Section 07900A JOINT SEALING.

3.1.6 Fire Seal

Where pipes pass through fire walls, fire-partitions, fire-rated pipe chase walls or floors above grade, a fire seal shall be provided as specified in Section 07840A FIRESTOPPING.

3.1.7 Supports

3.1.7.1 General

Hangers used to support piping 50 mm (2 inches) 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. 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 members shall not exceed the hanger and support spacing required for an individual pipe in the multiple pipe run. Threaded sections of rods shall not be formed or bent.

3.1.7.2 Pipe Hangers, Inserts, and Supports

Installation of 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.
- 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 shall 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. Type 39 saddles shall be used on insulated pipe 100 mm (4 inches) and larger when the temperature of the medium is 15 degrees C or higher. Type 39 saddles shall be welded to the pipe.
- h. Type 40 shields shall:
- (1) Be used on insulated pipe less than 100 mm (4 inches).
 - (2) Be used on insulated pipe 100 mm (4 inches) and larger when the temperature of the medium is 15 degrees C or less.
 - (3) Have a high density insert for all pipe sizes. High density inserts shall have a density of 128 kg per cubic meter (8 pcf) or greater.
- i. 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 1.5 m apart at valves. Operating temperatures in determining hanger spacing for PVC or CPVC pipe shall be 49 degrees C for PVC and 82 degrees C for CPVC. Horizontal pipe runs shall include allowances for expansion and contraction.
- j. Vertical pipe shall be supported at each floor, except at slab-on-grade, at intervals of not more than 4.5 m nor more than 2 m from end of risers, and at vent terminations. Vertical pipe risers shall include allowances for expansion and contraction.
- k. Type 35 guides using steel, reinforced polytetrafluoroethylene (PTFE) or graphite slides shall be provided to allow longitudinal pipe movement. Slide materials shall be suitable for the system operating temperatures, atmospheric conditions, and bearing loads encountered. Lateral restraints shall be provided as needed. Where steel slides do not require provisions for lateral restraint the following may be used:
- (1) On pipe 100 mm (4 inches) and larger when the temperature of the medium is 15 degrees C or higher, a Type 39 saddle, welded to the pipe, may freely rest on a steel plate.
 - (2) On pipe less than 100 mm (4 inches) a Type 40 shield, attached to the pipe or insulation, may freely rest on a steel plate.
 - (3) On pipe 100 mm (4 inches) and larger carrying medium less than 15 degrees C a Type 40 shield, attached to the pipe or insulation, may freely rest on a steel plate.
- l. Pipe hangers on horizontal insulated pipe shall be the size of the outside diameter of the insulation. The insulation shall be continuous through the hanger on all pipe sizes and applications.
- m. 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.

- n. Hangers and supports for plastic pipe shall not compress, distort, cut or abrade the piping, and shall allow free movement of pipe except where otherwise required in the control of expansion/contraction.

3.1.8 Welded Installation

Plumbing pipe weldments shall be as indicated. 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 connection may be made with either welding tees or forged branch outlet fittings. Branch outlet fittings shall be forged, flared for improvement of flow where attached to the run, and reinforced against external strains. Beveling, alignment, heat treatment, and inspection of weld shall conform to ASME B31.1. Weld defects shall be removed and repairs made to the weld, or the weld joints shall be entirely removed and rewelded. After filler metal has been removed from its original package, it shall be protected or stored so that its characteristics or welding properties are not affected. Electrodes that have been wetted or that have lost any of their coating shall not be used.

3.1.9 Pipe Cleanouts

Pipe cleanouts shall be the same size as the pipe except that cleanout plugs larger than 100 mm (4 inches) will not be required. A cleanout installed in connection with cast-iron soil pipe shall consist of a long-sweep 1/4 bend or one or two 1/8 bends extended to the place shown. An extra-heavy cast-brass or cast-iron ferrule with countersunk cast-brass head screw plug shall be caulked into the hub of the fitting and shall be flush with the floor. Cleanouts in connection with other pipe, where indicated, shall be T-pattern, 90-degree branch drainage fittings with cast-brass screw plugs, except plastic plugs shall be installed in plastic pipe. Plugs shall be the same size as the pipe up to and including 100 mm (4 inches). Cleanout tee branches with screw plug shall be installed at the foot of soil and waste stacks, at the foot of interior downspouts, on each connection to building storm drain where interior downspouts are indicated, and on each building drain outside the building. Cleanout tee branches may be omitted on stacks in single story buildings with slab-on-grade construction or where less than 450 mm of crawl space is provided under the floor. Cleanouts on pipe concealed in partitions shall be provided with chromium plated bronze, nickel bronze, nickel brass or stainless steel flush type access cover plates. Round access covers shall be provided and secured to plugs with securing screw. Square access covers may be provided with matching frames, anchoring lugs and cover screws. Cleanouts in finished walls shall have access covers and frames installed flush with the finished wall. Cleanouts installed in finished floors subject to foot traffic shall be provided with a chrome-plated cast brass, nickel brass, or nickel bronze cover secured to the plug or cover frame and set flush with the finished floor. Heads of fastening screws shall not project above the cover surface. Where cleanouts are provided with adjustable heads, the heads shall be cast iron or plastic.

3.2 WATER HEATERS AND HOT WATER STORAGE TANKS

3.2.1 Relief Valves

No valves shall be installed between a relief valve and its water heater or

storage tank. The P&T relief valve shall be installed where the valve actuator comes in contact with the hottest water in the heater. Whenever possible, the relief valve shall be installed directly in a tapping in the tank or heater; otherwise, the P&T valve shall be installed in the hot-water outlet piping. A vacuum relief valve shall be provided on the cold water supply line to the hot-water storage tank or water heater and mounted above and within 150 mm above the top of the tank or water heater.

3.2.2 Installation of Gas-Fired Water Heater

Installation shall conform to NFPA 54 for gas fired. Storage water heaters that are not equipped with integral heat traps and having vertical pipe risers shall be installed with heat traps directly on both the inlet and outlet. Circulating systems need not have heat traps installed. An acceptable heat trap may be a piping arrangement such as elbows connected so that the inlet and outlet piping make vertically upward runs of not less than 600 mm just before turning downward or directly horizontal into the water heater's inlet and outlet fittings. Commercially available heat traps, specifically designed by the manufacturer for the purpose of effectively restricting the natural tendency of hot water to rise through vertical inlet and outlet piping during standby periods may also be approved. A phenolic resin coating shall be provided.

3.2.3 Phenolic Resin Application Process

The phenolic resin coating shall be applied at either the coil or coating manufacturer's factory. The hot water coil shall be chemically cleaned to remove any scale if present and to etch the metal surface. The exposed exterior surface of the coil shall be abrasively cleaned to white metal blast in accordance with SSPC SP 5. The exterior surface shall be coated with the three-component coating system in the following sequence and manner. For immediate and final cure times and temperature, the recommendations of the coating manufacturer shall be followed.

- a. Wash Primer. One coat of wash primer shall be applied by flooding.
- b. Pigmented Base Coat. Pigmented baking phenolic coating shall be applied in several coats by immersion or flooding to a dry film thickness of 0.10 to 0.15 mm.
- c. Clear Top Coat. Clear non-pigmented baking phenolic top coat shall be applied in several coats by immersion or flooding. The final coat may be applied by spraying. The dry film thickness of the total coating system shall be between 0.13 and 0.18 mm.

3.2.4 Heat Traps

Piping to and from each water heater and hot water storage tank shall be routed horizontally and downward a minimum of 600 mm before turning in an upward direction.

3.2.5 Connections to Water Heaters

Connections of metallic pipe to water heaters shall be made with dielectric unions or flanges.

3.2.6 Expansion Tank

A pre-charged expansion tank shall be installed on the cold water supply

between the water heater inlet and the cold water supply shut-off valve. The Contractor shall adjust the expansion tank air pressure, as recommended by the tank manufacturer, to match incoming water pressure.

3.3 FIXTURES AND FIXTURE TRIMMINGS

Polished chromium-plated pipe, valves, and fittings shall be provided where exposed to view. Angle stops, straight stops, stops integral with the faucets, or concealed type of lock-shield, and loose-key pattern stops for supplies with threaded, sweat or solvent weld inlets shall be furnished and installed with fixtures. Where connections between copper tubing and faucets are made by rubber compression fittings, a beading tool shall be used to mechanically deform the tubing above the compression fitting. Exposed traps and supply pipes for fixtures and equipment shall be connected to the rough piping systems at the wall, unless otherwise specified under the item. Floor and wall escutcheons shall be as specified. Drain lines and hot water lines of fixtures for handicapped personnel shall be insulated and do not require polished chrome finish. Plumbing fixtures and accessories shall be installed within the space shown.

3.3.1 Fixture Connections

Where space limitations prohibit standard fittings in conjunction with the cast-iron floor flange, special short-radius fittings shall be provided. Connections between earthenware fixtures and flanges on soil pipe shall be made gastight and watertight with a closet-setting compound or neoprene gasket and seal. Use of natural rubber gaskets or putty will not be permitted. Fixtures with outlet flanges shall be set the proper distance from floor or wall to make a first-class joint with the closet-setting compound or gasket and fixture used.

3.3.2 Flushometer Valves

Flushometer valves shall be secured to prevent movement by anchoring the long finished top spud connecting tube to wall adjacent to valve with approved metal bracket. Flushometer valves for water closets shall be installed 1 m above the floor, except at water closets intended for use by the physically handicapped where flushometer valves shall be mounted at approximately 760 mm above the floor and arranged to avoid interference with grab bars. In addition, for water closets intended for handicap use, the flush valve handle shall be installed on the wide side of the enclosure. Bumpers for water closet seats shall be installed on the flushometer spud.

3.3.3 Height of Fixture Rims Above Floor

Lavatories shall be mounted with rim 775 mm above finished floor. Wall-hung drinking fountains and water coolers shall be installed with rim 1020 mm above floor. Wall-hung service sinks shall be mounted with rim 700 mm above the floor. Installation of fixtures for use by the physically handicapped shall be in accordance with CABO A117.1.

3.3.4 Shower Outfits

The area around the water supply piping to the mixing valves and behind the escutcheon plate shall be made watertight by caulking or gasketing.

3.3.5 Fixture Supports

Fixture supports for off-the-floor lavatories, urinals, water closets, and other fixtures of similar size, design, and use, shall be of the chair-carrier type. The carrier shall provide the necessary means of mounting the fixture, with a foot or feet to anchor the assembly to the floor slab. Adjustability shall be provided to locate the fixture at the desired height and in proper relation to the wall. Support plates, in lieu of chair carrier, shall be fastened to the wall structure only where it is not possible to anchor a floor-mounted chair carrier to the floor slab.

3.3.5.1 Support for Solid Masonry Construction

Chair carrier shall be anchored to the floor slab. Where a floor-anchored chair carrier cannot be used, a suitable wall plate shall be imbedded in the masonry wall.

3.3.5.2 Support for Concrete-Masonry Wall Construction

Chair carrier shall be anchored to floor slab. Where a floor-anchored chair carrier cannot be used, a suitable wall plate shall be fastened to the concrete wall using through bolts and a back-up plate.

3.3.5.3 Support for Steel Stud Frame Partitions

Chair carrier shall be used. The anchor feet and tubular uprights shall be of the heavy duty design; and feet (bases) shall be steel and welded to a square or rectangular steel tube upright. Wall plates, in lieu of floor-anchored chair carriers, shall be used only if adjoining steel partition studs are suitably reinforced to support a wall plate bolted to these studs.

3.3.5.4 Wall-Mounted Water Closet Gaskets

Where wall-mounted water closets are provided, reinforced wax, treated felt, or neoprene gaskets shall be provided. The type of gasket furnished shall be as recommended by the chair-carrier manufacturer.

3.3.6 Backflow Prevention Devices

Plumbing fixtures, equipment, and pipe connections shall not cross connect or interconnect between a potable water supply and any source of nonpotable water. Backflow preventers shall be installed where indicated and in accordance with ICC Plumbing Code at all other locations necessary to preclude a cross-connect or interconnect between a potable water supply and any nonpotable substance. In addition backflow preventers shall be installed at all locations where the potable water outlet is below the flood level of the equipment, or where the potable water outlet will be located below the level of the nonpotable substance. Backflow preventers shall be located so that no part of the device will be submerged. Backflow preventers shall be of sufficient size to allow unrestricted flow of water to the equipment, and preclude the backflow of any nonpotable substance into the potable water system. Bypass piping shall not be provided around backflow preventers. Access shall be provided for maintenance and testing. Each device shall be a standard commercial unit.

3.3.7 Access Panels

Access panels shall be provided for concealed valves and controls, or any item requiring inspection or maintenance. Access panels shall be of sufficient size and located so that the concealed items may be serviced,

maintained, or replaced. Access panels shall be as specified in Section 05500A MISCELLANEOUS METAL.

3.3.8 Sight Drains

Sight drains shall be installed so that the indirect waste will terminate 50 mm above the flood rim of the funnel to provide an acceptable air gap.

3.3.9 Traps

Each trap shall be placed as near the fixture as possible, and no fixture shall be double-trapped. Traps installed on cast-iron soil pipe shall be cast iron. Traps installed on steel pipe or copper tubing shall be recess-drainage pattern, or brass-tube type. Traps installed on plastic pipe may be plastic conforming to ASTM D 3311. Traps for acid-resisting waste shall be of the same material as the pipe.

3.3.10 Shower Pans

Before installing shower pan, subfloor shall be free of projections such as nail heads or rough edges of aggregate. Drain shall be a bolt-down, clamping-ring type with weepholes, installed so the lip of the subdrain is flush with subfloor.

3.3.10.1 General

The floor of each individual shower, the shower-area portion of combination shower and drying room, and the entire shower and drying room where the two are not separated by curb or partition, shall be made watertight with a shower pan fabricated in place. The shower pan material shall be cut to size and shape of the area indicated, in one piece to the maximum extent practicable, allowing a minimum of 150 mm for turnup on walls or partitions, and shall be folded over the curb with an approximate return of 1/4 of curb height. The upstands shall be placed behind any wall or partition finish. Subflooring shall be smooth and clean, with nailheads driven flush with surface, and shall be sloped to drain. Shower pans shall be clamped to drains with the drain clamping ring.

3.3.10.2 Metal Shower Pans

When a shower pan of required size cannot be furnished in one piece, metal pieces shall be joined with a flatlock seam and soldered or burned. The corners shall be folded, not cut, and the corner seam shall be soldered or burned. Pans, including upstands, shall be coated on all surfaces with one brush coat of asphalt. Asphalt shall be applied evenly at not less than 1 liter per square meter. A layer of felt covered with building paper shall be placed between shower pans and wood floors. The joining surfaces of metal pan and drain shall be given a brush coat of asphalt after the pan is connected to the drain.

3.3.10.3 Nonplasticized Chlorinated Polyethylene Shower Pans

Corners of nonplasticized chlorinated polyethylene shower pans shall be folded against the upstand by making a pig-ear fold. Hot-air gun or heat lamp shall be used in making corner folds. Each pig-ear corner fold shall be nailed or stapled 12 mm from the upper edge to hold it in place. Nails shall be galvanized large-head roofing nails. On metal framing or studs, approved duct tape shall be used to secure pig-ear fold and membrane. Where no backing is provided between the studs, the membrane slack shall be

taken up by pleating and stapling or nailing to studding 12 mm from upper edge. To adhere the membrane to vertical surfaces, the back of the membrane and the surface to which it will be applied shall be coated with adhesive that becomes dry to the touch in 5 to 10 minutes, after which the membrane shall be pressed into place. Surfaces to be solvent-welded shall be clean. Surfaces to be joined with xylene shall be initially sprayed and vigorously cleaned with a cotton cloth, followed by final coating of xylene and the joining of the surfaces by roller or equivalent means. If ambient or membrane temperatures are below 4 degrees C the membrane and the joint shall be heated prior to application of xylene. Heat may be applied with hot-air gun or heat lamp, taking precautions not to scorch the membrane. Adequate ventilation and wearing of gloves are required when working with xylene. Membrane shall be pressed into position on the drain body, and shall be cut and fit to match so that membrane can be properly clamped and an effective gasket-type seal provided. On wood subflooring, two layers of 0.73 kg per square meter (15 pound) dry felt shall be installed prior to installation of shower pan to ensure a smooth surface for installation.

3.3.10.4 Nonplasticized Polyvinyl Chloride (PVC) Shower Pans

Nonplasticized PVC shall be turned up behind walls or wall surfaces a distance of not less than 150 mm in room areas and 75 mm above curb level in curbed spaces with sufficient material to fold over and fasten to outside face of curb. Corners shall be pig-ear type and folded between pan and studs. Only top 25 mm of upstand shall be nailed to hold in place. Nails shall be galvanized large-head roofing type. Approved duct tape shall be used on metal framing or studs to secure pig-ear fold and membrane. Where no backing is provided between studs, the membrane slack shall be taken up by pleating and stapling or nailing to studding at top inch of upstand. To adhere the membrane to vertical surfaces, the back of the membrane and the surface to which it is to be applied shall be coated with adhesive that becomes dry to the touch in 5 to 10 minutes, after which the membrane shall be pressed into place. Trim for drain shall be exactly the size of drain opening. Bolt holes shall be pierced to accommodate bolts with a tight fit. Adhesive shall be used between pan and subdrain. Clamping ring shall be bolted firmly. A small amount of gravel or porous materials shall be placed at weepholes so that holes remain clear when setting bed is poured. Membrane shall be solvent welded with PVC solvent cement. Surfaces to be solvent welded shall be clean (free of grease and grime). Sheets shall be laid on a flat surface with an overlap of about 50 mm. Top edge shall be folded back and surface primed with a PVC primer. PVC cement shall be applied and surfaces immediately placed together, while still wet. Joint shall be lightly rolled with a paint roller, then as the joint sets shall be rolled firmly but not so hard as to distort the material. In long lengths, about 600 or 900 mm at a time shall be welded. On wood subflooring, two layers of 0.73 kg per square meter (15 pound) felt shall be installed prior to installation of shower pan to ensure a smooth surface installation.

3.4 VIBRATION-ABSORBING FEATURES

Mechanical equipment, including compressors and pumps, shall be isolated from the building structure by approved vibration-absorbing features, unless otherwise shown. Each foundation shall include an adequate number of standard isolation units. Each unit shall consist of machine and floor or foundation fastening, together with intermediate isolation material, and shall be a standard product with printed load rating. Piping connected to mechanical equipment shall be provided with flexible connectors. Isolation unit installation shall limit vibration to 80% percent of the lowest

equipment rpm.

3.5 WATER METER REMOTE READOUT REGISTER

The remote readout register shall be mounted at the location indicated or as directed by the Contracting Officer.

3.6 IDENTIFICATION SYSTEMS

3.6.1 Identification Tags

Identification tags made of brass, engraved laminated plastic, or engraved anodized aluminum, indicating service and valve number shall be installed on valves, except those valves installed on supplies at plumbing fixtures. Tags shall be 35 mm (1-3/8 inch) minimum diameter, and marking shall be stamped or engraved. Indentations shall be black, for reading clarity. Tags shall be attached to valves with No. 12 AWG, copper wire, chrome-plated beaded chain, or plastic straps designed for that purpose.

3.6.2 Pipe Color Code Marking

Color code marking of piping shall be as specified in Section 09900 PAINTS AND COATINGS.

3.7 ESCUTCHEONS

Escutcheons shall be provided at finished surfaces where bare or insulated piping, exposed to view, passes through floors, walls, or ceilings, except in boiler, utility, or equipment rooms. Escutcheons shall be fastened securely to pipe or pipe covering and shall be satin-finish, corrosion-resisting steel, polished chromium-plated zinc alloy, or polished chromium-plated copper alloy. Escutcheons shall be either one-piece or split-pattern, held in place by internal spring tension or setscrew.

3.8 PAINTING

Painting of pipes, hangers, supports, and other iron work, either in concealed spaces or exposed spaces, is specified in Section 09900 PAINTS AND COATINGS.

3.9 TESTS, FLUSHING AND DISINFECTION

3.9.1 Plumbing System

The following tests shall be performed on the plumbing system in accordance with ICC Plumbing Code.

- a. Drainage and Vent Systems Test. The final test shall include a smoke test.
- b. Building Sewers Tests.
- c. Water Supply Systems Tests.

3.9.1.1 Test of Backflow Prevention Assemblies

Backflow prevention assembly shall be tested using gauges specifically designed for the testing of backflow prevention assemblies. Gauges shall be tested annually for accuracy in accordance with the University of

Southern California's Foundation of Cross Connection Control and Hydraulic Research or the American Water Works Association Manual of Cross Connection (Manual M-14). Report form for each assembly shall include, as a minimum, the following:

Data on Device	Data on Testing Firm
Type of Assembly	Name
Manufacturer	Address
Model Number	Certified Tester
Serial Number	Certified Tester No.
Size	Date of Test
Location	
Test Pressure Readings	Serial Number and Test Data of
Gauges	

If the unit fails to meet specified requirements, the unit shall be repaired and retested.

3.9.1.2 Shower Pans

After installation of the pan and finished floor, the drain shall be temporarily plugged below the weep holes. The floor area shall be flooded with water to a minimum depth of 25 mm for a period of 24 hours. Any drop in the water level during test, except for evaporation, will be reason for rejection, repair, and retest.

3.9.2 Defective Work

If inspection or test shows defects, such defective work or material shall be replaced or repaired as necessary and inspection and tests shall be repeated. Repairs to piping shall be made with new materials. Caulking of screwed joints or holes will not be acceptable.

3.9.3 System Flushing

3.9.3.1 During Flushing

Before operational tests or disinfection, potable water piping system shall be flushed with potable water. Sufficient water shall be used to produce a water velocity that is capable of entraining and removing debris in all portions of the piping system. This requires simultaneous operation of all fixtures on a common branch or main in order to produce a flushing velocity of approximately 1.2 meters per second (4 fps) through all portions of the piping system. In the event that this is impossible due to size of system, the Contracting Officer (or the designated representative) shall specify the number of fixtures to be operated during flushing. Contractor shall provide adequate personnel to monitor the flushing operation and to ensure that drain lines are unobstructed in order to prevent flooding of the facility. Contractor shall be responsible for any flood damage resulting from flushing of the system. Flushing shall be continued until entrained dirt and other foreign materials have been removed and until discharge water shows no discoloration.

3.9.3.2 After Flushing

System shall be drained at low points. Strainer screens shall be removed, cleaned, and replaced. After flushing and cleaning, systems shall be prepared for testing by immediately filling water piping with clean, fresh potable water. Any stoppage, discoloration, or other damage to the finish,

furnishings, or parts of the building due to the Contractor's failure to properly clean the piping system shall be repaired by the Contractor. When the system flushing is complete, the hot-water system shall be adjusted for uniform circulation. Flushing devices and automatic control systems shall be adjusted for proper operation. All faucets and drinking water fountains, to include any device considered as an end point device by NSF 61, Section 9, shall be flushed a minimum of 1 L per 24 hour period, ten times over a 14 day period.

3.9.4 Operational Test

Upon completion of flushing and prior to disinfection procedures, the Contractor shall subject the plumbing system to operating tests to demonstrate satisfactory functional and operational efficiency. Such operating tests shall cover a period of not less than 8 hours for each system and shall include the following information in a report with conclusion as to the adequacy of the system:

- a. Time, date, and duration of test.
- b. Water pressures at the most remote and the highest fixtures.
- c. Operation of each fixture and fixture trim.
- d. Operation of each valve, hydrant, and faucet.
- e. Pump suction and discharge pressures.
- f. Temperature of each domestic hot-water supply.
- g. Operation of each floor and roof drain by flooding with water.
- h. Operation of each vacuum breaker and backflow preventer.
- i. Complete operation of each water pressure booster system, including pump start pressure and stop pressure.
- j. Compressed air readings at each compressor and at each outlet. Each indicating instrument shall be read at 1/2 hour intervals. The report of the test shall be submitted in quadruplicate. The Contractor shall furnish instruments, equipment, and personnel required for the tests; the Government will furnish the necessary water and electricity.

3.9.5 Disinfection

After operational tests are complete, the entire domestic hot- and cold-water distribution system shall be disinfected. System shall be flushed as specified, before introducing chlorinating material. The chlorinating material shall be hypochlorites or liquid chlorine. Water chlorination procedure shall be in accordance with AWWA M20. The chlorinating material shall be fed into the water piping system at a constant rate at a concentration of at least 50 parts per million (ppm). A properly adjusted hypochlorite solution injected into the main with a hypochlorinator, or liquid chlorine injected into the main through a solution-feed chlorinator and booster pump, shall be used. The chlorine residual shall be checked at intervals to ensure that the proper level is maintained. Chlorine application shall continue until the entire main is filled. The water shall remain in the system for a minimum of 24 hours.

Each valve in the system being disinfected shall be opened and closed several times during the contact period to ensure its proper disinfection. Following the 24-hour period, no less than 25 ppm chlorine residual shall remain in the system. Water tanks shall be disinfected by the addition of chlorine directly to the filling water. Following a 6 hour period, no less than 50 ppm chlorine residual shall remain in the tank. If after the 24 hour and 6 hour holding periods, the residual solution contains less than 25 ppm and 50 ppm chlorine respectively, flush the piping and tank with potable water, and repeat the above procedures until the required residual chlorine levels are satisfied. The system including the tanks shall then be flushed with clean water until the residual chlorine level is reduced to less than one part per million. During the flushing period each valve and faucet shall be opened and closed several times. Samples of water in disinfected containers shall be obtained from several locations selected by the Contracting Officer. The samples of water shall be tested for total coliform organisms (coliform bacteria, fecal coliform, streptococcal, and other bacteria) in accordance with AWWA EWW. The testing method used shall be either the multiple-tube fermentation technique or the membrane-filter technique. Disinfection shall be repeated until tests indicate the absence of coliform organisms (zero mean coliform density per 100 milliliters) in the samples for at least 2 full days. The system will not be accepted until satisfactory bacteriological results have been obtained.

3.9.6 Flushing of Potable Water System

As an option to the system flushing specified above, the potable water system shall be flushed and conditioned until the residual level of lead is less than that specified by the base industrial hygienist. The water supply to the building shall be tested separately to ensure that any lead contamination found during potable water system testing is due to work being performed inside the building.

3.10 PLUMBING FIXTURE SCHEDULE

P-1 WATER CLOSET:

Siphon-jet, elongated bowl, top supply spud, ASME A112.19.2M, floor mounted. Floor flange shall be copper alloy, cast iron, or plastic.

Gasket shall be wax type.

Seat - IAPMO Z124.5, Type A, white plastic, elongated, open front.

Flushometer Valve - ASSE 1037, large diaphragm type with non-hold-open feature, backcheck angle control stop, and vacuum breaker. Minimum upper chamber inside diameter of not less than 66.7 mm (2-5/8 inches) at the point where the diaphragm is sealed between the upper and lower chambers. The maximum water use shall be 6 liters per flush.

[AM0002}

~~Flush Valve in Flush Tank — Flush valve seats in tanks for flushing water closets shall be at least 25 mm (1 inch) above the flood level rim of the bowl connected thereto, except in approved water closet and flush tank combinations designed so that when the tank is flushed and the fixture is clogged or partially clogged, the flush valve shall close tightly so that water will not spill continuously over the rim of the bowl or back flow from the bowl to the tank.~~

P-2 WATER CLOSET HANDICAPPED:

Height of top rim of bowl shall be in accordance with CABO A117.1; other features are the same as P-1.

P-3 WATER CLOSET:

Siphon-jet, elongated bowl, top supply spud, ASME A112.19.2M, floor mounted. Floor flange shall be copper alloy, cast iron, or plastic.

Gasket shall be wax type.

Seat - IAPMO Z124.5, Type A, white plastic, elongated, open front.

Flush Tank - An adequate quantity of water shall be provided to flush and clean the fixture served. The water supply to flush tanks equipped for manual flushing shall be controlled by a float valve or other automatic device designed to refill the tank after each discharge, and to completely shut off the water flow to the tank when the tank is filled to operational capacity. Water closets having their flush valve seat located below the flood level rim of the closet bowl shall have a ballcock installed within a sheath or in a separate and isolated compartment of the tank, both to have visible discharge onto the floor in case of failure. Provision shall be made to automatically supply water to the fixture so as to refill the trap seal after each flushing. The water supply to flush tanks equipped for automatic flushing shall be controlled by a suitable timing device. Ballcocks shall meet ASSE 1002.

Flush Valve in Flush Tank - Flush valve seats in tanks for flushing water closets shall be at least 25 mm (1 inch) above the flood level rim of the bowl connected thereto, except in approved water closet and flush tank combinations designed so that when the tank is flushed and the fixture is clogged or partially clogged, the flush valve shall close tightly so that water will not spill continuously over the rim of the bowl or back flow from the bowl to the tank.

P-4 URINAL:

Wall hanging, with integral trap and extended shields, ASME A112.19.2M siphon jet. Top supply connection, back outlet.

Flushometer Valve - Similar to Flushometer Valve for P-1. The maximum water use shall be 3.8 liters per flush.

P-5 URINAL HANDICAPPED:

Height of top rim of bowl shall be in accordance with CABP A117.1; other features are the same as P-4

P-6 LAVATORY:

Manufacturer's standard sink depth, vitreous china ASME A112.19.2M, countertop, oval, counter top mount.

Faucet - Faucets shall meet the requirements of NSF 61, Section 9. Faucets shall be single type. Faucets shall have replaceable seats and washers. Valves and handles shall be copper alloy. The flow shall be limited to 0.16 liters per second at a flowing pressure of 549 kPa.

Handles - Lever type. Cast, formed, or drop forged copper alloy.

Drain - Pop-up drain shall include stopper, lift rods, jam nut, washer, and tail piece. See paragraph FIXTURES for optional plastic accessories.

P-7 LAVATORY, HANDICAPPED:

All features are the same as P-6.

P-8 Shower: Shower heads, CID A-A-240 shall be adjustable spray type and shall include a non-removable, tamperproof device to limit water flow to 0.16 liters per second (2.5 gpm) when tested in accordance with ASME A112.18.1M.

Wall Mounted: Shower head shall be adjustable spray, stainless steel or chromium plated brass with ball joint. Handles shall be manufacturer's option. Control valves shall be copper alloy and have metal integral parts of copper alloy, nickel alloy, or stainless steel. Valves shall be thermostatic mixing type. Shower head shall be vandalproof with integral back.

P-9 LAUNDRY SINK:

Double bowl, leg support 1219 x 508.0 mm (48 x 20 inches), stainless steel ASME A112.19.3M.

Faucet and Spout - Cast copper alloy, wrought copper alloy, cast iron, or stainless steel, with backflow preventer. Faucets shall have replaceable seat and the stem shall rotate onto the seat. Strainers shall have internal threads. Combination faucets shall be mounted on the tub back. Spouts shall be externally threaded for hose connection.

Handles - Cast copper alloy, wrought copper alloy, or stainless steel, lever type.

Traps - Copper alloy, or cast iron.

P-10 SERVICE SINK:

Enameled cast iron ASME A112.19.1M, copper alloy or stainless steel ASME A112.19.3M corner, floor mounted 711.2 mm (28 inches) square, 171.5 mm (6-3/4 inches) deep.

Faucet and Spout - Cast or wrought copper alloy, with top or bottom brace, with backflow preventer. Faucets shall have replaceable seat and the washer shall rotate onto the seat. Handles shall be four arm type. Strainers shall have internal threads.

Drain Assembly - Plug, cup strainer, crossbars, jam nuts, washers, couplings, stopper, etc., shall be copper alloy or stainless steel.

Trap - Cast iron, minimum 7.5 cm diameter.

P-11 WASHER CONNECTION BOX

The box shall be fabricated from 16 gauge steel, 9" high, 10-3/4" wide, with 2" drain connection and a white epoxy finish.

Valve - ball type with bottom supply and 1/2" sweat connection.

P-12 ELECTRIC DRINKING FOUNTAIN BI-LEVEL:

Drinking fountains shall meet the requirements of NSF 61, Section 9. Water cooler drinking fountains shall: be self contained, conform to ARI 1010, use one of the fluorocarbon gases conforming to ARI 700 and ASHRAE 34 which has an Ozone Depletion Potential of less than or equal to 0.05, have a capacity to deliver 30.2 liters per hour (8 gph) of water at 10 degrees C (50 degrees F) with an inlet water temperature of 27 degrees C (80 degrees F) while residing in a room environment of 32 degrees C (90 degrees F), and have self-closing valves. Self-closing valves shall have automatic stream regulators, have a flow control capability, have a push button actuation or have a cross-shaped index metal turn handle without a hood. Exposed surfaces of stainless steel shall have No. 4 general polish finish.

Spouts shall provide a flow of water at least 100 mm (4 inches) high so as to allow the insertion of a cup or glass under the flow of water.

Surface Wall-Mounted - One unit shall be surface wall-mounted 336.6 mm wide, 330.2 mm deep, and have a back height of 152.4 to 203.2 mm. The bowl shall be made of stainless steel. The unit shall have concealed fasteners and be for interior installation.

Handicapped - One unit shall be Handicapped type, surface wall-mounted. The dimensions shall be 381.0 mm (15 inches) wide, 508.0 mm (20 inches) deep, with a back height of 152.4 to 203.2 mm (6 to 8 inches). The unit shall clear the floor or ground by at least 200 mm (8 inches). A clear knee space shall exist between the bottom of the bowl and the floor or ground of at least 685 mm (27 inches) and between the front edge of the bowl and the body of the unit of at least 200 mm (8 inches). A 200 mm (8 inch) wide clear space shall exist on both sides of the unit. The spout height shall be no more than 1 m (36 inches) above the floor or ground to the outlet. The spout shall be at the front of the unit and direct the water flow in a trajectory that is parallel or nearly parallel to the front of the unit. The bowl shall be 165.1 mm (6-1/2 inches) high, made of stainless steel and be for interior installation.

3.11 POSTED INSTRUCTIONS

Framed instructions under glass or in laminated plastic, including wiring and control diagrams showing the complete layout of the entire system, shall be posted where directed. Condensed operating instructions explaining preventive maintenance procedures, methods of checking the system for normal safe operation, and procedures for safely starting and stopping the system shall be prepared in typed form, framed as specified above for the wiring and control diagrams and posted beside the diagrams. The framed instructions shall be posted before acceptance testing of the systems.

3.12 PERFORMANCE OF WATER HEATING EQUIPMENT

Standard rating condition terms are as follows:

EF = Energy factor, overall efficiency.

ET = Thermal efficiency with 21 degrees C delta T.

EC = Combustion efficiency, 100 percent - flue loss when smoke = 0 (trace is permitted).

SL = Standby loss in W/0.093 sq. m. based on 27 degrees C delta T, or
in percent per hour based on nominal 38 degrees C delta T.

HL = Heat loss of tank surface area.

V = Storage volume in liters

3.13 TABLES

TABLE I
PIPE AND FITTING MATERIALS FOR
DRAINAGE, WASTE, AND VENT PIPING SYSTEMS

Item #	Pipe and Fitting Materials	SERVICE					
		A	B	C	D	E	F
1	Cast iron soil pipe and fittings, hub and spigot, ASTM A 74 with compression gaskets	X	X	X	X	X	
2	Cast iron soil pipe and fittings hubless, CISPI 301 and ASTM A 888		X	X	X	X	
3	Cast iron drainage fittings, threaded, ASME B16.12 for use with Item 10	X		X	X		
4	Cast iron screwed fittings (threaded) ASME B16.4 for use with Item 10				X	X	
5	Grooved pipe couplings, ferrous and non-ferrous pipe ASTM A 536 and ASTM A 47/A 47M	X	X		X	X	
6	Ductile iron grooved joint fittings for ferrous pipe ASTM A 536 and ASTM A 47/A 47M for use with Item 5	X	X		X	X	
7	Bronze sand casting grooved joint pressure fittings for non-ferrous pipe ASTM B 584, for use with Item 5	X	X		X	X	
8	Wrought copper grooved joint pressure fittings for non-ferrous pipe ASTM B 75M C12200, ASTM B 152, ASTM B 152M, C11000, ASME B16.22 ASME B16.22 for use with Item 5	X	X				
9	Malleable-iron threaded fittings, galvanized ASME B16.3 for use with Item 10				X	X	
10	Steel pipe, seamless galvanized, ASTM A 53/A 53M, Type S, Grade B	X			X	X	
11	Seamless red brass pipe, ASTM B 43		X	X			
12	Bronzed flanged fittings, ASME B16.24 for use with Items 11 and 14				X	X	

TABLE I
PIPE AND FITTING MATERIALS FOR
DRAINAGE, WASTE, AND VENT PIPING SYSTEMS

Item #	Pipe and Fitting Materials	SERVICE					
		A	B	C	D	E	F
13	Cast copper alloy solder joint pressure fittings, ASME B16.18 for use with Item 14				X	X	
14	Seamless copper pipe, ASTM B 42				X		
15	Cast bronze threaded fittings, ASME B16.15				X	X	
16	Copper drainage tube, (DWV), ASTM B 306	X*	X	X*	X	X	
17	Wrought copper and wrought alloy solder-joint drainage fittings. ASME B16.29	X	X	X	X	X	
18	Cast copper alloy solder joint drainage fittings, DWV, ASME B16.23	X	X	X	X	X	
19	Acrylonitrile-Butadiene-Styrene (ABS) plastic drain, waste, and vent pipe and fittings ASTM D 2661, ASTM F 628	X	X	X	X	X	X
20	Polyvinyl Chloride plastic drain, waste and vent pipe and fittings, ASTM D 2665, ASTM F 891, (Sch 40) ASTM F 1760	X	X	X	X	X	X
22	High-silicon content cast iron pipe and fittings (hub and spigot, and mechanical joint), ASTM A 518/A 518M		X			X	X

SERVICE:

- A - Underground Building Soil, Waste and Storm Drain
- B - Aboveground Soil, Waste, Drain In Buildings
- C - Underground Vent
- D - Aboveground Vent
- E - Interior Rainwater Conductors Aboveground
- F - Corrosive Waste And Vent Above And Belowground
- * - Hard Temper

TABLE II
PIPE AND FITTING MATERIALS FOR PRESSURE PIPING SYSTEMS

Item No.	Pipe and Fitting Materials	SERVICE			
		A	B	C	D
1	Malleable-iron threaded fittings, a. Galvanized, ASME B16.3 for use with Item 4a	X	X	X	X
2	Grooved pipe couplings, ferrous pipe ASTM A 536 and ASTM A 47/A 47M, non-ferrous pipe, ASTM A 536 and ASTM A 47/A 47M,	X	X	X	
3	Ductile iron grooved joint fittings for ferrous pipe ASTM A 536 and ASTM A 47/A 47M, for use with Item 2	X	X	X	
4	Steel pipe: a. Seamless, galvanized, ASTM A 53/A 53M, Type S, Grade B b. Seamless, black, ASTM A 53/A 53M, Type S, Grade B	X	X	X	X
5	Seamless red brass pipe, ASTM B 43	X	X		X
6	Bronze flanged fittings, ASME B16.24 for use with Items 5 and 7	X	X		X
7	Seamless copper pipe, ASTM B 42	X	X		X
8	Seamless copper water tube, ASTM B 88, ASTM B 88M	X**	X**	X**	X***
9	Cast bronze threaded fittings, ASME B16.15 for use with Items 5 and 7	X	X		X
10	Wrought copper and bronze solder-joint pressure fittings, ASME B16.22 for use with Items 5 and 7	X	X	X	X
11	Cast copper alloy solder-joint pressure fittings, ASME B16.18 for use with Items 8 and 9	X	X	X	X

TABLE II
PIPE AND FITTING MATERIALS FOR PRESSURE PIPING SYSTEMS

Item No.	Pipe and Fitting Materials	SERVICE			
		A	B	C	D
12	Bronze and sand castings grooved joint pressure fittings for non-ferrous pipe ASTM B 584, for use with Item 2	X	X	X	
13	Polyethylene (PE) plastic pipe, Schedules 40 and 80, based on outside diameter ASTM D 2447	X			X
14	Polyethylene (PE) plastic pipe (SDR-PR), based on controlled outside diameter, ASTM D 3035	X			X
15	Polyethylene (PE) plastic pipe (SIDR-PR), based on controlled inside diameter, ASTM D 2239	X			X
16	Butt fusion polyethylene (PE) plastic pipe fittings, ASTM D 3261 for use with Items 14, 15, and 16	X			X
17	Socket-type polyethylene fittings for outside diameter-controlled polyethylene pipe, ASTM D 2683 for use with Item 15	X			X
18	Polyethylene (PE) plastic tubing, ASTM D 2737	X			X
19	Chlorinated polyvinyl chloride (CPVC) plastic hot and cold water distribution system, ASTM D 2846/D 2846M	X	X		X
20	Chlorinated polyvinyl chloride (CPVC) plastic pipe, Schedule 40 and 80, ASTM F 441/F 441M	X	X		X
21	Chlorinated polyvinyl chloride (CPVC) plastic pipe (SDR-PR) ASTM F 442/F 442M	X	X		X
22	Threaded chlorinated polyvinyl chloride (chloride CPVC) plastic pipe fittings, Schedule 80, ASTM F 437, for use with Items 20, and 21	X	X		X

TABLE II
PIPE AND FITTING MATERIALS FOR PRESSURE PIPING SYSTEMS

Item No.	Pipe and Fitting Materials	SERVICE			
		A	B	C	D
23	Socket-type chlorinated polyvinyl chloride (CPVC) plastic pipe fittings, Schedule 40, ASTM F 438 for use with Items 20, 21, and 22	X	X		X
24	Socket-type chlorinated polyvinyl chloride (CPVC) plastic pipe fittings Schedule 80, ASTM F 439 for use with Items 20, 21, and 22	X	X		X
25	Polyvinyl chloride (PVC) plastic pipe, Schedules 40, 80, and 120, ASTM D 1785	X			X
26	Polyvinyl chloride (PVC) pressure-rated pipe (SDR Series), ASTM D 2241	X			X
27	Polyvinyl chloride (PVC) plastic pipe fittings, Schedule 40, ASTM D 2466	X			X
28	Socket-type polyvinyl chloride (PVC) plastic pipe fittings, schedule 80, ASTM D 2467 for use with Items 26 and 27	X			X
29	Threaded polyvinyl chloride (PVC) plastic pipe fittings, schedule 80, ASTM D 2464	X			X
30	Joints for IPS pvs pipe using solvent cement, ASTM D 2672	X			X
31	Filament-wound reinforced thermosetting resin (RTRP) pipe, ASTM D 2996	X	X		
32	Steel pipeline flanges, MSS SP-44	X	X		
33	Fittings: brass or bronze; ASME B16.15, and ASME B16.18 ASTM B 828	X	X		
34	Carbon steel pipe unions, socket-welding and threaded, MSS SP-83	X	X	X	

TABLE II
PIPE AND FITTING MATERIALS FOR PRESSURE PIPING SYSTEMS

Item No.	Pipe and Fitting Materials	SERVICE			
		A	B	C	D
35	Malleable-iron threaded pipe unions ASME B16.39	X	X		
36	Nipples, pipe threaded ASTM A 733	X	X	X	
37	Crosslinked Polyethylene (PEX) Plastic Pipe ASTM F 877.	X			X

A - Cold Water Aboveground

B - Hot Water 82 degree C Maximum Aboveground

C - Compressed Air Lubricated

D - Cold Water Service Belowground

Indicated types are minimum wall thicknesses.

** - Type L - Hard

*** - Type K - Hard temper with brazed joints only or type K-soft temper without joints in or under floors

**** - In or under slab floors only brazed joints

TABLE III
STANDARD RATING CONDITIONS AND MINIMUM PERFORMANCE RATINGS FOR WATER HEATING
EQUIPMENT

A. Unfired Hot Water Storage

Volumes and inputs: maximum HL shall be 20.5 W/sq. meter

TERMS:

EF = Energy factor, overall efficiency.

ET = Thermal efficiency with 21 degrees C delta T.

EC = Combustion efficiency, 100 percent - flue loss when smoke = 0
(trace is permitted).

SL = Standby loss in W/0.09 sq. m. based on 27 degrees C delta T, or in
percent per hour based on nominal 32 degrees C delta T.

HL = Heat loss of tank surface area

V = Storage volume in gallons

-- End of Section --

SECTION 15500A

DESICCANT COOLING SYSTEMS

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 210/240	(1994) Unitary Air-Conditioning and Air-Source Heat Pump Equipment
ARI 700	(1999) Specifications for Fluorocarbon and Other Refrigerants
ARI 1060	(2001) Rating air to air energy recovery ventilation heat exchangers

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 307	(2000) Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
ASTM B 209	(2000) Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B 209M	(2000) Aluminum and Aluminum-Alloy Sheet and Plate (Metric)
ASTM B 210	(2000) Aluminum and Aluminum-Alloy Drawn Seamless Tubes
ASTM B 210M	(2000) Aluminum and Aluminum-Alloy Drawn Seamless Tubes (Metric)
ASTM D 1784	(1999a) Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM F 104	(1995) Nonmetallic Gasket Materials

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 15	(1994) Safety Code for Mechanical Refrigeration
ASHRAE 34	(1997) Number Designation and Safety Classification of Refrigerants

ASME INTERNATIONAL (ASME)

ASME B31.1 (1998) Power Piping

ASME BPVC SEC IX (1998) Boiler and Pressure Vessel Code;
Section IX, Welding and Brazing
Qualifications

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1 (1998) Motors and Generators

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

Drawings; G

Drawings, at least 5 weeks prior to beginning construction, providing adequate detail to demonstrate compliance with contract requirements. Drawings shall consist of:

a. Equipment layouts which identify assembly and installation details to include energy recovery equipment.

b. Piping layouts which identify all valves and fittings.

c. Plans and elevations which identify clearances required for maintenance and operation.

d. Wiring diagrams which identify each component individually, by showing actual location in equipment, and schematically, by showing all interconnected or interlocked relationships between components.

e. Foundation drawings, bolt-setting information, and foundation bolts prior to concrete foundation construction for all equipment indicated or required to have concrete foundations.

f. Details, if piping and equipment are to be supported other than as indicated, which include loading and type of frames, brackets, stanchions, or other supports.

SD-03 Product Data

Verification of Dimensions

A letter, at least 2 weeks prior to beginning construction, indicating the date the site was visited, confirming existing conditions, and noting any discrepancies found.

Desiccant Cooling System; G

Manufacturer's catalog data, at least 5 weeks prior to beginning

construction, highlighted to show model number, size, options, performance charts and curves, etc., in adequate detail to demonstrate compliance with contract requirements. Performance charts and curves shall provide performance data over the full range of outdoor conditions for which dehumidification will be required, with the conditions defined by the Contracting Officer. Manufacturer shall supply data on all energy recovery methods and equipment available for the system. Data shall include manufacturer's recommended installation instructions and procedures. If vibration isolation is specified for a unit, vibration isolator literature shall be included containing catalog cuts and certification that the isolation characteristics of the isolators provided meet the manufacturer's recommendations.

Spare Parts

Spare parts data for each different item of material and equipment specified, after approval of the detail drawings and not later than 2 months prior to the date of beneficial occupancy. The data shall include a complete list of parts and supplies, with source of supply.

Qualifications

Six copies of qualification procedures, and list of names and identification symbols of qualified welders and welding operators, prior to non-factory welding operations.

Field Instructions

Posted instructions, at least 2 weeks prior to construction completion, including equipment layout, wiring and control diagrams, piping, valves and control sequences, and typed, condensed, operation instructions. The condensed operation instructions shall include preventative maintenance procedures, methods of checking the system for normal and safe operation, and procedures for safely starting and stopping the system. The posted instructions shall be framed under glass or laminated plastic and be posted where indicated by the Contracting Officer.

Performance Tests

Test schedules, at least 2 weeks prior to the start of the field tests and the system performance test. The schedules shall identify the date, time, and location for the performance test.

Demonstrations

A schedule for training demonstrations, at least 2 weeks prior to the date of the proposed training course, identifying the date, time, and location for the training.

SD-06 Test Reports

Performance Tests; G

A report documenting the data taken versus the specified performance criteria, upon completion of installation and performance testing of the system. Six copies of the bound report (

216 x 279 mm (8-1/2 x 11 inches)) shall be provided. The report shall document compliance with the specified performance criteria upon completion and testing of the system. The report shall indicate the number of days covered by the tests and any conclusions as to the adequacy of the system. The report shall also include the following information and shall be taken at least three different times at outside dry-bulb temperatures that are at least 5 degrees C apart.

Inspections

A bound inspection report (216 x 279 mm (8-1/2 x 11 inches)) at the completion of one year of service. The report shall identify the condition of the desiccant system and shall include a comparison of the condition of the desiccant system with the manufacturer's recommended operating conditions.

SD-07 Certificates

Desiccant Cooling System; G

Proof of compliance with ARI, ASHRAE, ASME, or UL requirements where specified for the system, components, or equipment. The label or listing of the specified agency shall be acceptable evidence. In lieu of the label or listing, a written certificate from an approved, nationally recognized testing organization equipped to perform such services, shall be submitted stating that the items have been tested and conform to the requirements and testing methods of the specified agency. When performance requirements of this project's drawings and specifications vary from standard ARI rating conditions, computer printouts, catalog, or other application data certified by ARI or a nationally recognized laboratory as described above shall be included. If ARI does not have a current certification program that encompasses such application data, the manufacturer shall self certify that his application data complies with project performance requirements.

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals;G

Six complete bound copies (216 x 279 mm (8-1/2 x 11 inches)) of an operation and maintenance manual listing step-by-step procedures required for system startup, operation, maintenance, and shutdown. The manual shall include the manufacturer's name, model number, parts list, service manual, and a brief description of all equipment and their basic operating features. The manual shall include routine maintenance procedures, possible breakdowns and repairs, and a trouble shooting guide. The manuals shall include piping and equipment layouts and simplified wiring and control diagrams of the system as installed.

1.3 QUALIFICATIONS

Piping shall be welded in accordance with the qualified procedures, using performance qualified welders and welding operators in accordance with ASME BPVC SEC IX. Welding procedures qualified by others, and welders and welding operators qualified by another employer may be accepted as permitted by ASME B31.1. The Contracting Officer shall be notified 24 hours in advance of tests and the tests shall be performed onsite, if

practical. The welder or welding operator shall apply the assigned symbol near each weld personally made as a permanent record. Structural members shall be welded in accordance with Section 05090A WELDING, STRUCTURAL .

1.4 SAFETY REQUIREMENTS

Exposed moving parts, parts that produce high operating temperature, parts which may be electrically energized, and parts that may be a hazard to operating personnel shall be insulated, fully enclosed, guarded, or fitted with other types of safety devices. Safety devices shall be installed so that proper operation of equipment is not impaired.

1.5 DELIVERY, STORAGE, AND HANDLING

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

1.6 PROJECT/SITE CONDITIONS

1.6.1 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.

1.6.2 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 plumbing, fire protection, electrical, structural and any other features or conditions that would affect the work to be performed and shall arrange such work accordingly, furnishing required offsets, fittings, and accessories to meet such features or conditions.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Materials and equipment shall be the standard products of a manufacturer regularly engaged in the manufacturing of such products and shall essentially duplicate equipment which is similar in material, design, and workmanship. The standard products shall have been in satisfactory commercial or industrial use for two years prior to bid opening. The two-year 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, manufacturer's 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 6000 hours exclusive of the manufacturer's factory tests, can be shown. All products shall be supported by a service organization. The Contractor shall submit a certified list of qualified, permanent service organizations for support of the equipment including their addresses and qualifications. These service organizations shall be reasonably convenient to the equipment installation and shall be able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract. The system shall be a

complete stand alone system with all necessary controls, motors, fans, rotors, motors, drive components, pumps, reactivation components and filtration to provide automatic continuous operation. Internal regeneration heat sources shall be a part of the system, except external heat sources may be used under the following conditions: connections to external heat sources shall be fully coordinated with the system manufacturer, and connecting equipment such as pumps, piping, traps, etc., shall be as shown on the drawings and schedules. The desiccant shall be of the solid type on a rotary wheel .

2.2 NAMEPLATES

Each major component of equipment shall have the manufacturer's name, address, type or style, and catalog or serial number on a plate securely attached to the item of equipment. Nameplates shall be secured to the cabinet of dry desiccant units, indicating the equipment enclosed within the cabinet behind the nameplate. Cabinets shall have hinged panels, as specified, to facilitate maintenance of the component described on the nameplate secured to the cabinet.

2.3 ELECTRICAL WORK

Electrical equipment, motors, motor efficiencies, and wiring shall be in accordance with Section 16415A ELECTRICAL WORK, INTERIOR. Electrical motor driven equipment specified shall be provided complete with motors, motor starters, and controls (including variable speed control of process air flow for solid units, where applicable). Electrical characteristics and enclosure type shall be as shown, and unless otherwise indicated, all motors of 1 horsepower and above with open, dripproof, or totally enclosed fan cooled enclosures, shall be high efficiency type. Field wiring shall be in accordance with manufacturer's instructions. Each motor shall conform to NEMA MG 1 and be of sufficient size to drive the equipment at the specified capacity without exceeding the nameplate rating of the motor.

All motors shall be continuous duty with the enclosure specified. Motor starters shall be provided complete with thermal overload protection and other appurtenances necessary for the motor control indicated. Motors shall be furnished with a magnetic across-the-line or reduced voltage type starter as required by the manufacturer. Motor starter shall be provided with NEMA 1 enclosures. Manual or automatic control and protective or signal devices required for the operation specified and any control wiring required for controls and devices specified, but not shown, shall be provided.

2.4 MATERIALS

2.4.1 Gaskets

Gaskets shall conform to ASTM F 104 classification for compressed sheet with nitrile binder and acrylic fibers for maximum 371 degrees C service.

2.4.2 Bolts and Nuts

Bolts and nuts, except as required for piping applications, shall be in accordance with ASTM A 307. The bolt head shall be marked to identify the manufacturer and the standard with which the bolt complies in accordance with ASTM A 307.

2.5 DESICCANT SYSTEMS

2.5.1 Solid Desiccant System

The unit shall be a complete, factory assembled and tested system, suitable for indoor installation. Each unit shall produce a capacity as rated in accordance with ARI 1060. It shall be designed for either curb mounting or structural steel support. The unit shall include the following components as defined in paragraph SYSTEM COMPONENTS:

- a. Desiccant Rotor
- b. Supply Fan
- c. Regeneration Fan
- d. Regeneration and Process Heating System
- e. Filters

2.5.1.1 Control Package

Each unit shall be factory wired and equipped with a central electrical control panel mounted inside the service compartment. Variable-speed drive controller, if provided, shall also be mounted inside the service compartment. Switched lighting shall be provided in the service compartment so that the panel can be easily seen. Compartment shall be ventilated, if necessary, for cooling variable speed drive controller. A single power supply shall be required. All internal wiring shall be in accordance with the National Electrical Code. All electrical components required for automatic operation, based on signals from remotely mounted humidity and temperature sensors/controllers, shall be included. Connections to remote devices shall be made at the marked terminals. The internal control panel shall report discharge temperature and humidity. Additional reporting of all control data shall be available to a central control station, as specified in Section 15950A HEATING< VENTILATING< AND AIR CONDITIONING (HVAC) CONTROL SYSTEMS.

2.5.1.2 Unit Mounting

The unit shall be structural steel supported. The entire unit shall be isolated from the building structure on vibration isolators with submitted and published load ratings. Vibration isolators shall have isolation characteristics as recommended by the manufacturer for the unit supplied and the service intended.

2.6 SYSTEM COMPONENTS

2.6.1 Desiccant Rotor

Dehumidifiers shall be non-cyclic adsorption type with a single desiccant rotary structure designed for continuous operation. Construction arrangement shall provide counter flow of process and regeneration air streams with full face pressure seals to prevent cross leakage with static pressure differentials up to 200 mm water gauge. The rotary structure shall consist of a stable, hygroscopic desiccant material, such as Silica Gel, Titanium Silicate, or a Zeolite, deposited on a honey-combed substrate designed to maximize the desiccant area exposed to the air stream and minimize the thermal carryover from the regeneration side to the adsorption side. The design shall ensure laminar air flow through the structure for minimum pressure loss. The rotor shall be complete with an electric motor with over-current protection and a speed reducer assembly driving the rotor through a flexible circumferential drive belt. A slack side belt tensioner shall be included for automatic take-up.

2.6.2 Heat Exchanger

2.6.2.1 Thermal Rotor

The thermal rotor shall be of the rotary, non-hygroscopic type, to minimize the transfer of water vapor between the process and regeneration sides of the unit. The rotor shall be constructed and sized to maximize the transfer of heat from the supply air stream to the regeneration air stream while minimizing the transfer of moisture back to the supply air stream. Supply and cooling air streams shall be counter flow and the component fitted with full face contact seals on both sides to prevent leakage.

2.6.3 Fans (Solid Desiccant System) For Supply and Regeneration

The unit shall be equipped with two belt driven backward inclined blowers. A drive belt rated for minimum 150% of motor horsepower shall be used on each motor. The supply fan motor shall have sheaves for air balancing. The motors shall be nominal 3500 RPM, NEMA B with open dripproof housings and a minimum service factor of 1.15.

2.6.4 Heating and Cooling System (Solid Desiccant System)

Regeneration and process heating coils shall be of the finned tube type, and shall be constructed of 13 mm OD seamless copper tube mechanically bonded to aluminum fins. The coils shall include a flanged, heavy-gauge, galvanized steel housing for mounting to the unit. The coils shall be rated for 1135.6 kPa.

2.6.5 Filters (Solid Desiccant System)

Outside air inlets and return air plenums shall be equipped with 50 mm, [AM0002] ~~65%30%~~ minimum efficiency filters. Filters shall be pleated and disposable.

2.7 UNIT CONSTRUCTION

2.7.1 Solid Desiccant System

Unit shall be suitable for outdoor installation. It shall be designed for either structural or curb mounting without field modification. The enclosure system shall be air-tight (2% maximum leakage at 150% design static pressure from section to section). The unit base shall be constructed of formed minimum 10 GA steel coated with red-oxide primer. Cross members shall be located to support each major component. Lifting lugs shall be fitted to appropriate structural members. Unit exterior shall be painted with a low-gloss enamel.

2.7.1.1 Housing

The unit housing and internal partitions shall be constructed of minimum 18 GA galvanized steel with the exterior panels treated to allow for painting. All external walls shall be insulated with foil-faced fiber glass insulation at least 25 mm thick and secured by permanent mechanical fasteners welded to the panels. Adjoining panels shall be sealed by permanent mechanical fasteners welded to the panels. Adjoining panels shall be sealed to one another with silicone compound, as specified in Section 15080A THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.7.1.2 Service Panels

Removable service access panels shall be provided for all components. The openings shall be of sufficient size to allow service to all maintenance items. All service panels shall be provided with resilient gaskets and hardware to assure compression. Access doors shall be provided for boiler and control sections and shall have continuous hinges. Roof panels shall be sealed to provide a weather-tight enclosure.

2.8 DUCT WORK

2.8.1 Plenums and Ductwork

Desiccant units shall be provided with flanges on the air openings for duct connection. Inlet and outlet plenums shall be bolted to the flange with a gasket between the connection. Access doors, for servicing diffusers and eliminators, shall be provided in the inlet and outlet plenums. Inlet ductwork must be designed to allow uniform distribution of air across the entire opening. Outlet plenums and ductwork must allow adequate room for servicing the eliminators and must provide proper airflow through the equipment. Plenum and ductwork sizes shall be as shown and specified in Section 15895A AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM.

2.8.2 Regenerator Exhaust Ductwork

The regenerator exhaust ductwork shall be made of glass-fiber reinforced polyester (FRP) or monel. FRP must be rated for continuous duty at 82 degrees C. Duct joints should be of watertight construction. The exhaust plenum and duct should incorporate a drip collar to capture any condensation that occurs inside the duct. Long horizontal duct runs should be pitched slightly in the direction of air flow, and shall incorporate low-point condensate drains.

2.9 SUPPLEMENTAL COMPONENTS/SERVICES

2.9.1 Drain and Makeup Water Piping

Piping shall comply with the requirements of Section 15400A PLUMBING, GENERAL PURPOSE. Drains which connect to sanitary sewer system shall be connected by means of an indirect waste.

PART 3 EXECUTION

3.1 INSTALLATION

All work shall be performed in accordance with the manufacturer's published diagrams, recommendations, and equipment warranty requirements.

3.2 EQUIPMENT

Necessary supports shall be provided for all equipment, appurtenances, and pipe as required, including frames or supports. Housings shall be isolated from the building structure. If mechanical vibration isolators are not provided, vibration absorbing foundations shall be furnished. Each foundation shall include isolation units consisting of machine and floor or foundation fastenings, together with intermediate isolation material. Other floor-mounted equipment shall be set on not less than a 150 mm concrete pad doweled in place. Concrete foundations for floor mounted pumps shall have a mass equivalent to three times the weight of the

components, pump, base plate, and motor to be supported. In lieu of concrete pad foundation, concrete pedestal block with isolators placed between the pedestal block and the floor may be provided. Concrete pedestal block shall be of mass not less than three times the combined pump, motor, and base weights. Isolators shall be selected and sized based on load-bearing requirements and the lowest frequency of vibration to be isolated. Isolators shall limit vibration to 80 percent at lowest equipment rpm. Lines connected to pumps 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 and concrete-structured or cast-cooling towers shall be as specified in Section 03300 CAST-IN-PLACE STRUCTURAL CONCRETE. Equipment shall be properly leveled, aligned, and secured in place in accordance with manufacturer's instructions.

3.2.1 Conditioner Solution Concentration

Contractor shall provide the conditioner solution concentration capable of maintaining the humidity level specified on the drawings.

3.2.2 Automatic Controls

Automatic controls for the specified desiccant system shall be provided with the desiccant equipment. These controls shall operate automatically to balance the equipment capacity with the load on the air conditioning system, and shall be fully coordinated with and integrated into the temperature control system specified in Sections 15895A AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM and 15950A HEATING, VENTILATING AND AIR CONDITIONING (HVAC) CONTROL SYSTEMS.

3.2.3 General Piping, Valves, and Duct Installation

All piping, valve, and duct installation shall be made in accordance with the desiccant equipment manufacturers recommendation or in accordance with Sections 15895A AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM, 15181A CHILLED WATER PIPING AND ACCESSORIES, and 15400A PLUMBING, GENERAL PURPOSE.

3.3 PERFORMANCE TESTS

Before each desiccant system is accepted, tests to demonstrate the general operating characteristics of all equipment shall be conducted by a registered professional engineer or an approved manufacturer's startup representative experienced in system startup and testing, at such times as directed. The tests shall measure quantities listed below. Tests shall cover a period of not less than 2 days for each system and shall demonstrate that the entire system is functioning in accordance with the drawings and specifications. Corrections and adjustments shall be made as necessary and tests shall be re-conducted to demonstrate that the entire system is simultaneously functioning as specified. A report shall be prepared for each desiccant system, including the information outlined below. Data for the tests shall be taken at least three different times at outside wet-bulb temperatures which are at least 3 degrees C apart.

3.3.1 Solid (Wheel) Desiccant System:

- a. Date and outside weather conditions (at least two parameters to define the state of the outside air: DB, Gr./LB, Wb, relative

humidity).

b. The load on the system based on the following:

- (1) CFM entering the system (Process and Regeneration).
- (2) Process side - entering air conditions (Db, Gr./LB).
- (3) Process side - discharge air conditions (Db, Gr./LB).
- (4) Process side - post coolant capacity (tons).
- (5) Regenerator side - entering air conditions (Db, Gr./LB).
- (6) Regenerator side - discharge air conditions (Db, Gr./LB).
- (7) Regenerator side - heat source capacity (Btu/hr).
- (8) Running current, voltage and proper phase sequence for each phase of all motors.
- (9) The actual on-site setting of all operating and safety controls.

3.4 PIPE COLOR CODE MARKING

Color code marking of piping shall be as specified in Section 09900 [AM0002] PAINTS AND COATINGS PAINTING, GENERAL.

3.5 INSPECTIONS

The manufacturer of the liquid desiccant system shall supply, free of charge, testing of solution samples sent to them by the customer every two months for the life of the equipment. The manufacturer of each type system shall inspect the systems after one year of operation to insure the systems are operating properly.

3.6 MANUFACTURER'S FIELD SERVICE

The services of a factory-trained representative shall be provided for 2 days. The representative shall advise on the proper operation and servicing of the equipment and make any adjustments necessary to insure full compliance with design criteria.

3.7 CLEANING AND ADJUSTING

Equipment shall be wiped clean, with all traces of oil, dust, dirt, or paint spots removed. Temporary filters shall be provided for all fans that are operated during construction, and new filters shall be installed after all construction dirt has been removed from the building. 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 the setting indicated or directed. Fans shall be adjusted to the speed indicated by the manufacturer to meet specified conditions.

3.8 DEMONSTRATIONS

Contractor shall conduct a training course for the operating staff as designated by the Contracting Officer. The training period shall consist of a total 4 hours of normal working time and 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 Operation and Maintenance Manuals as well as demonstrations of routine maintenance operations.

3.9 SERVICE CONTRACT

Contractor shall provide a five (5) year, unconditional maintenance contract for the Desiccant cooling system (symbol ERU) to include the desiccant wheel, lubrication, [AM0002] fansfan, belts, motors, VFD, dampers, coils, and filters as required for periodic replacement.

3.10 [AM0002] FRAMED CHARTS AND GRAPHICS

Install framed charts and graphics with a glass cover on the wall of the mechanical room. The chart and graphics shall indicate all control components contained within the unit and its associated location. Nominal operating temperatures shall be identified on the graphics and listed in the chart as a function of the Outside Air and Return/Exhaust Air. The chart and graphics shall be presented in a manner that the maintenance personnel can use them to calculate and determine Supply Air to coils and other factors needed to verify performance of the unit without the need of a computer interface.

-- End of Section --

SECTION 15620A

LIQUID CHILLERS

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 450	(1999) Water-Cooled Refrigerant Condensers, Remote Type
ARI 460	(2000) Remote Mechanical-Draft Air-Cooled Refrigerant Condensers
ARI 480	(1995) Refrigerant-Cooled Liquid Coolers, Remote Type
ARI 495	(1999) Refrigerant Liquid Receivers
ARI 550/590	(1998) Water-Chilling Packages Using the Vapor Compression Cycle
ARI 560	(1992) Absorption Water Chilling and Water Heating Packages
ARI 575	(1994) Method of Measuring Machinery Sound Within an Equipment Space
ARI 700	(1999) Specifications for Fluorocarbon and Other Refrigerants
ARI 740	(1998) Refrigerant Recovery/Recycling Equipment

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 307	(2000) Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
ASTM B 117	(1997) Operating Salt Spray (Fog) Apparatus
ASTM D 520	(2000) Zinc Dust Pigment

ASTM E 84 (2000a) Surface Burning Characteristics of Building Materials

ASTM F 104 (1995) Nonmetallic Gasket Materials

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 15 (1994) Safety Code for Mechanical Refrigeration

ASHRAE 34 (1997) Number Designation and Safety Classification of Refrigerants

ASHRAE 64 (1995) Methods of Testing Remote Mechanical-Draft Evaporative Refrigerant Condensers

AMERICAN WELDING SOCIETY (AWS)

AWS Z49.1 (1999) Safety in Welding and Cutting

ASME INTERNATIONAL (ASME)

ASME BPVC SEC IX (1998) Boiler and Pressure Vessel Code; Section IX, Welding and Brazing Qualifications

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

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1 (1998) Motors and Generators

NEMA MG 2 (1989) Safety Standard for Construction and Guide for Selection, Installation, and Use of Electric Motors and Generators

NEMA SM 23 (1991) Steam Turbines for Mechanical Drive Service

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 37 (2002) Installation and Use of Stationary Combustion Engines and Gas Turbines

NFPA 54 (1999) National Fuel Gas Code

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE J 537 (1996) Storage Batteries

UNDERWRITERS LABORATORIES (UL)

UL 1236 (1994; Rev thru Mar 1999) Battery Chargers for Charging Engine-Starter Batteries

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

Drawings; ,
Installation; ,

Drawings, at least 5 weeks prior to beginning construction, provided in adequate detail to demonstrate compliance with contract requirements. Drawings shall consist of:

- a. Equipment layouts which identify assembly and installation details.
- b. Plans and elevations which identify clearances required for maintenance and operation.
- c. Wiring diagrams which identify each component individually and all interconnected or interlocked relationships between components.
- d. Foundation drawings, bolt-setting information, and foundation bolts prior to concrete foundation construction for all equipment indicated or required to have concrete foundations.
- e. Details, if piping and equipment are to be supported other than as indicated, which include loadings and type of frames, brackets, stanchions, or other supports.

SD-03 Product Data

Refrigeration System; G,

Manufacturer's standard catalog data, at least 5 weeks prior to the purchase or installation of a particular component, highlighted to show material, size, options, performance charts and curves, etc. in adequate detail to demonstrate compliance with contract requirements. Data shall include manufacturer's recommended installation instructions and procedures. Data shall be adequate to demonstrate compliance with contract requirements as specified within the paragraphs:

- a. Liquid Chiller
- b. Chiller Components
- c. Accessories

If vibration isolation is specified for a unit, vibration isolator literature shall be included containing catalog cuts and certification that the isolation characteristics of the isolators provided meet the manufacturer's recommendations.

Spare Parts; ,

Spare parts data for each different item of equipment specified, after approval of detail drawings and not later than 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, a recommended spare parts list for 1 year of operation, and a list of the parts recommended by the manufacturer to be replaced on a routine basis.

Posted Instructions; ,

Posted instructions, at least 2 weeks prior to construction completion, including equipment layout, wiring and control diagrams, piping, valves and control sequences, and typed condensed operation instructions. The condensed operation instructions shall include preventative maintenance procedures, methods of checking the system for normal and safe operation, and procedures for safely starting and stopping the system. The posted instructions shall be framed under glass or laminated plastic and be posted where indicated by the Contracting Officer.

Verification of Dimensions; ,

A letter, at least 2 weeks prior to beginning construction, including the date the site was visited, conformation of existing conditions, and any discrepancies found.

Manufacturer's Multi-Year Compressor Warranty; ,

Manufacturer's multi-year warranty for compressor(s) in air-cooled liquid chillers as specified.

Factory Tests; ,

Schedules, at least 2 weeks prior to the factory test, which identify the date, time, and location for each test. Schedules shall be submitted for both the Chiller Performance Test and the Chiller Sound Test.

System Performance Tests; ,

A schedule, at least 2 weeks prior to the start of related testing, for the system performance tests. The schedules shall identify the proposed date, time, and location for each test.

Demonstrations; ,

A schedule, at least 2 weeks prior to the date of the proposed training course, which identifies the date, time, and location for the training.

SD-06 Test Reports

Factory Tests; ,

Six copies of the report shall be provided in bound 216 x 279 mm (8 1/2 x 11 inch) booklets. Reports shall certify the compliance with performance requirements and follow the format of the required testing standard for both the Chiller Performance Tests and the

Chiller Sound Tests. Test report shall include certified calibration report of all test instrumentation. Calibration report shall include certification that all test instrumentation has been calibrated within 6 months prior to the test date, identification of all instrumentation, and certification that all instrumentation complies with requirements of the test standard. Test report shall be submitted 1 week after completion of the factory test.

System Performance Tests; ,

Six copies of the report shall be provided in bound 216 x 279 (8 1/2 x 11 inch) booklets. The report shall document compliance with the specified performance criteria upon completion and testing of the system. The report shall indicate the number of days covered by the tests and any conclusions as to the adequacy of the system. The report shall also include the following information and shall be taken at least three different times at outside dry-bulb temperatures that are at least 3 degrees C (5 degrees F) apart:

- a. Date and outside weather conditions.
- b. The load on the system based on the following:
 - (1) The refrigerant used in the system.
 - (2) Condensing temperature and pressure.
 - (3) Suction temperature and pressure.
 - (4) Running current, voltage and proper phase sequence for each phase of all motors.
 - (5) The actual on-site setting of all operating and safety controls.
 - (6) Chilled water pressure, flow and temperature in and out of the chiller.
 - (7) The position of the capacity-reduction gear at machine off, one-third loaded, one-half loaded, two-thirds loaded, and fully loaded.

SD-07 Certificates

Refrigeration System; ,

Where the system, components, or equipment are specified to comply with requirements of AGA, NFPA, ARI, ASHRAE, ASME, or UL, 1 copy of proof of such compliance shall be provided. The label or listing of the specified agency shall be acceptable evidence. In lieu of the label or listing, a written certificate from an approved, nationally recognized testing organization equipped to perform such services, stating that the items have been tested and conform to the requirements and testing methods of the specified agency may be submitted. When performance requirements of this project's drawings and specifications vary from standard ARI rating conditions, computer printouts, catalog, or other application data certified by ARI or a nationally recognized laboratory as described above shall be included. If ARI does not have a current certification program that encompasses such application data, the manufacturer may self certify that his application data complies with project performance requirements in accordance with the specified test standards.

Service Organization; ,

A certified list of qualified permanent service organizations for support of the equipment which includes their addresses and qualifications. The service organizations shall be reasonably convenient to the equipment installation and be able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

SD-10 Operation and Maintenance Data

Operation Manuals; ,

Six complete copies of an operation manual in bound 216 x 279 (8 1/2 x 11 inch) booklets listing step-by-step procedures required for system startup, operation, abnormal shutdown, emergency shutdown, and normal shutdown at least 4 weeks prior to the first training course. The booklets shall include the manufacturer's name, model number, and parts list. The manuals shall include the manufacturer's name, model number, service manual, and a brief description of all equipment and their basic operating features.

Maintenance Manuals; ,

Six complete copies of maintenance manual in bound 216 x 279 (8 1/2 x 11 inch) booklets listing routine maintenance procedures, possible breakdowns and repairs, and a trouble shooting guide. The manuals shall include piping and equipment layouts and simplified wiring and control diagrams of the system as installed.

1.3 SAFETY REQUIREMENTS

Exposed moving parts, parts that produce high operating temperature, parts which may be electrically energized, and parts that may be a hazard to operating personnel shall be insulated, fully enclosed, guarded, or fitted with other types of safety devices. Safety devices shall be installed so that proper operation of equipment is not impaired. Welding and cutting safety requirements shall be in accordance with AWS Z49.1.

1.4 DELIVERY, STORAGE, AND HANDLING

Stored items shall be protected from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Proper protection and care of all material both before and during installation shall be the Contractor's responsibility. Any materials found to be damaged shall be replaced at the Contractor's expense. During installation, piping and similar openings shall be capped to keep out dirt and other foreign matter.

1.5 PROJECT/SITE CONDITIONS

1.5.1 Verification of Dimensions

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

1.5.2 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 plumbing, fire protection, electrical, structural and finish conditions that would affect the work to

be performed and shall arrange such work accordingly, furnishing required offsets, fittings, and accessories to meet such conditions.

1.6 MANUFACTURER'S MULTI-YEAR COMPRESSOR WARRANTY

The Contractor shall provide a 5 year parts only (excludes refrigerant) manufacturer's warranty on the air-cooled chiller compressor(s). This warranty shall be directly from the chiller manufacturer to the Government and shall be in addition to the standard one-year warranty of construction.

The manufacturer's warranty shall provide for the repair or replacement of the chiller compressor(s) that become inoperative as a result of defects in material or workmanship within 5 years after the date of final acceptance. When the manufacturer determines that a compressor requires replacement, the manufacturer shall furnish new compressor(s) at no additional cost to the Government. Upon notification that a chiller compressor has failed under the terms of the warranty, the manufacturer shall respond in no more than 6 hours. Response shall mean having a manufacturer-qualified technician onsite to evaluate the extent of the needed repairs. The warranty period shall begin on the same date as final acceptance and shall continue for the full product warranty period.

1.6.1 Local Service Representative

The Contractor shall furnish with each manufacturer's multi-year warranty the name, address, and telephone number (day, night, weekend, and holiday) of the service representative nearest to the location where the equipment is installed. Upon a request for service under the multi-year warranty, the service representative shall honor the warranty during the warranty period, and shall provide the services prescribed by the terms of the warranty.

1.6.2 Equipment Warranty Tags

At the time of installation, each item of manufacturer's multi-year warranted equipment shall be tagged with a durable, oil- and water-resistant tag, suitable for interior and exterior locations, resistant to solvents, abrasion, and fading due to sunlight. The tag shall be attached with copper wire or a permanent, pressure-sensitive, adhesive backing. The tag shall be installed in an easily noticed location attached to the warranted equipment. The tag for this equipment shall be similar to the following in format, and shall contain all of the listed information:

MANUFACTURER'S MULTI-YEAR WARRANTY EQUIPMENT TAG

Equipment/Product Covered: _____
 Manufacturer: _____ Model No.: _____ Serial No.: _____
 Warranty Period: From _____ to _____
 Contract No.: _____
 Warranty Contact: _____
 Name: _____
 Address: _____
 Telephone: _____

STATION PERSONNEL SHALL PERFORM PREVENTIVE
 MAINTENANCE AND OPERATIONAL MAINTENANCE

PART 2 PRODUCTS

2.1 STANDARD COMMERCIAL PRODUCTS

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 satisfactory commercial or industrial use for 2 years prior to bid opening. The 2 year use shall include applications of equipment and materials under similar circumstances and of similar size. The 2 years experience shall be satisfactorily completed by a product which has been sold or is offered for sale on the commercial market through advertisements, manufacturer's catalogs, or brochures. Products having less than a 2 year field service record shall 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. Products shall be supported by a service organization. System components shall be environmentally suitable for the indicated locations.

2.2 NAMEPLATES

Major equipment including chillers, compressors, compressor drivers, condensers, liquid coolers, receivers, refrigerant leak detectors, heat exchangers, fans, and motors shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the item of equipment. Plates shall be durable and legible throughout equipment life and made of anodized aluminum. Plates shall be fixed in prominent locations with nonferrous screws or bolts.

2.3 ELECTRICAL WORK

Electrical equipment, motors, motor efficiencies, and wiring shall be in accordance with Section 16415A ELECTRICAL WORK, INTERIOR. Electrical motor driven equipment specified shall be provided complete with motors, motor starters, and controls. Electrical characteristics shall be as shown, and unless otherwise indicated, all motors of 746 kW (1 hp) and above with open, dripproof, totally enclosed, or explosion proof fan cooled enclosures, shall be high efficiency type. Field wiring shall be in accordance with manufacturer's instructions. Each motor shall conform to NEMA MG 1 and NEMA MG 2 and be of sufficient size to drive the equipment at the specified capacity without exceeding the nameplate rating of the motor.

Motors shall be continuous duty with the enclosure specified. Motor starters shall be provided complete with thermal overload protection and other appurtenances necessary for the motor control indicated. Motors shall be furnished with a magnetic across-the-line or reduced voltage type starter as required by the manufacturer. Motor duty requirements shall allow for maximum frequency start-stop operation and minimum encountered interval between start and stop. Motors shall be sized for the applicable loads. Motor torque shall be capable of accelerating the connected load within 20 seconds with 80 percent of the rated voltage maintained at motor terminals during one starting period. Motor bearings shall be fitted with grease supply fittings and grease relief to outside of enclosure. Manual or automatic control and protective or signal devices required for the operation specified and any control wiring required for controls and devices specified, but not shown, shall be provided.

2.4 SELF-CONTAINED LIQUID CHILLER

Unless necessary for delivery purposes, units shall be assembled, leak-tested, charged (refrigerant and oil), and adjusted at the factory. In lieu of delivery constraints, a chiller may be assembled, leak-tested, charged (refrigerant and oil), and adjusted at the job site by a factory representative. Unit components delivered separately shall be sealed and charged with a nitrogen holding charge. Unit assembly shall be completed

in strict accordance with manufacturer's recommendations. Chiller shall operate within capacity range and speed recommended by the manufacturer. Parts weighing 23 kg or more which must be removed for inspection, cleaning, or repair, such as motors, gear boxes, cylinder heads, casing tops, condenser, and cooler heads, shall have lifting eyes or lugs. Chiller shall include all customary auxiliaries deemed necessary by the manufacturer for safe, controlled, automatic operation of the equipment. Chiller shall be provided with a single point wiring connection for incoming power supply. Chiller's condenser and liquid cooler shall be provided with standard water boxes with flanged connections.

2.5 LIQUID CHILLER

Total chiller system shall be constructed and rated in accordance with ARI 550/590. Individual chiller components shall be constructed and rated in accordance with the applicable ARI standards. Chiller system shall be conform to ASHRAE 15. Chiller shall be assembled, leak-tested, charged (refrigerant and oil), and adjusted at the job site in strict accordance with manufacturer's recommendations. Unit components delivered separately shall be sealed and charged with a nitrogen holding charge. Unit assembly shall be completed in strict accordance with manufacturer's recommendations. Chiller shall operate within capacity range and speed recommended by the manufacturer. Parts weighing 23 kg or more which must be removed for inspection, cleaning, or repair, shall have lifting eyes or lugs. Chiller shall include all customary auxiliaries deemed necessary by the manufacturer for safe, controlled, automatic operation of the equipment. Chiller's condenser and liquid cooler shall be provided with standard water boxes with flanged connections. As a minimum, chiller shall include the following components as defined in paragraph CHILLER COMPONENTS.

- a. Refrigerant and oil
- b. Structural base
- c. Chiller refrigerant circuit
- d. Controls package
- e. Receiver
- f. Tools

2.5.1 Compressor-Chiller Unit

As a minimum, the compressor-chiller unit shall include the following components as defined in paragraph CHILLER COMPONENTS.

- a. Rotary screw compressor
- b. Compressor driver, electric motor
- c. Compressor driver connection
- d. Liquid cooler (evaporator)

2.5.2 Air-Cooled Condenser

Condenser shall be a factory-fabricated and assembled unit, consisting of coils, fans, and electric motor drive. Condenser shall be constructed and

rated in accordance with ARI 460. Unless the condenser coil is completely protected through inherent design, louvered panel coil guards shall be provided by the manufacturer to prevent physical damage to the coil. Manufacturer shall certify that the condenser and associated equipment are designed for the submitted condensing temperature. For design conditions, if matched combination catalog ratings matching remote condensers to compressors are not available, the Contractor shall furnish a crossplotting of the gross heat rejection of the condenser against the gross heat rejection of the compressor, for the design conditions to show the compatibility of the equipment furnished.

2.5.2.1 Condenser Casing

Condenser casing shall be aluminum not less than 2 mm (0.080 inch) or hot-dip galvanized steel not lighter than 1.2 mm (18 gauge) .

2.5.2.2 Coil

Condenser coil shall be of the extended-surface fin-and-tube type and shall be constructed of seamless copper tubes with compatible aluminum fins. Fins shall be soldered or mechanically bonded to the tubes and installed in a metal casing. Coils shall be circuited and sized for a minimum of 3 degrees C subcooling and full pumpdown capacity. Coil shall be factory leak and pressure tested after assembly in accordance with ASHRAE 15.

2.5.2.3 Fans

Fans shall be centrifugal or propeller type as best suited for the application. Fans shall be direct or V-belt driven. Belt drives shall be completely enclosed within the unit casing or equipped with a guard. When belt drive is provided, an adjustable sheave to furnish not less than 20 percent fan-speed adjustment shall be provided. Sheaves shall be selected to provide the capacity indicated at the approximate midpoint of the adjustment. Fans shall be statically and dynamically balanced.

2.6 CHILLER COMPONENTS

2.6.1 Refrigerant and Oil

Refrigerants shall be one of the fluorocarbon gases. Refrigerants shall have number designations and safety classifications in accordance with ASHRAE 34. Refrigerants shall meet the requirements of ARI 700 as a minimum. Refrigerants shall have an Ozone Depletion Potential (ODP) of less than or equal to 0.05.

2.6.2 Structural Base

Chiller and individual chiller components shall be provided with a factory-mounted structural steel base (welded or bolted) or support legs. Chiller and individual chiller components shall be isolated from the building structure by means of molded neoprene isolation pads.

2.6.3 Chiller Refrigerant Circuit

Chiller refrigerant circuit shall be completely piped and factory leak tested. For multicompressor units, not less than 2 independent refrigerant circuits shall be provided. Circuit shall include as a minimum a combination filter and drier, combination sight glass and moisture indicator, liquid-line solenoid valve for reciprocating, an electronic or

thermostatic expansion valve with external equalizer, charging ports, compressor service valves for field-serviceable compressors, and superheat adjustment.

2.6.4 Controls Package

Chiller shall be provided with a complete factory-mounted , prewired electric or microprocessor based control system. Controls package shall contain as a minimum a digital display or acceptable gauges, an on-auto-off switch, motor starters, disconnect switches, power wiring, and control wiring. Controls package shall provide operating controls, monitoring capabilities, programmable setpoints, safety controls, and EMCS interfaces as defined below.

2.6.4.1 Operating Controls

Chiller shall be provided with the following adjustable operating controls as a minimum.

- a. Leaving chilled water temperature control
- b. Adjustable timer or automated controls to prevent a compressor from short cycling
- c. Automatic lead/lag controls (adjustable) for multi-compressor units
- d. Load limiting
- e. System capacity control to adjust the unit capacity in accordance with the system load and the programmable setpoints. Controls shall automatically re-cycle the chiller on power interruption.
- f. Startup and head pressure controls to allow system operation at all ambient temperatures down to 5 degrees C
- g. Fan sequencing for air-cooled condenser

2.6.4.2 Monitoring Capabilities

During normal operations, the control system shall be capable of monitoring and displaying the following operating parameters. Access and operation of display shall not require opening or removing any panels or doors.

- a. Entering and leaving chilled water temperatures
- b. Self diagnostic
- c. Operation status
- d. Operating hours
- e. Number of starts
- f. Compressor status (on or off)
- g. Refrigerant discharge and suction pressures
- h. Oil pressure

2.6.4.3 Programmable Setpoints

The control system shall be capable of being reprogrammed directly at the unit. The programmable setpoints shall include the following as a minimum.

- a. Leaving Chilled Water Temperature

2.6.4.4 Safety Controls with Manual Reset

Chiller shall be provided with the following safety controls which automatically shutdown the chiller and which require manual reset.

- a. Low chilled water temperature protection
- b. High condenser refrigerant discharge pressure protection
- c. Low evaporator pressure protection
- d. Chilled water flow detection
- e. High motor winding temperature protection
- f. Low oil flow protection if applicable

2.6.4.5 Safety Controls with Automatic Reset

Chiller shall be provided with the following safety controls which automatically shutdown the chiller and which provide automatic reset.

- a. Over/under voltage protection
- b. Chilled water flow interlock

2.6.4.6 Remote Alarm

During the initiation of a safety shutdown, a chiller's control system shall be capable of activating a remote alarm bell. In coordination with the chiller, the contractor shall provide an alarm circuit (including transformer if applicable) and a minimum 100 mm (4 inch) diameter alarm bell. Alarm circuit shall activate bell in the event of machine shutdown due to the chiller's monitoring of safety controls. The alarm bell shall not sound for a chiller that uses low-pressure cutout as an operating control.

2.6.4.7 Energy Management Control System (EMCS) Interface

The control system shall be capable of communicating all data to a remote integrated DDC processor through a single shielded cable. The data shall include as a minimum all system operating conditions, capacity controls, and safety shutdown conditions. The control system shall also be capable of receiving at a minimum the following operating commands.

- a. Remote Unit Start/Stop
- b. Remote Chilled Water Reset

c.

2.6.5 Compressor(s)

2.6.5.1 Reciprocating Compressor(s)

Rotating parts shall be statically and dynamically balanced at the factory to minimize vibration. Compressors shall be capable of operating at partial-load conditions without increased vibration over the normal vibration at full load operation and shall be capable of continuous operation down to the lowest step of unloading as specified. Compressors of size 7.45 kW (10 horsepower) and above shall have an oil lubrication system of the reversible, forced-feed type with oil strainer. Shaft seal in open-type units shall be mechanical type. Piston speed for open-type compressors shall not exceed the manufacturer's recommendation or 6 m/s (1200 fpm), whichever is less. Compressors shall include:

- a. Vertical, V, W, or radial cylinder design
- b. Oil lubrication
- c. Integrally cast block of close-grained iron or cast aluminum block with hardened steel cylinder sleeves
- d. Oil-level bull's eye
- e. Cast cylinder heads
- f. Cast-aluminum or forged-steel connecting rods
- g. Cast iron or forged-steel crankshaft
- h. Main bearings of the sleeve-insert type
- i. Crankcase oil heaters controlled as recommended by the manufacturer
- j. Suction and discharge refrigerant service valves that are flange connected, wrench operated, with cap
- k. A strainer on the suction side of the compressor

2.6.5.2 Rotary Screw Compressor(s)

Compressors shall operate stably for indefinite time periods at any stage of capacity reduction without hot-gas bypass. Provision shall be made to insure proper lubrication of bearings and shaft seals on shutdown with or without electric power supply. Rotary screw compressors shall include:

- a. An open or hermetic, positive displacement, oil-injected design directly driven by the compressor driver. Compressor shall allow access to internal compressor components for repairs, inspection, and replacement of parts.
- b. Rotors which are solid steel forging with sufficient rigidity for proper operation.
- c. A maximum rotor operating speed no greater than 3600 RPM.
- d. Casings of cast iron, precision machined for minimal clearance

about periphery of rotors.

- e. A lubrication system of the forced-feed type that provides oil at the proper pressure to all parts requiring lubrication.
- f. Shaft main bearings of the sleeve type with heavy duty bushings or rolling element type in accordance with ABMA 9 or ABMA 11. Bearings shall be conservatively loaded and rated for an L(10) life of not less than 200,000 hours.
- g. A differential oil pressure or flow cutout to allow the compressor to operate only when the required oil pressure or flow is provided to the bearings.
- h. A temperature- or pressure-initiated, hydraulically actuated, single-slide-valve, capacity-control system to provide minimum automatic capacity modulation from 100 percent to 15 percent.
- i. An oil separator and oil return system to remove oil entrained in the refrigerant gas and automatically return the oil to the compressor.
- j. Crankcase oil heaters controlled as recommended by the manufacturer.

2.6.6 Compressor Driver, Electric Motor

Motors, starters, , wiring, etc. shall be in accordance with paragraph ELECTRICAL WORK. Motor starter shall be unit mounted as indicated with starter type, wiring, and accessories coordinated with the chiller manufacturer. Starter shall be able to operate in temperatures up to 120 degrees F.

2.6.7 Compressor Driver Connections

Each machine driven through speed-increasing gears shall be so designed as to assure self-alignment, interchangeable parts, proper lubrication system, and minimum unbalanced forces. Bearings shall be of the sleeve or roller type. Gear cases shall be oil tight. Shaft extensions shall be provided with seals to retain oil and exclude all dust.

2.6.8 Liquid Cooler (Evaporator)

Cooler shall be of the shell-and-coil or shell-and-tube type design. Condenser's refrigerant side shall be designed and factory pressure tested to comply with ASHRAE 15. Condenser's water side shall be designed and factory pressure tested for not less than 1,000 kPa. Cooler shell shall be constructed of seamless or welded steel. Coil bundles shall be totally removable and arranged to drain completely. Tubes shall be seamless copper, plain, integrally finned with smooth bore or integrally finned with enhanced bore. Each tube shall be individually replaceable. Tubes shall be installed into carbon mild steel tube sheets by rolling. Tube baffles shall be properly spaced to provide adequate tube support and cross flow. Performance shall be based on a water velocity not less than 0.91 m/s (3 fps) nor more than 3.7 m/s (12 fps) and a fouling factor of [AM0002] 0.01762 sq. m k/kw (0.0001 sq. ft. -hr- degree F/Btu)0.0005.

2.6.9 Air-Cooled Condenser Coil

Condenser coil shall be of the extended-surface fin-and-tube type and shall

be constructed of seamless copper tubes with compatible aluminum fins. Fins shall be soldered or mechanically bonded to the tubes and installed in a metal casing. Coils shall be circuited and sized for a minimum of 3 degrees C subcooling and full pumpdown capacity. Coil shall be factory leak and pressure tested after assembly in accordance with ASHRAE 15. Coil shall be entirely coated with the manufacturer's standard epoxy or vinyl coating.

2.6.10 Receivers

Liquid receivers not already specified herein as an integral factory-mounted part of a package, shall be designed, fitted, and rated in accordance with the recommendations of ARI 495, except as modified herein. Receiver shall bear a stamp certifying compliance with ASME BPVC SEC VIII D1 and shall meet the requirements of ASHRAE 15. Inner surfaces shall be thoroughly cleaned by sandblasting or other approved means. Each receiver shall have a storage capacity not less than 20 percent in excess of that required for the fully-charged system. Each receiver shall be equipped with inlet, outlet drop pipe, drain plug, purging valve, relief valves of capacity and setting required by ASHRAE 15, and two bull's eye liquid-level sight glasses. Sight glasses shall be in the same vertical plane, 90 degrees apart, perpendicular to the axis of the receiver, and not over 75 mm horizontally from the drop pipe measured along the axis of the receiver. In lieu of bull's eye sight glass, external gauge glass with metal glass guard and automatic closing stop valves may be provided.

2.6.11 Tools

One complete set of special tools, as recommended by the manufacturer for field maintenance of the system, shall be provided. Tools shall be mounted on a tool board in the equipment room or contained in a toolbox as directed by the Contracting Officer.

2.7 ACCESSORIES

2.7.1 Refrigerant Signs

Refrigerant signs shall be a medium-weight aluminum type with a baked enamel finish. Signs shall be suitable for indoor or outdoor service. Signs shall have a white background with red letters not less than 12 mm in height.

2.7.1.1 Installation Identification

Each new refrigerating system shall be provided with a refrigerant sign which indicates the following as a minimum:

- a. Contractor's name.
- b. Refrigerant number and amount of refrigerant.
- c. The lubricant identity and amount.
- d. Field test pressure applied.

2.7.1.2 Controls and Piping Identification

Refrigerant systems containing more than 50 kg of refrigerant shall be provided with refrigerant signs which designate the following as a minimum:

- a. Valves or switches for controlling the refrigerant flow and the refrigerant compressor(s).
- b. Pressure limiting device(s).

2.7.2 Refrigerant Recovery/Recycle System

A manually initiated refrigerant recovery/recycle system shall be provided, consisting of a motor-driven, air- or water-cooled, reciprocating condensing unit and a receiver of sufficient capacity to store the entire refrigerant charge of the largest water-chilling system. For refrigerants with atmospheric pressure boiling temperature below 20 degrees C the receiver shall be sized so that it is no more than 80 percent full at 32 degrees C . For refrigerants with atmospheric pressure boiling temperature above 20 degrees C , the receiver shall be sized so that it is no more than 90 percent full at 32 degrees C . The recovery/recycle system condensing unit shall be assembled as a complete unit and meet the requirements of ASHRAE 15. The system components shall be portable and shall include all valves, connections, and controls required for operation. Receiver and relief devices shall conform to the requirements of ASME BPVC SEC VIII D1. The recovery/recycle system shall be tested and listed to conform to ARI 740 for refrigerant recovery/recycle systems by a recognized national testing laboratory. For refrigerants with atmospheric pressure boiling temperature below 20 degrees C , the recovery/recycle unit shall have an ARI 740 vapor refrigerant recovery rate of no less than 8.5 kg/minute . For refrigerants with atmospheric pressure boiling temperature above 20 degrees C , the recovery/recycle unit shall have an ARI 740 vapor refrigerant recovery rate of no less than 1.0 kg/minute .

2.7.3 Gaskets

Gaskets shall conform to ASTM F 104 - classification for compressed sheet with nitrile binder and acrylic fibers for maximum 371 degrees C (700 degrees F) service.

2.7.4 Bolts and Nuts

Bolts and nuts, except as required for piping applications, shall be in accordance with ASTM A 307. The bolt head shall be marked to identify the manufacturer and the standard with which the bolt complies in accordance with ASTM A 307.

2.8 FABRICATION

2.8.1 Factory Coating

Unless otherwise specified, equipment and component items, when fabricated from ferrous metal, shall be factory finished with the manufacturer's standard finish, except that items located outside of buildings shall have weather resistant finishes that will withstand 500 hours exposure to the salt spray test specified in ASTM B 117 using a 5 percent sodium chloride solution. Immediately after completion of the test, the specimen shall show no signs of blistering, wrinkling, cracking, or loss of adhesion and no sign of rust creepage beyond 3 mm on either side of the scratch mark. Cut edges of galvanized surfaces where hot-dip galvanized sheet steel is used shall be coated with a zinc-rich coating conforming to ASTM D 520, Type I.

2.8.2 Factory Applied Insulation

Chiller shall be provided with factory installed insulation on surfaces subject to sweating including the liquid cooler, suction line piping, economizer, and cooling lines. Insulation on heads of coolers may be field applied, however it shall be installed to provide easy removal and replacement of heads without damage to the insulation. Where motors are the gas-cooled type, factory installed insulation shall be provided on the cold-gas inlet connection to the motor per manufacturer's standard practice. Factory insulated items installed outdoors are not required to be fire-rated. As a minimum, factory insulated items installed indoors shall have a flame spread index no higher than 75 and a smoke developed index no higher than 150. Factory insulated items (no jacket) installed indoors and which are located in air plenums, in ceiling spaces, and in attic spaces shall have a flame spread index no higher than 25 and a smoke developed index no higher than 50. Flame spread and smoke developed indexes shall be determined by ASTM E 84. Insulation shall be tested in the same density and installed thickness as the material to be used in the actual construction. Material supplied by a manufacturer with a jacket shall be tested as a composite material. Jackets, facings, and adhesives shall have a flame spread index no higher than 25 and a smoke developed index no higher than 50 when tested in accordance with ASTM E 84.

2.9 SUPPLEMENTAL COMPONENTS/SERVICES

2.9.1 Chilled Water Piping and Accessories

Chilled water piping and accessories shall be provided and installed in accordance with Section 15181A CHILLED WATER PIPING AND ACCESSORIES.

2.9.2 Temperature Controls

Chiller control packages shall be fully coordinated with and integrated into the temperature control system specified in Section 15895A AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM and 15950A HEATING, VENTILATING AND AIR CONDITIONING (HVAC) CONTROL SYSTEMS .

PART 3 EXECUTION

3.1 INSTALLATION

Work shall be performed in accordance with the manufacturer's published diagrams, recommendations, and equipment warranty requirements. Where equipment is specified to conform to the requirements of ASME BPVC SEC VIII D and ASME BPVC SEC IX, the design, fabrication, and installation of the system shall conform to ASME BPVC SEC VIII D1 and ASME BPVC SEC IX.

3.2 MANUFACTURER'S FIELD SERVICE

The services of a factory-trained representative shall be provided for 2 days. The representative shall advise on the following:

a. Hermetic machines:

(1) Testing hermetic water-chilling unit under pressure for refrigerant leaks; evacuation and dehydration of machine to an absolute pressure of not over 300 microns.

(2) Charging the machine with refrigerant.

(3) Starting the machine.

3.3 CLEANING AND ADJUSTING

Equipment shall be wiped clean, with all traces of oil, dust, dirt, or paint spots removed. Temporary filters shall be provided for all fans that are operated during construction, and new filters shall be installed after all construction dirt has been removed from the building. 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. Testing, adjusting, and balancing shall be as specified in Section 15990A TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS.

3.4 SYSTEM PERFORMANCE TESTS

Before each refrigeration system is accepted, tests to demonstrate the general operating characteristics of all equipment shall be conducted by a registered professional engineer or an approved manufacturer's start-up representative experienced in system start-up and testing, at such times as directed. Tests shall cover a period of not less than 48 hours for each system and shall demonstrate that the entire system is functioning in accordance with the drawings and specifications. Corrections and adjustments shall be made as necessary and tests shall be re-conducted to demonstrate that the entire system is functioning as specified. Prior to acceptance, service valve seal caps and blanks over gauge points shall be installed and tightened. Any refrigerant lost during the system startup shall be replaced. If tests do not demonstrate satisfactory system performance, deficiencies shall be corrected and the system shall be retested. Tests shall be conducted in the presence of the Contracting Officer. Water and electricity required for the tests will be furnished by the Government. Any material, equipment, instruments, and personnel required for the test shall be provided by the Contractor. Field tests shall be coordinated with Section 15990A TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS.

3.5 DEMONSTRATIONS

Contractor shall conduct a training course for the operating staff as designated by the Contracting Officer. The training period shall consist of a total 8 hours of normal working time and start after the system is functionally completed but prior to final acceptance tests. The field posted instructions shall cover all of the items contained in the approved operation and maintenance manuals as well as demonstrations of routine maintenance operations.

-- End of Section --

SECTION 15974

BUILDING AUTOMATION & CONTROL SYSTEMS FOR LACKLAND AFB

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 the basic designation only.

AIR MOVEMENT AND CONTROL ASSOCIATION, INC. (AMCA)

AMCA 500 1991 Test Methods for Louvers, Dampers and Shutters

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 135 (1995) A Data Communication Protocol for Building Automation and Control Networks (BACnet)

CODE OF FEDERAL REGULATIONS (CFR)

47 CFR 15 (1996) Radio Frequency Devices

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEE 142 (1991) Recommended Practice for Grounding of Industrial and Commercial Power Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS (1993) Industrial Controls and Systems

NEMA 250 (1991) Enclosures for Electrical Equipment (1000 Volts Maximum)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (1996) National Electrical Code

SHEET METAL & AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION, INC. (SMACNA)

SMACNA-07 Ref Title

UNDERWRITERS LABORATORIES (UL)

UL 506	(1994) (R 1993) Specialty Transformers
UL 916	(1994) Energy Management Equipment
UL 1449	(1996) Transient Voltage Surge Suppressors

1.2 SYSTEM DESCRIPTION

The Building Automation & Control System (BACS) shall utilize intelligent distributed control modules which communicate over a controller network in accordance with ANSI/ASHRAE 135, herein after referred to as "BACnet". The system shall provide the Direct Digital Control (DDC), Energy Management, and Building Automation functions for complete operation of heating, ventilating and air conditioning (HVAC) systems. Provide new BACS consisting of Notebook computers, DDC controllers, routers, Local Area Networks (LANs), software, and associated equipment and accessories using BACnet as the native communication protocol. The system is to control all mechanical equipment, including terminal unit equipment (fan coil units, etc.), fans, pumps, central plant machinery and other specified equipment, directly without intervening electric, analog electronic, or pneumatic controls. A non-BACnet system meeting the functional requirements of this Specification shall be an acceptable alternative; the non-BACnet system shall include bi-directional protocol translators (gateways) that convert the non-BACnet system communication protocol to the BACnet protocol which will interoperate with BACnet Ethernet over twisted pair 10BaseT and Fiber Optic cabling systems. [AM0002] The BACS shall be compatible with and communicate with the existing Johnson Controls Metasys. Furnish and install the NCU and DX9100 controller as manufactured by Johnson Controls for compliance and interface.

1.2.1 Basic Features

1.2.1.1 System Hardware

All hardware Listed Underwriters Laboratory for Open Energy Management Equipment (PAZX) under the U.L. standard for safety 916, with integral labels showing rating. All hardware complies with Code of Federal Regulation 47 CFR 15, Radio Frequency Devices.

1.2.1.2 Fully Programmable

System designed for high-speed data processing; fully programmable, using advanced graphical programming tools.

1.2.1.3 Communications Network

The communication network between controllers utilize BACnet over EIA-485 MS/TP, at least 76 Kbaud, and/or BACnet over ARCNET 156 Kbaud at the Data Link Layer.

1.2.1.4 System Auto-restart

Auto-restart of complete system, including DDC controllers, network controllers and routers, without operator intervention, on resumption of power after a power failure.

1.2.1.5 Zone Control Functions

Zone by zone DDC control of space temperature, scheduling, optimum starting, equipment alarm reporting, and override timers for after-hours usage. A zone is the area served by one controller for each terminal unit.

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-01 Data

Equipment Data; G

The equipment data shall be in booklet form, indexed to the unique identifiers, shall consist of data sheets that document compliance with the specification and shall include a copy of each control system bill of materials. Catalog cuts shall be in booklet form indexed by device type. Where multiple components are shown on a catalog cut, the application specific component shall be marked. Data shall include, but not be limited to, the following:

- a. BACnet routers, converters and gateways.
- b. Auto-dial/auto-answer modems.
- c. Notebook computer(s).
- d. Hand-held terminal(s).
- e. Digital controllers and controller cabinets.
- f. Input and output (I/O) devices.
- g. Surge and transient protection.

Software; G

Descriptions of software, including but not limited to, operating systems and utility software; diagnostic routines; DDC software; communications programs; and user interface software.

Training; G

A training course in the maintenance and operation of the BACS, approved 60 days prior to the start of training. The training shall be oriented to the specific systems being installed under this contract. One training manual shall be furnished for each trainee, plus two additional copies delivered for archival storage at the project site. The manual shall include the agenda, the defined objectives for each lesson, and a detailed description of the subject matter for each lesson. Two copies of audiovisual materials shall be delivered for archival storage at the project site, either as a part of the printed training manuals or on the same media as that to be used during the training session.

SD-02 Drawings

System Drawings; G.

The system drawings shall include the following:

- a. A drawing index.

b. A list of symbols.

c. A series of drawings for each HVAC control system using abbreviations, symbols, nomenclature and identifiers as shown on the contract drawings. Each control-system element on a drawing shall have a unique identifier as shown.

Each series of drawings for an HVAC control system shall include a schematic as shown on the contract drawings, a wiring diagram, a list of equipment with manufacturer and model number, controller/control panel arrangement drawing and an HVAC control-system sequence of operation. The sequence of operation for each HVAC control system shall be in the language and format of this specification. No operational deviations from specified sequences will be permitted without prior written approval of the Contracting Officer. The sequence of operation shall refer to each device by its unique identifier.

The wiring diagram shall show the interconnection of wires and cables to controller terminal blocks and to the identified terminals of starters and packaged equipment, with all necessary jumpers and ground connections. The wiring diagram shall show the labels of all conductors. All sources of power required for HVAC control systems and for packaged equipment control systems shall be identified back to the panelboard circuit breaker number, controller, magnetic starter, or packaged control equipment circuit. Each power supply and transformer not integral to a starter or packaged equipment shall be shown. The connected volt-ampere load and the power supply volt-ampere rating shall be shown.

d. A system block diagram.

e. Controller/control panel installation, block diagrams, and wiring diagrams.

f. Controller/control panel physical layout and schematics.

g. Details of surge protection device installations.

h. Valve schedules.

The valve schedule shall include each valve's unique identifier size, flow coefficient (Cv), pressure drop at specified flow rate, spring range, positive-positioner range, and actuator size, supported by close-off pressure data, dimensions, operation rate, and access and clearance requirements data.

i. Damper schedules.

The damper schedule shall contain each damper's each actuator's identifier, nominal and actual sizes, orientation of axis and frame, direction of blade rotation, spring ranges, operation rate, positive-positioner ranges, location of actuators and damper end switches, arrangement of sections in multisection dampers, and methods of connecting dampers, actuators, and linkages. The damper schedule shall include the maximum expected velocity through the damper at the intended location and 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; and access and clearance requirements.

Site Testing; G.

Two copies of the test procedures for the site testing. The site testing procedures shall identify each item to be tested and shall clearly describe each test. The test procedures shall include a list of the test equipment to be used for site testing, manufacturer and model number, and the date of calibration and accuracy of calibration, within 6 months of the test date.

Performance Verification Testing; G.

Two copies of the test procedures for the performance verification test. The test procedures shall explain in detail, step-by-step actions and expected results to demonstrate compliance with the specified requirements. Written approval by the Government of the performance verification test procedures shall be one of the prerequisites for commencing the performance verification test.

Commissioning Procedures; G.

Commissioning procedures for each HVAC control system, and for each type of terminal unit control system. The procedures shall reflect the language and format of this specification. The commissioning procedures shall refer to the devices by their unique identifiers as shown and shall include step-by-step configuration procedures for each system. The configuration procedures shall include a configuration check sheet showing all configuration parameters.

Two copies of Commissioning Procedures, in booklet form and indexed, for each system, 60 days prior to system commissioning. Commissioning procedures shall include general instructions on how to set control parameters including setpoints; proportional, integral, and derivative mode constants; contact output settings for the specific devices provided. Commissioning procedures shall be specific to each HVAC system, shall detail the steps involved, and shall refer to the procedures in the booklet for specific devices.

SD-03 Product Data

Equipment Data; G.

The equipment data shall be in booklet form, indexed to the unique identifiers, shall consist of data sheets that document compliance with the specification and shall include a copy of each control system bill of materials. Catalog cuts shall be in booklet form indexed by device type. Where multiple components are shown on a catalog cut, the application specific component shall be marked. Data shall include but not limited to the following:

- a. BACnet routers, converters and gateways.
- b. Auto-dial/auto-answer modems.

- c. Notebook computer(s).
- d. Hand-held terminal(s).
- e. Digital controllers and controller cabinets.
- f. Input and output (I/O) devices.
- g. Surge and transient protection.

Software; G.

Descriptions of software, including but not limited to operating systems and utility software; diagnostic routines; DDC software; communications programs; and user interface software.

SD-06 Test Reports

Test Reports; G.

Two copies of the site testing data. Original copies of all data produced during site testing , including results of each test procedure, after approval of the site tests.

Performance Verification Report; G.

Two copies of the performance verification test report after completion of a successful test.

Documentation of test results for the entire HVAC control system complete, in booklet form and indexed, within 30 days after each test.

Control System Calibration, Adjustments, and Commissioning; G.

Two copies of the calibration, adjustment and commissioning report which shall include setpoints and proportional, integral and derivative mode constant settings, calibration data for all I/O devices, and all the data resulting from adjusting the control system devices and commissioning HVAC control systems.

SD-10 Operation and Maintenance Data

Technical Data Package; G.

Operation and maintenance data in manual format. Final copies of the manuals bound in hardback, loose leaf binders, at least 2 weeks prior to training course. The manuals shall have a table of contents and tab sheets. Tab sheets shall be placed at the beginning of each chapter or section and at the beginning of each appendix. Each manual's contents shall be identified on the cover.

The manuals shall include the names, addresses, and telephone numbers of each subcontractor installing equipment and systems, and of the nearest service representatives for each item of equipment and each system. The draft copy used during site testing shall be updated with any changes required, prior to final submission of the manual. The final copies delivered after completion of the endurance test shall include modifications made during installation checkout and acceptance. Manuals shall include:

Functional Design Manual; G.

Two copies of the functional design manual which shall identify the operational requirements for the system and explain the theory of operation, design philosophy, and specific functions. A description of hardware and software functions, interfaces, and requirements shall be included for all system operating modes.

Hardware Manual; G.

Two copies of the hardware manual which shall describe equipment furnished, including:

- a. General description and specifications.
- b. Installation and checkout procedures.
- c. Equipment electrical schematics and layout drawings.
- d. System schematics and I/O device wiring lists.
- e. Alignment and calibration procedures.
- f. Manufacturer's repair parts list indicating sources of supply.

Software Manual; G.

Two copies of the software manual which shall describe the functions of all software, and shall include all other information necessary to enable proper loading, testing and operation including, but not limited to the following:

- a. Definitions of terms and functions.
- b. Operator commands.
- c. System access requirements.
- d. Data entry requirements.
- e. Descriptions of application software.
- f. Description of database structure and interface with programs.
- g. Alarms.

Operator's Manual; G.

Four complete copies of operation manuals for each HVAC control system, in booklet form and indexed, outlining the step-by-step procedures required for each HVAC control system's startup, operation, and shutdown. The manuals shall include all detail drawings, equipment data, and manufacturer supplied operation manuals for all equipment.

Maintenance Manual; G.

Four complete copies of maintenance manuals, indexed in booklet form listing maintenance procedures. The maintenance instructions shall include a maintenance check list for each HVAC control system. Maintenance manuals shall include spare parts data and recommended maintenance tool kits for all control devices. Maintenance instructions shall include recommended repair methods, either field repair, factory repair, or whole-item replacement. The manual shall contain a list of service organizations qualified to service the HVAC control system, including the service organization name and telephone number. If operation and maintenance manuals are provided in a common volume, they shall be clearly differentiated and separately indexed.

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.

1.5 TESTING

1.5.1 Site Testing

Personnel, equipment, instrumentation, and supplies shall be provided as necessary to perform site testing, adjusting, calibration and commissioning. The tests shall not be conducted during scheduled seasonal off periods of base heating and cooling systems. Wiring shall be tested for continuity and for ground, open, and short circuits. Tubing systems shall be tested for leaks. Ground rods installed by the Contractor shall be tested as specified in IEEE 142. Written Government approval of the specific site testing procedures shall be obtained prior to any test. Written notification of any planned site testing, commissioning or tuning shall be given at least 14 calendar days prior to any test.

1.5.2 Control System Calibration, Adjustments, and Commissioning

Instrumentation and controls shall be calibrated and the specified accuracy shall be verified using test equipment with calibration traceable to NIST standards. Mechanical control devices shall be adjusted to operate as specified. 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. Control system commissioning shall be performed for each HVAC system. The report describing results of functional tests, diagnostics, and calibrations, including written certification, shall state that the installed complete system has been calibrated, tested, and is ready to begin performance verification testing. The report shall also include a copy of the approved performance verification test procedure.

1.5.3 Performance Verification Test

Compliance of the HVAC control system with the contract documents shall be demonstrated. Using test plans and procedures previously approved, physical and functional requirements of the project, including communication requirements shall be demonstrated. The performance verification test procedures shall explain, step-by-step, the actions and

expected results that will demonstrate that the control systems perform in accordance with the sequences of operation. The performance verification test shall not be started until after receipt of written permission by the Government, based on the Contractor's written certification of successful completion of site testing and training.

1.5.4 Coordination with HVAC System Balancing

The HVAC control system shall be tuned after all air-system and hydronic-system balancing has been completed, minimum damper positions set and a report issued. Commissioning may be performed prior to or simultaneous with HVAC system balancing.

1.5.5 Posted Instructions

Instructions on letter-size sheets and half-size plastic laminated drawings for each system, showing the final installed conditions, shall be placed in each HVAC control panel. The posted instructions shall include the control sequence, control schematic, ladder diagram, wiring diagram, valve schedules, damper schedules, commissioning procedures, and preventive maintenance instructions.

1.6 TRAINING

1.6.1 General

The 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 course shall be taught at the project site for a period of 10 training days. A training day is defined as 8 hours of classroom instruction, including breaks and lunch time, Monday through Friday, during the daytime shift in effect at the training facility. For guidance in planning the required instruction, the Contractor shall assume that the attendees will have a high school education or equivalent, some experience using Windows-based software, and are familiar with HVAC systems. No training shall be scheduled until training manuals and O&M manuals have been approved by the Government.

1.6.2 Operator Training

The operator's course shall be taught for a total of 7 training days. Training shall be classroom, but have hands-on operation of similar digital controllers. Upon completion of this course, students should be fully proficient in the operation of each system function. This course shall include but not be limited to:

- a. Theory of operation
- b. Hardware architecture
- c. Operation of the system
- d. Operator commands
- e. Control sequence programming
- f. Data base entry
- g. Reports and logs

- h. Alarm reports
- i. Diagnostics

1.6.3 Maintenance Personnel Training

a. The system maintenance course shall be taught for a period of 3 training days. The course shall include but not be limited to:

- (1) Physical layout of each piece of hardware.
- (2) Troubleshooting and diagnostics procedures.
- (3) Repair instructions.
- (4) Preventive maintenance procedures and schedules.
- (5) Calibration procedures.

b. Troubleshooting, checkout and calibration of the working system shall be accomplished in a classroom setting and repeated on-site.

1.7 QUALITY ASSURANCE

1.7.1 Standard Products

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. Material and equipment shall be standard products of a manufacturer regularly engaged in the manufacturing of such product, using similar materials, design and workmanship. Items of the same type and purpose shall be identical, including equipment, assemblies, parts and components.

1.7.2 Single-source Responsibility

The HVAC Controls Contractor shall have single-source responsibility for the complete acquisition, installation, and proper operation of the BACS. The equipment items shall be supported by a service organization. The Contractor shall submit a certified list of qualified permanent service organizations and qualifications. These service organizations shall be reasonably convenient to the equipment on a regular and emergency basis during the warranty period.

1.7.3 Verification of Dimensions

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

1.7.4 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, and shall

furnish all work necessary to meet such conditions.

PART 2 PRODUCTS

2.1 GENERAL EQUIPMENT REQUIREMENTS

2.1.1 Conformance to BACnet

All controllers and network devices shall conform to the BACnet protocol. Each type device shall have a protocol implementation conformance statement (PICS) that identifies all of the portions of BACnet that are implemented in each device. Each PICS shall include device description and manufacturer, supported functional groups, supported application services and object types, data link layer options, and supported segmented requests and responses.

2.1.2 Electrical and Electronic Devices

Electrical, electronic, and electropneumatic devices not located within an HVAC control panel shall have a NEMA ICS 1 enclosure in accordance with NEMA 250 unless otherwise shown. Control panels shall have ambient condition ratings of plus 2 to 50 degrees C and 10 to 95 percent relative humidity, noncondensing. Devices installed outdoors shall operate within limit ratings of minus 2 to 63 degrees C. I/O devices shall be rated for continuous operation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified or normally encountered for the installed location.

2.1.3 Multiple Controller Requirement

Where the system to be controlled by the BACS is located in multiple mechanical rooms, each mechanical room shall have at least one digital controller. Digital 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. Each mechanical system shall have its own dedicated controller or group of controllers.

2.1.4 Nameplates, Lens Caps, and Tags

Nameplates and lens caps bearing legends as shown and tags bearing device unique identifiers as shown shall be engraved or stamped characters. Nameplates shall be permanently attached to HVAC/DDC control panel doors. For each field device and equipment item not in a finished area, a plastic or metal tag with equipment name and point identifier shall be attached. Each air flow measurement station shall have a tag showing flow rate range for signal output range, duct size and identifier as shown.

2.2 BACNET ROUTERS, CONVERTERS, AND GATEWAYS

2.2.1 Routers

BACnet routers shall be conformance class 6 devices interconnecting two or more BACnet networks to form a internetwork. Routers shall have the routing functionality of interconnecting BACnet Ethernet high speed LAN, to BACnet MS/TP LAN or BACnet ARCNET high speed LAN. BACnet PTP (RS-232 point-to-point) communication shall be available on routers by including modems; PTP/modem shall operate under the BACnet half-router communication protocol.

2.2.2 Converters

A converter shall be provided to interface notebook computers and hand held terminals from its RS-232 serial port to system controllers on the BACnet LANs (Ethernet, MS/TP, ARCNET).

2.2.3 Gateways

BACnet gateways shall be microprocessor based protocol translators performing bi-directional translation between BACnet and non-BACnet protocols. Gateways shall be BACnet conformance class 6 devices. Each gateway shall have a database containing local and global data. Local data shall be unique from gateway to gateway, and global data shall be the same type in every gateway. Implement analog and digital point data, descriptors, time and trend schedule data, and network data for all mechanical/electrical systems connected to the DDC system. Points shall be viewed and commanded on the BACnet side of the gateway in the same manner as those points connected to non-BACnet controllers. Multiple gateways shall be provided as required to meet or exceed the capacity of the DDC system. Gateway features and connections shall include but not limited to the following:

- a. Full and transparent translation of any point data on the non-BACnet LAN to the BACnet format.
- b. Communications and alarm processing software.
- c. Operating system and utility software.
- d. Nonvolatile memory/battery-backed RAM for storage of system items.
- e. Built-in 10BaseT Interface for communications via BACnet Ethernet LAN.
- f. RS-232 port for notebook computer, or modem to remote site.
- g. Configuration tool software, a Windows-based program to create device application and data files that define controllers and points, and provide point data information between the two networks.

2.3 DIRECT DIGITAL CONTROL (DDC) DEVICES

DDC controllers shall be stand-alone microprocessor-based devices with sufficient memory and point capacity to perform specified functions and operations. Controllers shall be BACnet conformance class 3 or class 4 devices. Total number of I/O hardware points connected to a single digital controller shall not exceed 85 percent of the controller's point capacity; I/O expansion units and multiplexing of I/O are not permitted. All digital controllers shall operate within limit ratings of 35 to 120 degrees F and 10 percent to 95 percent relative humidity, noncondensing. Provide real time clock with each controller on the highest level LAN. Backup power shall be provided to each controller's clock and random access memory (RAM) by a battery or capacitor with sufficient capacity to maintain operation for a minimum of 72 hours during a line power outage. Closed-loop control functions shall include proportional, proportional plus integral, and proportional plus integral plus derivative (PID) control capability. Controllers shall have communication ports for connection to BACnet MS/TP or ARCNET LAN.

2.3.1 I/O Functions

I/O functions shall be integral to each digital controller, and shall include the following:

a. Analog Inputs: Allowable input types are 2 or 3 wire 1000 ohm (or higher) platinum resistance temperature detectors (RTDs), stable 10,000 ohm thermistors, and 4 to 20 mAdc. Thermistor and direct RTD inputs must have appropriate conversion curves stored in controller software or firmware. Analog to digital (A/D) conversion shall be a minimum of 10 bits resolution.

b. Digital Inputs: Digital inputs shall sense open/close, on/off, or other two state indications. Input device contacts shall be nonpowered.

c. Pulse Accumulator: The pulse accumulator function shall have the same characteristics as the digital input function, except that, in addition, a buffer shall be provided to totalize pulses and allow for interrogation by the controller. The pulse accumulator shall accept rates up to 10 pulses per second.

d. Analog Outputs: Analog outputs shall be 2-10 Vdc or 4-20 mAdc. Digital-to-analog (D/A) conversion shall be a minimum of 8 bits resolution.

e. Digital Outputs: Digital outputs shall provide contact closures for momentary and maintained operation of output devices. Outputs shall have a minimum closure duration of 0.1 second with contacts rated for a minimum of 1 ampere at 24 Vac.

2.3.2 Digital Controller Cabinet

Each digital controller cabinet shall protect the controller from dust and be rated NEMA 1, unless specified otherwise. Controller cabinets or enclosures shall be lockable with common keying. Provide door switch wired to input of controller for intrusion alarm annunciation. A 120 Vac, 15 amp, 60 Hz duplex outlet shall be provided for each separate location of controller cabinet on the highest level LAN. The duplex outlet shall be on a separate circuit from the digital controllers.

2.3.3 Terminal-Unit Controls

Terminal-unit controllers shall be manufactured by the same company as the digital controllers. Unit controllers shall be conformance class 3, stand-alone, microprocessor-based controllers connected to a lower level LAN; controllers shall communicate with the digital controllers. Unit controllers may deviate from stand-alone only in receiving energy management and time information from a stand-alone digital controller. Unit controllers may be used for the control of variable air volume (VAV) boxes, fan coil units, and heat pumps. Controls for VAV boxes shall consist of a velocity-sensing device in the primary air entering the box, a room temperature sensing element, a damper actuator, and a unit controller; a duct pressure switch shall be included when VAV box is provided with recirculation fan. Each controller shall operate the damper for cooling and the recirculation fan and duct coil for heating. Terminal units shall be as specified in Section 15895 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM.

2.4 DDC SOFTWARE

Each digital controller shall contain an operating system, self-test diagnostic routines, start-up software, and application programs and routines as specified. The operating system shall control and schedule controller activities, and maintain a point database that includes all parameters and constraints. Controllers shall automatically start-up on return of power after a failure, and previous operating parameters shall exist or shall be automatically downloaded from a controller or host workstation on the higher level LAN. In addition to specified programs and routines, provide software in respective controllers required to perform the indicated "control sequences of operation". The sequence of control shall be written to include all conventional control operations (e.g. temperature and pressure control loops), time event operations, energy management functions (night setback, reset schedules, and optimum start-stop routines), demand limiting, safeties, and emergency conditions.

2.4.1 Database Modification

Software shall be provided to modify the control program database. Database modification shall be accomplished through connected computer or hand-held terminal or through a keypad integral to the controller.

2.4.2 Runtime Accumulation

Resettable runtime accumulation shall be provided for each controlled electrical motor.

2.4.3 Scheduled Start-Stop

Programs shall be provided to start and stop equipment based on time-of-day schedules for each day of the week, and on holiday schedules. Programs shall automatically adjust for leap years, and make daylight savings time and standard time adjustments.

2.4.4 Optimum Start-Stop

Programs shall be provided to 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, indoor and outdoor air conditions using predictive software to determine the minimum time of HVAC system operation required to satisfy space environmental conditions at the start of the occupied cycle, and determine the earliest time for stopping equipment at the day's end.

2.4.5 Demand Limiting

Software shall be provided to shed electrical loads when the building or base is near peak demand. The program shall continuously monitor pulses from a building's electric meter and with predictive software, calculate a predicted power demand. When the predicted demand exceeds a preset target, the program shall shed loads on a prescheduled priority basis to reduce the connected load before the actual peak exceeds the target. Program demand limiting routines into the sequence of control.

2.4.6 Point Override

I/O and virtual points shall be able to be software overridden in the

software and commanded to any possible value.

2.4.7 Alarming

I/O points and virtual points shall be alarmable. Alarm limits shall be adjustable on analog points.

2.4.8 Messages

Messages shall be operator defined and assigned to alarm points. Messages shall be displayed when a point goes into alarm.

2.4.9 Trending

DDC system shall have the capability to trend I/O and virtual points. Points associated into groups. A trend report may be set up for each group. The period between logging consecutive trend values shall range from one minute to 60 minutes as a minimum. Trend data type shall be selectable as either averages over the logging period or instantaneous values at the time of logging. The minimum number of consecutive trend values stored at one time shall be 30 per variable. When trend memory is full, the most recent data shall overwrite the oldest data. Trend data shall be capable of being uploaded to workstation computer. Trend data shall be available on a real time basis; trend data shall appear either numerically or graphically on a connected notebook computer screen as the data is being processed from the DDC system data environment. Trend reports shall be capable of being uploaded to workstation disc and archived.

2.4.10 Status Display

Current status of I/O and virtual points shall be displayed on command. Points shall be associated into functional groups, such as all the I/O and virtual points associated with control of a single air handling unit, and displayed as a group, so the status of a single mechanical system can be readily checked. A group shall be selectable from a menu of groups having meaningful names; such as AHU-1, Boiler System, Chiller System, and other such names.

2.4.11 Power Loss

In event of a power outage, each controller shall assume a disabled status and outputs shall go a user-definable state. Upon restoration of power, DDC system shall perform an orderly restart, with sequencing of outputs.

2.4.12 Program Transfer

Control programs and database shall be capable of being down-loaded from workstation computer to controllers and uploaded to workstation from controllers. Every digital controller in the DDC system shall be capable of being downloaded and uploaded through a single controller on the highest level LAN.

2.5 PORTABLE COMPUTERS AND TERMINALS

The BACS primary operator/maintenance terminals shall be notebook computers and hand-held terminals used to perform command entry, database and alarm management, system monitoring and control setpoint adjustment, and other related functions.

2.5.1 Notebook Computer

Notebook computer with instruction manual and universal carrying case shall be provided. Computer shall include but not limited to:

- a. 1.7 GHz or faster Pentium III or IV Processor, 256MB RAM.
- b. 40GB Hard Drive, 40X CD-ROM Drive, 3.5" Diskette Drive.
- c. 14" Color Display, Parallel and Serial Ports.
- d. Windows 2000 or Windows XP Operating System.
- e. Network Management, Communications and Utility Software.

2.5.2 Hand-Held Terminals

Hand-held terminal or communications-and-programming device with instruction manual and direct connection cable to communicate with controllers shall be provided. Hand-held terminal shall connect to high and low level LAN controllers directly or to a jack at room-temperature-sensing element locations. Provide one additional hand-held device, manual, and cable per 60 controllers. Notebook computers with the required functionality may be provided as an alternative to hand-held terminals.

2.6 DAMPERS

2.6.1 Damper Assembly

A single damper section shall have blades no longer than 1,220 mm and shall be no higher than 1,830 mm . Maximum damper blade width shall be 200 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. All blade-operating linkages shall be within the frame so that blade-connecting devices within the same section will 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 1.01 mm water gauge at 5 meters per sec (0.04-inch water gauge at 1,000 fpm) in the wide-open position. Frames shall not be less than 50 mm in width. Dampers shall be tested in accordance with AMCA 500.

2.6.1.1 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.

2.6.1.2 Damper Types

Dampers shall be parallel or opposed blade type. Parallel blades shall be used for on-off dampers and opposed blades shall be used for modulating

dampers.

2.6.2 Outside-Air, Return-Air, and Relief-Air Dampers

The 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 0.0968 cubic meter per sec per square meter at 100 mm (20 cfm per square foot at 4 inches) water gauge static pressure when closed. Seals shall be suitable for an operating temperature range of -40 to +93 degrees C . Dampers shall be rated at not less than 10 meters per sec air velocity.

2.6.3 Mechanical and Electrical Space Ventilation Dampers

The dampers shall be as shown. Dampers shall not leak in excess of (0.406 cubic meter per sec per square meter at 100 mm) water gauge static pressure when closed. Dampers shall be rated at not less than 7.6 meters per sec (1500 fpm) air velocity.

2.7 AUTOMATIC CONTROL VALVES

2.7.1 Valve Assembly

Valves shall have stainless-steel stems and stuffing boxes with extended necks to clear the piping insulation. Valve bodies shall be designed for not less than 860 KPa (125 psig) working pressure of 150 percent of the system operating pressure, whichever is greater. Valve leakage rating shall be .01 percent of rated Cv.

2.7.2 Butterfly-Valve Assembly

Butterfly valves shall be threaded lug type suitable for dead-end service, and for 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 -30 to + 120 degrees C . Valves shall have a manual means of operation independent of the actuator.

2.7.3 Two-Way Valves

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

2.7.4 Three-way Valves

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

2.7.5 Fan Coil -Unit-Coil Valves

Control valves with either flare-type or solder-type ends shall be provided for duct or terminal-unit coils. Flare nuts shall be furnished for each flare-type end valve.

2.7.6 Valves for Chilled-Water Service.

Bodies for valves 38 mm and smaller shall be brass or bronze, with threaded or union ends. Bodies for valves from 50 mm to 76 mm inclusive shall be of brass, bronze or iron. Bodies for 50 mm (2-inch) valves shall have threaded ends. Bodies for valves from 63 mm to 76 mm shall have

flanged-end connections. Valve Cv shall be within 100 percent to 125 percent of the Cv shown. Internal valve trim shall be brass or bronze except that valve stems may be type 316 stainless steel. Valves 100 mm (4 inches) and larger shall be butterfly valves.

2.7.7 Valves for Hot-Water Service Below 120 degrees C

Bodies for valves 38 mm (1-1/2 inches) and smaller shall be brass or bronze, with threaded or union ends. Bodies for 50 mm (2-inch) valves shall have threaded ends. Bodies for valves from 2 inches to 3 inches inclusive shall be of brass, bronze, or iron. Bodies or valves 100 mm (4 inches) and larger shall be iron. Bodies for valves 50 mm (2-inch) inches and larger shall be provided with flanged-end connections. Valve Cv shall be within 100 percent to 125 percent of the Cv shown. Internal trim (including seats, seat rings, modulating plugs, and springs) of valves controlling water hotter than 100 degrees C shall be type 316 stainless steel. Internal trim for valves controlling water 100 degrees C or less shall be brass or bronze. Nonmetallic parts of hot-water control valves shall be suitable for a minimum continuous operating temperature or 120 degrees C or 50 degrees F above the system design temperature, whichever is higher. Valves 100 mm and larger shall be butterfly valves.

2.7.8 Valves for High-Temperature Hot-Water Service Above 250 Degrees F

Valve bodies shall be rated ANSI Class 300, as in ASME B16.34. Valve and actuator combination shall be normally closed. Bodies shall be carbon steel, globe type with welded ends on valves 25 mm (1-inch) and larger. Valves smaller than 25 mm (1-inch) shall have socket-weld ends. Packing shall be virgin polytetrafluoroethylene (PTFE). Valve Cv shall be within 100 percent to 125 percent of the Cv shown.

2.8 ACTUATORS

2.8.1 General Requirements

Actuators shall fail to their spring-return positions as shown on signal or power failure and shall have a visible position indicator. Actuators shall open or close the devices to which they are applied within 60 seconds after a full scale input signal change. Electric or electronic actuators operating in parallel or in sequence shall have an auxiliary actuator driver. Pneumatic actuators shall be rated for 172 KPa (25 psig) operating pressure except for high-pressure cylinder-type actuators. Actuators shall be pneumatic, electric or electronic as shown.

2.8.2 Damper Actuators

Actuators shall smoothly operate the devices to which they are applied. Actuators shall fully open and close the devices to which they are applied and shall have a full stroke response time of 60 seconds or less. The actuator stroke shall be limited by an adjustable stop in the direction of power stroke. The actuators shall be provided with mounting and connecting hardware.

2.8.3 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.

2.9 INPUT AND OUTPUT (I/O) DEVICES

2.9.1 Measurements

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

- a. Room/space temperature, 4 to 38 degrees C .
- b. Duct temperature, -18 to +65 degrees C .
- c. Chilled-water temperature, -2 to +38 degrees C .
- d. Heating hot water temperature, 4 to 115 degrees C .
- e. Outside-air temperature, -18 to +115 degrees C .
- f. Relative humidity, 5 to 95 percent.
- g. Fluid and gas pressure or differential pressure range: select minimum required for the application.

2.9.2 Resistance Temperature Detectors (RTDs)

RTD sensors shall be 1000 ohm, or higher, platinum elements that are compatible with the digital controllers. Sensors shall be encapsulated in epoxy, series 300 stainless steel, anodized aluminum, or copper.

Temperature sensor accuracy shall be 0.1 percent (1 ohm) of expected ohms (1000 ohms) at 0 degrees C . Temperature sensor stability error over five years shall not exceed 0.25 degree F cumulative. When 2 or 3 wire RTDs are connected directly to the controller, keep lead resistance error to 0.14 degree C (0.25 degree F) or less. Total error for a RTD circuit shall not exceed 0.5 degree F, which includes sensor error, lead resistance error or 4 to 20 milliampere transmitter error, and A/D conversion resolution error.

Provide manufacturer documentation and the Contractor's engineering calculations which support that the proposed RTD circuit will have a total error of 0.28 degrees C or less for the specified application. Provide 4 to 20 milliampere transmitters for RTDs where digital controllers do not meet temperature resolution requirement of 0.14 degree C (0.25 degree F) or do not support direct connection of RTDs.

2.9.3 Thermistors

Precision thermistors may be used in temperature sensing applications below 93 degrees C . Sensor accuracy over the application range shall be 0.20 degrees C (0.36 degrees F) or less between the range of 0 to 63 degrees C .

Sensor manufacturer shall utilize 100 percent screening to verify accuracy. Thermistors shall be pre-aged, and inherently stable. Stability error of the thermistor over five years shall not exceed 0.14 degree C (0.25 degree F) cumulative. Sensor element and leads shall be encapsulated. Bead thermistors are not allowed. A/D conversion resolution error shall be kept to 0.05 degree C (0.1 degree F) . Total error for a thermistor circuit shall not exceed 0.28 degrees C , which includes sensor error and digital controller A/D conversion resolution error. Provide thermistor and digital controller manufacturer documentation and the Contractor's engineering calculations which support that the proposed thermistor input circuit will have a total error of 0.28 degrees C or less.

2.9.4 Temperature Sensor Details

a. Room Type: Conceal element behind protective cover matched the room interior.

b. Duct Averaging Type: Continuous averaging RTDs for ductwork applications shall be 1 foot in length for each 0.3716 square meter (4

square feet) of ductwork cross-sectional area with a minimum length of 1,830 mm . Probe type duct sensors of 25 mm length minimum are acceptable in ducts 3,660 mm square and less.

c. Immersion Type: Total immersion depth (76 mm to 150 mm) as required for the application for use with thermowells, unless otherwise indicated.

d. Outside Air Type: Sensor shall have weatherproof housing, and sunshield to minimize solar effects. Mount element at least 76 mm from building outside wall.

2.9.5 Transmitters

Transmitters shall have 4 to 20 ma output linearly scaled to the temperature, pressure, humidity, or flow range being sensed. Transmitter shall be matched to the sensor, factory calibrated, and sealed. Total error shall not exceed 0.1 percent of 20 milliampere (0.02 milliampere) at any point across the 4 to 20 ma span. Supply voltage shall be 24 Vdc. Transmitters shall have noninteractive offset and span adjustments. For temperature sensing, transmitter stability shall not exceed 0.05 degrees C (0.09 degree F) a year.

2.9.6 Thermowells

Thermowells shall be Series 300 stainless steel with threaded brass plug and chain, 2-inch lagging neck and extension-type well, and inside diameter and insertion length as required for the application.

2.9.7 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 sunshields shall be PVC, or painted white or shall be unpainted aluminum.

2.9.8 Relative Humidity Instruments

The instrument (humidity sensor and transmitter) shall be a 2 wire loop-powered device and have an output of 4 to 20 mAdc proportional to 5 to 95 percent relative humidity input. Accuracy shall be plus or minus 2 percent of full scale within the range 20 to 80 percent relative humidity. Sensing element shall be chilled mirror type, polymer, or thin film polymer type. Supply voltage shall be 24 Vdc. Transmitter shall include offset and span adjustments. Provide instrument with weather-proof housing for outdoor applications.

2.9.9 Pressure and Differential Pressure Instruments

The instrument shall be a pressure transmitter with an integral sensing element. The instrument overpressure rating shall be 300 percent of the operating pressure. Sensor-transmitter assembly accuracy shall be plus or minus 1 percent of full scale. The transmitter shall be a 2 wire, loop-powered device and have an output of 4 to 20 mAdc proportional to the input pressure range. Each transmitter shall have offset and span adjustments.

2.9.10 Flow Switches

Flow switches shall have a repetitive accuracy of plus or minus 1 percent of full scale. Switch actuation shall be adjustable over the flow operating flow range. The switch shall have a snap-action Form C contact rated for the application.

2.9.11 Pressure and Differential Pressure Switches

Each switch shall have an adjustable trip setpoint, and single pole double throw contacts rated for the application. Provide taps for sensing lines to be connected to duct pressure fittings designed to sense air pressure; fittings shall be of the angled-tip type with tips pointing into the air stream. Switches shall withstand pressure surges up to 150 percent of rated pressure. Each pressure switch shall be selected so that operating pressure trip point is approximately midpoint of pressure switch adjustable range. Repetitive accuracy shall be 2 percent.

2.9.12 Insertion Freeze Protection Switch

Electric switch shall be capillary type. Provide special purpose insertion thermostats with flexible elements a minimum of 6100 mm in length for coil face areas up to 3.7 square meters. Switch contacts shall be rated for motor starter circuit voltage being interrupted. Switch shall be equipped with auxiliary set of contacts for input of switch status to digital controller. Provide additional elements or longer elements for larger coils at the rate of 305 mm length of element per 0.37 square meter of coil. Serpentine entire airflow. A freezing condition at 460 mm increments along the sensing element shall activate the thermostatic switch. Switch shall require manual reset after activation.

2.9.13 Current-Sensing Switches

Current-sensing switches shall be of a design that provides a normally-open single pole single throw contact rated for the application. Switches shall be single unit construction with provisions for firm mounting. Each current-sensing switch shall have a single thru-hole for passage of current-carrying conductors, selected for operation at a nominal 50 percent of current rating of sensed device. The Contractor shall use multiple turns of sensed leads for higher rate loads.

2.9.14 Energy Metering Devices

2.9.14.1 Electric Meters

Watt-hour meters with pulse initiators shall be as specified in Section 16375 ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND. Pulse initiator shall be connected to respective digital controller.

2.9.14.2 Gas Meters

Gas meters with pulse switches shall be as specified in Section 02556 GAS DISTRIBUTION SYSTEM. Pulse switch shall be connected to respective digital controller.

2.9.14.3 Water Meters

Water meters with pulse switches shall be as specified in Section 02510 WATER DISTRIBUTION SYSTEM. Pulse switch shall be connected to respective digital controller.

2.9.15 Pneumatic to Electronic Transducers

Pneumatic-to-electronic transducers shall convert 3 to 15 psig pressure input signal to a 4 to 20 mA_{dc} output signal. Supply voltage shall be 24 V_{dc}. Accuracy shall be 1 percent or better. Linearity shall be 0.1 percent.

2.9.16 Thermostats

Thermostat ranges shall be selected so that the setpoint is adjustable between plus or minus 10 degrees F of the setpoint shown. Thermostats shall be electronic or low-voltage electric. Modulating room and modulating capillary 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 -15 to -13 degrees C for each output. Room thermostats shall be enclosed with separate locking covers (guards). Low-temperature-protection thermostats shall be low-temperature safety thermostats, with normally-open and normally-closed contacts and a 6100 mm element which shall respond to the coldest 460 mm segment.

2.9.17 Control Relays

Relays shall be double pole, double throw (DPDT), UL listed, with contacts rated for the application, and enclosed in a dustproof enclosure. Equip with a light indicator which is lit when coil is energized and is off when coil is not energized. Relays shall be socket type, plug into a fixed base, and be replaceable without need of tools or removing wiring.

2.9.18 Humidity Sensors

Humidity sensors shall be of design for duct mounting and utilizing permanent, calibratable sensor unit. Chemical or other devices which must be replaced from time to time are not acceptable. Range shall be 0-100% RH, accuracy +/- 2%, response time approximately 15 seconds, temperature coefficient and linearity +/- 0.1 degrees C, with transmitter compatible with the system.

2.10 INDICATING DEVICES

2.10.1 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 228 mm (9-inch) scale. Thermometers for piping systems shall have rigid stems with straight, angular, or inclined pattern. All stems shall have expansion heads as required to prevent breakage at extreme temperatures; the space between bulb and stem shall be filled with a heat-transfer medium. Non-averaging air-duct thermometers shall have perforated stem guards and 45-degree adjustable duct flanges with locking mechanism. Averaging air-duct thermometers shall have no less than 89 mm dial, with black legend on white background, and pointer traveling through a 270-degree arc. Thermometers shall have an accuracy of plus or minus 1 percent of scale range. Select thermometer ranges so normal temperatures are approximately equal to midpoint readings on the scale, unless otherwise specified.

2.10.2 Pressure Gauges

Gauges shall be 50 mm (2-inch) (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 2 percent of scale range. Select gauge ranges so normal pressures are approximately equal to the midpoint readings on the scale, unless, otherwise specified. Gauges shall conform to ANSI/ASME B40.1. Provide gauges as specified for the following applications:

a. Hydronic System: Gauges for hydronic-system applications shall have ranges and graduations as shown.

b. Low Differential Pressure: Gauges for low differential-pressure measurements shall be 114 mm (4-1/2-inch) (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.

2.11 ELECTRICAL POWER AND DISTRIBUTION

Wiring and cable circuits shall be provided for all DDC apparatus, including wiring to transformer. Provide circuit and wiring protection in accordance with NFPA 70. A source 120 volts or less, 60 hz, two-pole, three wire with ground shall be provided. Devices shall be UL listed or FM approved. All electrical, electronic, and electro-pneumatic devices not located within a DDC panel shall have an enclosure NEMA 1 in accordance with NEMA 250 unless otherwise shown.

2.11.1 Nonconducting Wiring Duct

Nonconducting wiring duct in control panels shall have slotted sides, snap-on duct covers, fittings for connecting ducts, mounting clips for securing ducts, and wire-retaining clips.

2.11.2 Terminal Blocks

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

2.11.3 Transformers

Transformers shall conform to UL 506. Power digital controllers on the highest level LAN from dedicated circuit breakers. Transformers for digital controllers serving terminal equipment on lower level LANs shall be fed from the fan motor leads or fed from the nearest distribution panel board or motor control center, using circuits provided for the purpose. Provide a fuse cutout on the secondary side of the transformer.

2.11.4 Surge Protection

Surge and transient protection consist of devices installed externally to digital controllers.

2.11.4.1 Power Line Surge Protection

Surge suppressors external to digital controller, shall be installed on all incoming AC power. Surge suppressor shall be rated by UL 1449, and have

clamping voltage ratings below the following levels:

- a. Normal Mode (Line to Neutral): 350 Volts
- b. Common Mode (Line to Ground): 350 Volts

2.11.4.2 Communications Line Surge Protection

Protected from surges. metal oxide varistor (MOV) protection, rated for the application, shall be installed at the equipment. Additional protection, gas tubes rated for the application, shall be installed within 915 mm of the building cable entrance.

2.11.4.3 Sensor and Control Wiring Surge Protection

Controllers shall have sensor and control wiring surge protection with optical isolation, metal oxide varistors (MOV), or silicon avalanche devices. Fuses are not permitted for surge protection.

2.11.5 Wiring

2.11.5.1 Control Wiring for 24-Volt Circuits

Control wiring for 24-volt circuits shall be insulated copper 1.195 mm (18 AWG) minimum and shall be rated for 300-volt service.

2.11.5.2 Wiring for 120-volt Circuits

Wiring for 120-volt circuits shall be 2 mm (14 AWG) minimum and shall be rated for 600-volt service.

2.11.5.3 Analog Signal Wiring Circuits

Analog signal wiring for analog inputs and analog outputs shall be 1.195 mm (18 AWG) , single or multiple twisted pair. Each pair shall be 100 percent shielded, and have 1 mm (20 AWG) drain wire. Each wire shall have insulation rated to 300 volts.

2.11.5.4 Instrumentation Cable

Instrumentation cable shall be 1.195 mm (18 AWG) , stranded copper, single or multiple-twisted, minimum 50 mm lay of wist, 100 percent shielded pairs, and shall have a 300-volt insulation. Each pair shall have a 1 mm (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 1 mm (20 AWG) tinned-copper cable drain wire, and overall cable insulation.

2.12 FIRE PROTECTION DEVICES

Smoke detectors shall be as specified in Section 13851 FIRE DETECTION AND ALARM SYSTEM, ADDRESSABLE.

2.13 FIBER OPTIC (FO) CABLE & APPARATUS

2.13.1 FO Cable

The FO cable shall be totally dielectric, with a minimum of 12 optical fibers unless otherwise indicated. The fibers shall be multimode, graded

index, solid glass waveguides, and shall have a nominal core diameter of 62.5 micrometers. The outside diameter of the glass-cladded fiber shall be nominally 125 micrometers, and shall be concentric with the fiber core. FO cable for outdoor applications shall be of loose tube construction with a maximum of four fibers per tube. Cable may be of loose tube or tight buffer construction for indoor applications. Plenum cable shall meet UL 910, and riser cable shall meet UL 1666. FO cable shall be continuous with no factory splices.

2.13.2 FO Connectors

FO connectors shall be ST style, multimode, field installable, self-aligning and centering. Provide ST style connectors for FO cables and patchcords. Connectors shall not require polishing or epoxy during installation, with no compromise in performance.

2.13.3 Fiber Interconnect Center

The fiber interconnect center shall be an enclosure unit designed to terminate, store, and protect up to 24 FO connections. Equip unit with 24 ST style multimode adapters. Interconnect center design features shall include easy access to individual connections, ample room for feed-through cables, and strain-relief provisions for multiple cables within unit. Furnish labels to document fiber connections and routing.

PART 3 EXECUTION

3.1 INSTALLATION

Perform installation under supervision of competent technicians regularly employed in the installation of DDC systems. Provide components for a complete and operational DDC system.

3.1.1 Wiring Criteria

a. Input/output identification: Permanently label each field wire at each end with the identification specified.

b. Surge Protection: Install surge protection no more than three feet from where communication cable enters building.

c. Grounding: Ground controllers and cabinets to a good earth ground. Ground controller to a ground in accordance with Section 16415 ELECTRICAL WORK, INTERIOR. Grounding of the green ac ground wire, at the breaker panel, alone is not adequate. Run metal conduit from controller panels to adequate building grounds. Ground sensor drain wire shields at controller end.

d. Signal Wiring: Install analog signal wiring in conduit separate from AC power circuits.

e. Contractor is responsible for correcting all associated ground loop problems.

3.1.2 Digital Controllers

a. Do not divide control of a single mechanical system such as an air handling unit, boiler, chiller, or terminal equipment between two or more controllers. A single controller or master/slave controllers

shall manage control functions for a single mechanical system.

b. Provide digital control cabinets that protect digital controller electronics from dust, at locations shown on the drawings.

c. Provide a main power switch at each highest level LAN digital controller within controller cabinet.

d. No multiplexing of points is allowed.

3.1.3 Temperature Sensors

Provide temperature sensors in locations to sense the appropriate condition. Provide sensor where they are easy to access and service without special tools. Calibrate sensors to accuracy specified. In no case will sensors designed for one application be installed for another application such as replacing a duct sensor with a room sensor.

3.1.3.1 Room Temperature Sensors

Provide on interior walls to sense average room temperature conditions. Avoid locations which may be covered by office furniture. Room temperature sensors should not be mounted on exterior walls when other locations are available. Mount center line of sensor at 5 feet above finished floor.

3.1.3.2 Duct Mounted Sensors

a. Provide sensors in ductwork in general locations as indicated. Select specific sensor location within duct to accurately sense appropriate air temperatures. Do not locate sensors in dead air spaces or positions obstructed by ducts or equipment. Install gaskets between the sensor housing and duct wall. Seal duct and insulation penetrations.

b. String duct averaging sensors between two rigid supports in a serpentine position to sense average conditions. Thermally isolate temperature sensing elements from supports. Provide duct access doors to averaging sensors.

c. Locate freeze protection sensors in appropriate locations to sense lowest temperatures, to avoid potential problems with air stratification.

3.1.3.3 Immersion Temperature Sensors

Provide thermowells for sensors measuring temperatures in liquid applications or pressure vessels. Locate wells to sense continuous flow conditions. Do not install wells using extension couplings. Where piping diameters are smaller than the length of the wells, provide wells in piping at elbows to effect proper flow across entire area of well. Wells shall not restrict flow area to less than 70 percent of pipe area. Increase piping size as required to avoid restriction. Provide thermowells with thermal transmission material within the well to speed the response of temperature measurement. Provide wells with sealing nuts to contain the thermal transmission material.

3.1.3.4 Outside Air Temperature Sensors

Provide outside air temperature sensor on north side of the building, away

from exhaust hoods, air intakes and other areas that may affect temperature readings. Provide sunshields to protect outside air sensor from direct sunlight.

3.1.3.5 Low Temperature Protection Temperature Switch

For each 40 square feet of coil-face area, provide a temperature switch to sense the temperature at the location shown. Provide temperature switch sensing element in a serpentine pattern.

3.1.4 Damper Actuators

Actuators shall not be mounted in the air stream.

3.1.5 Thermometers

Provide thermometers at locations indicated. Mount thermometers to allow readability when standing on the floor.

3.1.6 Pressure Sensors

3.1.6.1 Differential Pressure

a. General: Install pressure sensing tips in locations to sense appropriate pressure conditions.

b. Pumping Proof with Differential Pressure Switches: Install high pressure side between pump discharge and check valve.

3.1.7 Pressure Gages

Install pressure gages at locations indicated. Mount pressure gages to allow readability while standing on the floor.

3.1.8 Control Drawings

a. Post laminated copies of record (as-built) control system drawings in each mechanical room.

b. Provide 6 sets of record (as-built) drawings to the activity.

3.2 COMMISSIONING PROCEDURES

3.2.1 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.

3.2.1.1 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 requirement 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 controller (such as starter auxiliary contacts, and external systems) may

be simulated in steps 1, 2, and 3. With each operational-mode signal change, controller output relay contacts shall be observed to ensure that they function.

3.2.1.2 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.

3.2.1.3 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 controller 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-controller 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-controller 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.

3.2.1.4 Insertion and Immersion Temperatures

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

3.2.1.5 Averaging Temperature

Averaging-temperature sensing element and transmitter-to-controller readout calibration accuracy shall be checked every 2 feet 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 SITE TESTING

3.3.1 General

a. Demonstrate compliance of the BACS with the contract documents. Furnish personnel, equipment, instrumentation, and supplies necessary to perform site testing. Ensure that tests are performed by competent employees of the DDC system installer or the DDC system manufacturer regularly employed in the testing and calibration of DDC systems.

b. Tests are subject to oversight and approval by the Contracting Officer. The testing shall not be run during scheduled seasonal off-periods of heating and cooling systems. Performance verification test shall ensure proper execution of the sequence of operation and proper tuning of control loops.

c. Obtain approval of the plan for each phase of testing before beginning that phase of testing. Give to the Contracting Officer

written notification of planned testing at least 30 days prior to test. Notification shall be accompanied by the proposed test procedures. In no case will the Contractor be allowed to start testing without written Government approval of test procedures. The test procedures shall consist of detailed instructions for complete testing to prove performance of the heating, ventilating and air-conditioning system and digital control system. Conduct performance verification test during one week of continuous HVAC and DDC systems operation and before final acceptance of work.

3.3.2 Performance Verification Test

Test procedures shall include tests outlined in the following paragraphs.

a. Check the operation of each output to verify correct operation. Command digital outputs on and off. Command analog outputs to minimum range, such as 4 mA, and maximum range, such as 20 mA, measure and record commanded and actual output values. Document each command and result for the test report.

b. With the digital controller, apply a control signal to each actuator and verify that the actuator operates properly from its normal position to full range of stroke position. Record actual spring ranges and normal positions for all modulating control valves and dampers. Include documentation in the test report.

c. Demonstrate that programming is not lost after a power failure, and digital controllers automatically resume proper control after a power failure.

d. Show that surge protection, meeting the requirements of this specification, has been installed on incoming power to the digital controllers and on communications lines.

e. Furnish the Government graphed trends to show the sequence of operation is executed in correct order. Demonstrate the HVAC system operates properly through the complete sequence of operation, for example seasonal, occupied/unoccupied, warm-up. Demonstrate proper control system response for abnormal conditions for which there is a specified response by simulating these conditions. Demonstrate hardware interlocks and safeties work. Demonstrate the control system performs the correct sequence of control after a loss of power.

f. Furnish the Government graphed trends of control loops to demonstrate the control loop is stable and that setpoint is maintained. Control loop response shall respond to setpoint changes and stabilize in 1 minute. Control loop trend data shall be instantaneous and the time between data points shall not be greater than one minute.

3.3.3 Test Reporting for Performance Verification Tests

a. Document all tests with detailed test results. Explain in detail the nature of each failure and corrective action taken.

b. After the Performance Verification Tests, identify, determine causes, replace, repair or calibrate equipment that fails to meet the specification, and deliver a written report to the Government.

c. Provide a written report containing test documentation after

the Performance Verification Tests. Convene a test review meeting at the job site to present the results to the Government. As part of this test review meeting, demonstrate by performing all portions of the performance verification test that each failure has been corrected. Based on the report and test review meeting, the Government will determine either the restart point or successful completion of testing.

Do not commence retesting until after receipt of written notification by the Government. At the conclusion of retesting, assessment will be repeated.

-- End of Section --

SECTION 15995A

COMMISSIONING OF HVAC SYSTEMS

PART 1 GENERAL

1.1 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-03 Product Data

Commissioning Team; IO,

List of team members who will represent the Contractor in the pre-commissioning checks and functional performance testing, at least 2 weeks prior to the start of pre-commissioning checks. Proposed revision to the list, prior to the start of the impacted work.

Test Procedures; IO,

Detailed procedures for pre-commissioning checks and functional performance tests, at least 4 weeks prior to the start of pre-commissioning checks.

Test Schedule; G, RE

Schedule for pre-commissioning checks and functional performance tests, at least 2 weeks prior to the start of pre-commissioning checks.

SD-06 Test Reports

Test Reports; G, RE

Completed pre-commissioning checklists and functional performance test checklists organized by system and by subsystem and submitted as one package. The results of failed tests shall be included along with a description of the corrective action taken.

1.2 SEQUENCING AND SCHEDULING

The work described in this Section shall begin only after all work required in related Sections, including Section 15950A HEATING, VENTILATING AND AIR CONDITIONING (HVAC) CONTROL SYSTEMS and Section 15990A TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS, has been successfully completed, and all test and inspection reports and operation and maintenance manuals required in these Sections have been submitted and approved.

PART 2 PRODUCTS (Not Applicable)

PART 3 EXECUTION

3.1 COMMISSIONING TEAM AND CHECKLISTS

The Contractor shall designate team members to participate in the pre-commissioning checks and the functional performance testing specified herein. In addition, the Government will be represented by a representative of the Contracting Officer, the Design Agent's Representative, and the Using Agency. The team members shall be as follows:

Designation	Function
Q	Contractor's Chief Quality Control Representative
M	Contractor's Mechanical Representative
E	Contractor's Electrical Representative
T	Contractor's Testing, Adjusting, and Balancing Representative
C	Contractor's Controls Representative
D	Design Agent's Representative
O	Contracting Officer's Representative
U	Using Agency's Representative

Each checklist shown in appendices A and B shall be completed by the commissioning team. Acceptance by each commissioning team member of each pre-commissioning checklist item shall be indicated by initials and date unless an "X" is shown indicating that participation by that individual is not required. Acceptance by each commissioning team member of each functional performance test checklist shall be indicated by signature and date.

3.2 TESTS

The pre-commissioning checks and functional performance tests shall be performed in a manner which essentially duplicates the checking, testing, and inspection methods established in the related Sections. Where checking, testing, and inspection methods are not specified in other Sections, methods shall be established which will provide the information required. Testing and verification required by this section shall be performed during the Commissioning phase. Requirements in related Sections are independent from the requirements of this Section and shall not be used to satisfy any of the requirements specified in this Section. The Contractor shall provide all materials, services, and labor required to perform the pre-commissioning checks and functional performance tests. A pre-commissioning check or functional performance test shall be aborted if any system deficiency prevents the successful completion of the test or if any participating non-Government commissioning team member of which participation is specified is not present for the test. The Contractor shall reimburse the Government for all costs associated with effort lost due to tests that are aborted. These costs shall include salary, travel costs and per diem (where applicable) for Government commissioning team members.

3.2.1 Pre-Commissioning Checks

Pre-commissioning checks shall be performed for the items indicated on the checklists in Appendix A. Deficiencies discovered during these checks shall be corrected and retested in accordance with the applicable contract requirements.

3.2.2 Functional Performance Tests

Functional performance tests shall be performed for the items indicated on the checklists in Appendix B. Functional performance tests shall begin only after all pre-commissioning checks have been successfully completed. Tests shall prove all modes of the sequences of operation, and shall verify all other relevant contract requirements. Tests shall begin with equipment or components and shall progress through subsystems to complete systems. Upon failure of any functional performance test checklist item, the Contractor shall correct all deficiencies in accordance with the applicable contract requirements. The checklist shall then be repeated until it has been completed with no errors.

APPENDIX A

PRE-COMMISSIONING CHECKLISTS

Pre-commissioning checklist - Piping

For Chilled Water and Hot Water Piping System

Checklist Item	Q	M	E	T	C	D	O	U
Installation								
a. Piping complete.	___	___	X	___	X	___	___	___
b. As-built shop drawings submitted.	___	___	X	___	X	___	___	___
c. Piping flushed and cleaned.	___	___	X	___	X	___	___	___
d. Strainers cleaned.	___	___	X	___	X	___	___	___
e. Valves installed as required.	___	___	X	___	X	___	___	___
f. Piping insulated as required.	___	___	X	___	X	___	___	___
g. Thermometers and gauges installed as required.	___	___	X	___	X	___	___	___
h. Verify operation of valves.	___	___	X	___	___	___	___	___
i. Air vents installed as specified.	___	___	X	X	X	___	___	___
j. Flexible connectors installed as specified	___	___	X	X	X	___	___	___
k. Verify that piping has been labeled and valves identified as specified.	___	___	X	___	___	___	___	___
Testing, Adjusting, and Balancing (TAB)								
a. Hydrostatic test complete.	___	___	X	___	X	___	___	___
b. TAB operation complete.	___	___	X	___	___	___	___	___

Pre-commissioning Checklist - Ductwork

For Air Handler: AHU1, ERU[AM002]F

Checklist Item	Q	M	E	T	C	D	O	U
Installation								
a. Ductwork complete.	___	___	X	___	X	___	___	___
b. As-built shop drawings submitted.	___	___	X	___	X	___	___	___
c. Ductwork leak test complete.	___	___	X	___	X	___	___	___
NOTE: The first bracketed item d will be used for Army projects, the second for Air Force projects.								
d. Fire dampers, smoke dampers, and access doors installed as required with installation of each verified by the specified team members initialing each location on a copy of the as-built drawings.	___	___	X	___	X	___	___	___
e. Ductwork insulated as required.	___	___	X	___	X	___	___	___
f. Thermometers and gauges installed as required.	___	___	___	___	___	___	___	___
g. Verify open/closed status of dampers.	___	___	X	___	X	___	___	___
h. Verify smoke dampers operation.	___	___	X	___	___	___	___	___
i. Flexible connectors installed as specified	___	___	X	___	X	___	___	___
Testing, Adjusting, and Balancing (TAB)								
a. TAB operation complete.	___	___	X	___	X	___	___	___

Pre-commissioning Checklist - Pumps

For Pump: HP1, HP2, CP1, CP2, BP1, AND HWCP1

Checklist Item	Q	M	E	T	C	D	O	U
Installation								
a. Pumps grouted in place.	___	___	X	X	X	___	___	___
b. Pump vibration isolation devices functional.	___	___	X	X	X	___	___	___
c. Pump/motor coupling alignment verified.	___	___	X	X	X	___	___	___
d. Piping system installed.	___	___	X	X	X	___	___	___
e. Piping system pressure tested.	___	___	X	X	X	___	___	___
f. Pump not leaking.	___	___	X	X	X	___	___	___
g. Field assembled couplings aligned to meet manufacturer's prescribed tolerances.	___	___	X	X	X	___	___	___
Electrical								
a. Power available to pump disconnect.	___	___	___	X	X	___	___	___
b. Pump rotation verified.	___	___	___	X	X	___	___	___
c. Control system interlocks functional.	___	___	___	X	___	___	___	___
d. Verify that power disconnect is located within sight of the unit it controls.	___	___	___	X	___	___	___	___
Testing, Adjusting, and Balancing (TAB)								
a. Pressure/temperature gauges installed.	___	___	X	___	X	___	___	___
b. Piping system cleaned.	___	___	X	X	X	___	___	___
c. Chemical water treatment complete.	___	___	X	X	X	___	___	___
d. Water balance complete.	___	___	X	___	X	___	___	___
e. Water balance with design maximum flow.	___	___	X	___	X	___	___	___
f. TAB Report submitted.	___	___	X	___	X	___	___	___

Pre-commissioning Checklist - Packaged Air Cooled Chiller

For Chiller: CH1

Checklist Item	Q	M	E	T	C	D	O	U
Installation								
a. Chiller properly piped.	___	___	X	___	___	___	___	___
b. Chilled water pipe leak tested.	___	___	X	X	X	___	___	___
c. Verify that refrigerant used complies with specified requirements.	___	___	X	X	X	___	___	___
d. Any damage to coil fins has been repaired.	___	___	X	___	X	___	___	___
e. Manufacturer's required maintenance clearance provided.	___	___	X	X	X	___	___	___
Electrical								
a. Power available to unit disconnect.	___	___	___	X	___	___	___	___
b. Power available to unit control panel.	___	___	___	X	___	___	___	___
c. Separate power is supplied to electric heating tape.	___	___	___	X	___	___	___	___
d. Verify that power disconnect is located within sight of the unit it controls.	___	___	___	X	___	___	___	___
Controls								
a. Factory startup and checkout complete.	___	___	X	X	___	___	___	___
b. Chiller safety/protection devices tested.	___	___	X	X	___	___	___	___
c. Chilled water flow switch installed.	___	___	X	X	___	___	___	___
d. Chilled water flow switch tested.	___	___	X	X	___	___	___	___
e. Chilled water pump interlock installed.	___	___	X	X	X	___	___	___
f. Chilled water pump interlock tested.	___	___	___	X	___	___	___	___

Pre-commissioning Checklist - Hot Water Boiler

For Boiler: B1

Checklist Item	Q	M	E	T	C	D	O	U
Installation								
a. Boiler flue installed.	___	___	X	___	___	___	___	___
b. Boiler hot water piping installed.	___	___	X	___	___	___	___	___
c. Boiler hot water piping tested.	___	___	X	X	___	___	___	___
d. Boiler makeup water piping installed.	___	___	X	___	___	___	___	___
g. Boiler gas piping installed.	___	___	X	X	X	___	___	___
h. Boiler gas piping tested.	___	___	X	X	X	___	___	___
i. Manufacturer's required maintenance clearance provided.	___	___	X	___	___	___	___	___
Startup								
a. Boiler system cleaned and filled with treated water.	___	___	X	___	___	___	___	___
b. Boiler safety/protection devices, including high temperature burner shut-off, low water cutoff, flame failure, pre and post purge, have been tested.	___	___	___	X	___	___	___	___
c. Verify that PRV rating conforms to boiler rating.	___	___	___	X	___	___	___	___
d. Boiler water treatment system functional.	___	___	X	X	___	___	___	___
e. Boiler startup and checkout complete.	___	___	X	X	___	___	___	___
f. Combustion efficiency demonstrated.	___	___	X	___	X	___	___	___
Electrical								
a. Verify that power disconnect is located within sight of the unit served.	___	___	___	X	___	___	___	___
Controls								
a. Hot water pump interlock installed.	___	___	___	X	___	___	___	___
b. Hot water pump interlock tested.	___	___	___	X	___	___	___	___
c. Hot water heating system balanced.	___	___	X	X	___	___	___	___
d. Hot water heating controls operational.	___	___	X	X	___	___	___	___

Pre-commissioning Checklist - Fan Coil Unit

For Fan Coil Unit: FCX, FC2 THRU FCB (All units as scheduled)

Checklist Item	Q	M	E	T	C	D	O	U
Installation								
a. Vibration isolation devices installed.	___	___	X	X	X	___	___	___
b. Access doors/removable panels are operable and sealed.	___	___	X	___	X	___	___	___
c. Casing undamaged.	___	___	X	X	X	___	___	___
d. Insulation undamaged.	___	___	X	X	X	___	___	___
e. Condensate drainage is unobstructed.	___	___	X	X	X	___	___	___
f. Fan belt adjusted.	___	___	X	___	X	___	___	___
g. Any damage to coil fins has been repaired.	___	___	X	___	X	___	___	___
h. Manufacturer's required maintenance clearance provided.	___	___	X	X	X	___	___	___

Electrical

a. Power available to unit disconnect.	___	___	___	X	___	___	___	___
b. Power available to unit control panel.	___	___	___	X	___	___	___	___
c. Proper motor rotation verified.	___	___	___	___	X	___	___	___
d. Verify that power disconnect is located within sight of the unit it controls.	___	___	___	X	___	___	___	___

Coils

a. Chilled water piping properly connected.	___	___	X	X	X	___	___	___
b. Chilled water piping pressure tested.	___	___	X	X	X	___	___	___
c. Hot water piping properly connected.	___	___	X	___	___	___	___	___
d. Hot water piping pressure tested.	___	___	X	___	___	___	___	___

Controls

a. Control valves/actuators properly installed.	___	___	X	___	___	___	___	___
---	-----	-----	---	-----	-----	-----	-----	-----

Pre-commissioning Checklist - Fan Coil Unit

For Fan Coil Unit: FCX, FC2 THRU FCB (All units as scheduled)

Checklist Item	Q	M	E	T	C	D	O	U
b. Control valves/actuators operable.	___	___	X	X	___	___	___	___
c. Verify proper location and installation of thermostat.	___	___	X	___	___	___	___	___
Testing, Adjusting, and Balancing (TAB)								
a. Construction filters removed and replaced.	___	___	X	___	___	___	___	___
b. TAB results +10%/-0% of L/s shown on drawings								
c. TAB Report submitted.	___	___	X	___	X	___	___	___

Pre-commissioning Checklist - Ventilation Fan

For Exhaust Fan: VF1

Checklist Item	Q	M	E	T	C	D	O	U
Installation								
a. Fan belt adjusted.	___	___	X	___	X	___	___	___
Electrical								
a. Power available to fan disconnect.	___	___	___	X	___	___	___	___
b. Proper motor rotation verified.	___	___	___	___	X	___	___	___
c. Verify that power disconnect is located within sight of the unit it controls.	___	___	___	X	___	___	___	___
Controls								
a. Control interlocks properly installed.	___	___	___	X	___	___	___	___
b. Control interlocks operable.	___	___	___	X	___	___	___	___
c. Dampers/actuators properly installed.	___	___	X	___	___	___	___	___
d. Dampers/actuators operable.	___	___	X	___	___	___	___	___
e. Verify proper location and installation of thermostat.	___	___	X	___	___	___	___	___
Testing, Adjusting, and Balancing (TAB)								
a. TAB results +10%/-0% to L/s shown on drawings	___	___	X	___	X	___	___	___
b. TAB Report submitted.	___	___	X	___	X	___	___	___

Pre-commissioning Checklist - HVAC System Controls

For HVAC System: AHU1, [AM002] ERUERV, B1 AND PUMPS, CH1 AND PUMPS, FCX AND FC2 THROUGH FC8 (all listed units)

Checklist Item	Q	M	E	T	C	D	O	U
Installation								
a. As-built shop drawings submitted.	___	___	X	X	___	___	___	___
b. Layout of control panel matches drawings.	___	___	X	X	___	___	___	___
c. Framed instructions mounted in or near control panel.	___	___	X	X	___	___	___	___
d. Components properly labeled (on inside and outside of panel).	___	___	X	X	___	___	___	___
e. Control components wired to each labeled terminal strip.	___	___	X	X	___	___	___	___
f. EMCS connection made to each labeled terminal strip as shown.	___	___	X	X	___	___	___	___
g. Control wiring labeled at all terminations, splices, and junctions.	___	___	X	X	___	___	___	___
h. Shielded wiring used on electronic sensors.	___	___	X	X	___	___	___	___
Main Power								
a. 110 volt AC power available to panel.	___	___	___	X	___	___	___	___
Testing, Commissioning, and Balancing								
a. Testing, Commissioning, and Balancing Report submitted.	___	___	X	___	___	___	___	___

Pre-commissioning Checklist - Air Handling Unit

For Air Handling Unit: AHU1 ~~[AM002] AND ERU~~

Checklist Item	Q	M	E	T	C	D	O	U
Installation								
a. Vibration isolation devices installed.	__	__	X	X	X	__	__	__
b. Inspection and access doors are operable and sealed.	__	__	X	__	X	__	__	__
c. Casing undamaged.	__	__	X	X	X	__	__	__
d. Insulation undamaged.	__	__	X	X	X	__	__	__
e. Condensate drainage is unobstructed.	__	__	X	X	X	__	__	__
f. Fan belt adjusted.	__	__	X	__	X	__	__	__
g. Any damage to coil fins has been repaired.	__	__	X	__	X	__	__	__
h. Manufacturer's required maintenance clearance provided.	__	__	X	X	X	__	__	__
Electrical								
a. Power available to unit disconnect.	__	__	__	X	X	__	__	__
b. Power available to unit control panel.	__	__	__	X	__	__	__	__
c. Proper motor rotation verified.	__	__	__	__	X	__	__	__
d. Verify that power disconnect is located within sight of the unit it controls.	__	__	__	X	__	__	__	__
e. Power available to electric heating coil.	__	__	__	X	__	__	__	__
Coils								
a. Chilled water piping properly connected.	__	__	X	__	__	__	__	__
b. Chilled water piping pressure tested.	__	__	X	X	X	__	__	__
c. Hot water piping properly connected.	__	__	X	__	__	__	__	__
d. Hot water piping pressure tested.	__	__	X	X	__	__	__	__
e. Air vents installed on water coils with								

Pre-commissioning Checklist - Air Handling Unit

For Air Handling Unit: AHU1 ~~[AM002] AND ERU~~

Checklist Item	Q	M	E	T	C	D	O	U
shutoff valves as specified.	___	___	X	X	X	___	___	___
f. Any damage to coil fins has been repaired.	___	___	X	___	X	___	___	___
Controls								
a. Control valves/actuators properly installed.	___	___	X	___	___	___	___	___
b. Control valves/actuators operable.	___	___	X	___	___	___	___	___
c. Dampers/actuators properly installed.	___	___	X	___	___	___	___	___
d. Dampers/actuators operable.	___	___	X	___	___	___	___	___
e. Verify proper location and installation of thermostat.	___	___	X	___	___	___	___	___
Testing, Adjusting, and Balancing (TAB)								
a. Construction filters removed and replaced.	___	___	X	___	X	___	___	___
b. TAB results +10%/-0% L/s shown on drawings.	___	___	X	___	X	___	___	___
c. TAB Report submitted.	___	___	X	___	X	___	___	___

[AM002]Pre-commissioning Checklist - Energy Recovery Unit

For Energy Recovery Unit: ERU

Checklist Item Q M E T C D O U

Installation

- a. Vibration isolation devices installed. X X X
- b. Inspection and access doors are operable and sealed. X X
- c. Casing undamaged. X X X
- d. Insulation undamaged. X X X
- e. Condensate drainage is unobstructed. X X X
- f. Fan belt adjusted. X X
- g. Any damage to coil fins has been repaired. X X
- h. Manufacturer's required maintenance clearance provided. X X X

Electrical

- a. Power available to unit disconnect. X X
- b. Power available to unit control panel. X
- c. Proper supply fan motor rotation verified. X
- d. Proper return/exhaust fan motor rotation verified
- e. Proper enthalpy wheel rotation verified
- f. Verify that power disconnect is located within sight of the unit it controls. X

Coils

- a. Chilled water piping properly connected. X
- b. Chilled water piping pressure tested. X X X
- c. Hot water piping properly connected. X
- d. Hot water piping pressure tested. X X
- e. Air vents installed on water coils with shutoff valves as specified. X X X
- f. Any damage to coil fins has been repaired. X X

[AM002]Pre-commissioning Checklist - Energy Recovery Unit

For Energy Recovery Unit: ERU

<u>Checklist Item</u>	<u>Q</u>	<u>M</u>	<u>E</u>	<u>T</u>	<u>C</u>	<u>D</u>	<u>O</u>	<u>U</u>
<u>Controls</u>								
<u>a. Control valves/actuators properly installed.</u>								<u>X</u>
<u>b. Control valves/actuators operable.</u>								<u>X</u>
<u>c. Dampers/actuators properly installed.</u>								<u>X</u>
<u>d. Dampers/actuators operable.</u>								<u>X</u>
<u>Testing, Adjusting, and Balancing (TAB)</u>								
<u>a. Construction filters removed and replaced.</u>					<u>X</u>		<u>X</u>	
<u>b. TAB results +10%/-0% L/s shown on drawings.</u>					<u>X</u>		<u>X</u>	
<u>c. TAB Report submitted.</u>					<u>X</u>		<u>X</u>	

APPENDIX B

FUNCTIONAL PERFORMANCE TESTS CHECKLISTS

Functional Performance Test Checklist - Pumps

For Pump: HP1, HP2, CP1, CP2, BP1, AND HWCP1

Prior to performing this checklist, ensure that for closed loop systems, system is pressurized and the make-up water system is operational or, for open loop systems, that the sumps are filled to the proper level.

1. Activate pump start using control system commands (all possible combination, on/auto, etc.). ON _____ AUTO _____ OFF _____

a. Verify pressure drop across strainer:

Strainer inlet pressure _____ kPa (____ psig)
 Strainer outlet pressure _____ kPa (____ psig)

b. Verify pump inlet/outlet pressure reading, compare to Testing, Adjusting, and Balancing (TAB) Report, pump design conditions, and pump manufacturer's performance.

	DESIGN	SYSTEM TEST	ACTUAL
Pump inlet pressure (kPa gauge)	_____	_____	_____
Pump outlet pressure (kPa gauge)	_____	_____	_____

c. Operate pump at shutoff and at 100 percent of designed flow when all components are in full flow. Plot test readings on pump curve and compare results against readings taken from flow measuring devices.

	SHUTOFF	100 percent
Pump inlet pressure (kPa gauge)	_____	_____
Pump outlet pressure	_____	_____
Pump flow rate (L/s)	_____	_____

d. Operate pump at shutoff and at minimum flow or when all components are in full by-pass. Plot test readings on pump curve and compare results against readings taken from flow measuring devices.

	SHUTOFF	100 percent
Pump inlet pressure (kPa gauge)	_____	_____
Pump outlet pressure	_____	_____
Pump flow rate (L/s)	_____	_____

2. Verify motor amperage each phase and voltage phase to phase and phase to ground for both the full flow and the minimum flow conditions.

a. Full flow:

	PHASE 1	PHASE 2	PHASE 3
Amperage	_____	_____	_____
Voltage	_____	_____	_____
Voltage	_____	_____	_____
Voltage to ground	_____	_____	_____

b. Minimum flow:

Functional Performance Test Checklist - Pumps

For Pump: HP1, HP2, CP1, CP2, BP1, AND HWCP1

	PHASE 1	PHASE 2	PHASE 3
Amperage	_____	_____	_____
Voltage	_____	_____	_____
Voltage	_____	_____	_____
Voltage to ground	_____	_____	_____

3. Unusual vibration, noise, etc.

4. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

Signature and Date

Contractor's Chief Quality Control Representative

Contractor's Mechanical Representative

Contractor's Electrical Representative

Contractor's Testing, Adjusting and Balancing Representative

Contractor's Controls Representative

Contracting Officer's Representative

Using Agency's Representative

Functional Performance Test Checklist - Air Handling Unit

For Air Handling Unit: AHU1 [AM002]AND ERU

1. Functional Performance Test: Contractor shall verify operation of air handling unit as per specification including the following:

a. The following shall be verified when the {supply fan operating}__
{supply and return fans operating}_____ mode is initiated:

- (1) All dampers in normal position. _____
- (2) All valves in normal position. _____
- (3) System safeties allow start if safety conditions are met. _____

b. Occupied mode of operation - economizer de-energized.

- (1) Outside air damper at minimum position. _____
- (2) Return air damper open. _____
- (3) Relief air damper at minimum position_____. _____
- (4) Chilled water control valve modulating to maintain space cooling temperature set point. _____
- (5) Hot water control valve modulating to maintain space heating temperature set point input from outside air temperature controller. _____

~~c. Occupied mode of operation - economizer energized.~~

- ~~(1) Outside air damper modulated to maintain mixed air temperature set point. _____~~
- ~~(2) Relief air damper modulates with outside air damper according to sequence of operation. _____~~
- ~~(3) Chilled water control valve modulating to maintain space cooling temperature set point. _____~~

d. Unoccupied mode of operation

- (1) All dampers in normal position. _____
- (2) Verify low limit space temperature is maintained as specified in sequence of operation. _____

e. The following shall be verified when the supply fan off—~~or supply and exhaust fans off~~ mode is initiated:

- (1) All dampers in normal position. _____
- (2) All valves in normal position. _____
- (3) Fan de-energizes. _____

Functional Performance Test Checklist - Air Handling Unit

For Air Handling Unit: AHU1 [AM002]AND-ERU

f. Verify cooling coil and heating coil operation by varying thermostat set point from cooling set point to heating set point and returning to cooling set point. _____

g. Verify safety shut down initiated by smoke detectors. _____

h. Verify safety shut down initiated by low temperature protection thermostat. _____

2. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

Signature and Date

Contractor's Chief Quality Control Representative _____

Contractor's Mechanical Representative _____

Contractor's Electrical Representative _____

Contractor's Testing, Adjusting and Balancing Representative _____

Contractor's Controls Representative _____

Contracting Officer's Representative _____

Using Agency's Representative _____

[AM002] Functional Performance Test Checklist - Energy Recovery Unit

For Energy Recovery Unit: ERU

1. Functional Performance Test: Contractor shall verify operation of air handling unit as per specification including the following:

a. The following shall be verified when the supply and return fans operating mode is initiated:

(1) All dampers in normal position.

(2) All valves in normal position.

(3) System safeties allow start if safety conditions are met.

b. Mode of operation.

(1) Outside air damper open.

(3) Chilled water control valve modulating to maintain discharge cooling temperature set point or dewpoint set point.

(5) Hot water control valve modulating to maintain discharge heating temperature set point.

f. Verify cooling coil and heating coil operation by varying discharge set point from cooling set point to heating set point and returning to cooling set point.

g. Verify cooling coil de-humidification by varying supply air dewpoint set point.

g. Verify safety shut down initiated by smoke detectors.

h. Verify safety shut down initiated by low temperature protection thermostat.

2. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

Signature and Date

Contractor's Chief Quality Control Representative

Contractor's Mechanical Representative

Contractor's Electrical Representative

Contractor's Testing, Adjusting and Balancing Representative

Contractor's Controls Representative

[AM002] Functional Performance Test Checklist - Energy Recovery Unit

For Energy Recovery Unit: ERU

Contracting Officer's Representative

Using Agency's Representative

Functional Performance Test Checklist - Packaged Air Cooled Chiller

For Chiller: CH1

1. Functional Performance Test: Contractor shall demonstrate operation of chilled water system as per specifications including the following: Start building air handler to provide load for chiller. Activate controls system chiller start sequence as follows.

- a. Start chilled water pump and establish chilled water flow. Verify chiller-chilled water proof-of-flow switch operation. _____
- b. Verify control system energizes chiller start sequence. _____
- c. Verify chiller senses chilled water temperature above set point and control system activates chiller start. _____
- d. Verify functioning of "soft start" sequence. _____
- e. Shut off air handling equipment to remove load on chilled water system. Verify chiller shutdown sequence is initiated and accomplished after load is removed. _____
- f. Restart air handling equipment one minute after chiller shut down. Verify chiller restart sequence. _____

2. Verify chiller inlet/outlet pressure reading, compare to Testing, Adjusting, and Balancing (TAB) Report, chiller design conditions, and chiller manufacturer's performance data.

	DESIGN	SYSTEM TEST	ACTUAL
Chiller inlet pressure (kPa gauge)	_____	_____	_____
Chiller outlet pressure (kPa gauge)	_____	_____	_____

3. Verify chiller amperage each phase and voltage phase-to-phase and phase-to-ground.

	PHASE 1	PHASE 2	PHASE 3
Amperage	_____	_____	_____
Voltage	_____	_____	_____
Voltage	_____	_____	_____
Voltage to ground	_____	_____	_____

4. Record the following information:

Ambient dry bulb temperature _____ degrees C
 Ambient wet bulb temperature _____ degrees C
 Entering chilled water temperature _____ degrees C
 Leaving chilled water temperature _____ degrees C

5. Unusual vibration, noise, etc.

Functional Performance Test Checklist - Packaged Air Cooled Chiller

For Chiller: CH1

6. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

Signature and Date

Contractor's Chief Quality Control Representative

Contractor's Mechanical Representative

Contractor's Electrical Representative

Contractor's Testing, Adjusting and Balancing Representative

Contractor's Controls Representative

Contracting Officer's Representative

Using Agency's Representative

Functional Performance Test Checklist - Hot Water Boiler

For Boiler: B1

1. Functional Performance Test: Contractor shall demonstrate operation of hot water system as per specifications including the following: Start building heating equipment to provide load for boiler. Activate controls system boiler start sequence as follows.

a. Start hot water pump and establish hot water flow. Verify boiler hot water proof-of-flow switch operation. _____

b. Verify control system energizes boiler start sequence. _____

c. Verify boiler senses hot water temperature below set point and control system activates boiler start. _____

d. Shut off building heating equipment to remove load on hot water system. Verify boiler shutdown sequence is initiated and accomplished after load is removed. _____

2. Verify boiler inlet/outlet pressure reading, compare to Test and Balance (TAB) Report, boiler design conditions, and boiler manufacturer's performance data.

	DESIGN	SYSTEM TEST	ACTUAL
Boiler inlet pressure (kPa gauge)	_____	_____	_____
Boiler outlet pressure (kPa gauge)	_____	_____	_____
Boiler flow rate (L/s)	_____	_____	_____
Flue-gas temperature at boiler outlet	_____	_____	_____
Percent carbon dioxide in flue-gas	_____	_____	_____
Draft at boiler flue-gas exit	_____	_____	_____
Draft or pressure in furnace	_____	_____	_____
Stack emission pollutants concentration	_____	_____	_____
Fuel type	_____	_____	_____
Combustion efficiency	_____	_____	_____

3. Record the following information:

Ambient temperature _____ degrees C
 Entering hot water temperature _____ degrees C
 Leaving hot water temperature _____ degrees C

4. Verify temperatures in item 3 are in accordance with the reset schedule. _____

5. Verify proper operation of boiler safeties. _____

6. Unusual vibration, noise, etc.

Functional Performance Test Checklist - Hot Water Boiler

For Boiler: B1

7. Visually check refractory for cracks or spalling and refractory and tubes for flame impingement.

8. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

Signature and Date

Contractor's Chief Quality Control Representative

Contractor's Mechanical Representative

Contractor's Electrical Representative

Contractor's Testing, Adjusting and Balancing Representative

Contractor's Controls Representative

Contracting Officer's Representative

Using Agency's Representative

Functional Performance Test Checklist - Fan Coil Units

The Contracting Officer will select fan coil units to be spot-checked during the functional performance test. The number of terminals shall not exceed 10 percent in the living units and 12 units in the Commons area, 4 per floor..

1. Functional Performance Test: Contractor shall demonstrate operation of selected fan coils as per specifications including the following:

a. Cooling only fan coils:

(1) Verify fan coil unit response to room temperature set point adjustment. Changes to be cooling set point to cooling set point minus 10 degrees and return to cooling set point. _____

(2) Check blower fan air flow. _____ L/s
Check blower fan air flow.

(3) Check cooling coil water flow. _____ L/s
Check cooling coil water flow.

(4) Verify proper operation of cooling water control valve. _____

b. Cooling/heating fan coils:

(1) Verify fan coil unit response to room temperature set point adjustment. Changes to be cooling set point to heating set point and return to cooling set point. _____

(2) Check blower fan air flow. _____ L/s
Check blower fan air flow.

(3) Check cooling coil water flow. _____ L/s
Check cooling coil water flow.

(4) Verify proper operation of cooling water control valve. _____

(5) Check cooling mode inlet air temperature. _____ degrees C
Check cooling mode inlet air temperature.

(6) Check cooling mode outlet air temperature. _____ degrees C
Check cooling mode outlet air temperature.

(7) Check heating coil water flow. _____ L/s
Check heating coil water flow.

(8) Verify proper operation of heating water control valve. _____

(9) Check heating mode inlet air temperature. _____ degrees C
Check heating mode inlet air temperature.

(10) Check heating mode outlet air temperature. _____ degrees C
Check heating mode outlet air temperature.

2. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

Functional Performance Test Checklist - Fan Coil Units

Signature and Date

Contractor's Chief Quality Control Representative

Contractor's Mechanical Representative

Contractor's Electrical Representative

Contractor's Testing, Adjusting and Balancing Representative

Contractor's Controls Representative

Contracting Officer's Representative

Using Agency's Representative

Functional Performance Test Checklist - HVAC Controls

For HVAC System: AHU1, ERU, B1 AND PUMPS, CH1 AND PUMPS, FCX AND FD2 THROUGH FC8 (all listed units)

The Contracting Officer will select HVAC control systems to undergo functional performance testing. The number of systems shall not exceed 10 percent .

1. Functional Performance Test: Contractor shall verify operation of HVAC controls by performing the following tests:

a. Verify that controller is maintaining the set point by manually measuring the controlled variable with a thermometer, sling psychrometer, inclined manometer, etc.

b. Verify sensor/controller combination by manually measuring the controlled medium. Take readings from control panel display and compare readings taken manually. Record all readings.

Sensor _____
Manual measurement _____
Panel reading value _____

c. Verify system stability by changing the controller set point as follows:

- (1) Air temperature - 10 degrees F
- (2) Water temperature - 10 degrees F
- (3) Static pressure - 10 percent of set point
- (4) Relative humidity - percent (RH)

The control system shall be observed for 10 minutes after the change in set point. Instability or excessive hunting will be unacceptable.

- d. Verify interlock with other HVAC controls.
- e. Verify interlock with fire alarm control panel.
- f. Verify interlock with EMCS.

2. Verify that operation of control system conforms to that specified in the sequence of operation.

3. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

Signature and Date

Contractor's Chief Quality Control Representative _____

Contractor's Mechanical Representative _____

Functional Performance Test Checklist - HVAC Controls

For HVAC System: AHU1, ERU, B1 AND PUMPS, CH1 AND PUMPS, FCX AND FD2 THROUGH FC8 (all listed units)

Contractor's Electrical Representative _____

Contractor's Testing, Adjusting and Balancing Representative _____

Contractor's Controls Representative _____

Contractor's Officer's Representative _____

Using Agency's Representative _____

-- End of Section --