UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2021
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DIVISION 23 - HEATING, VENTILATING, AND AIR CONDITIONING (HVAC)

SECTION 23 63 00.00 10

COLD STORAGE REFRIGERATION SYSTEMS

10/07

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USACE / NAVFAC / AFCEC / NASA | **UFGS-23 63 00.00 10 (October 2007)**

Preparing Activity: USACE | **Superseding UFGS-23 63 00.00 10 (April 2006)**

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SECTION 23 63 00.00 10

COLD STORAGE REFRIGERATION SYSTEMS
10/07

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NOTE: This guide specification covers the requirements for refrigeration equipment for cold storage facilities.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).

****

PART 1 GENERAL

1.1 REFERENCES

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NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a Reference Identifier (RID) outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.
****

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

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI 420	(2008) Performance Rating of Forced-Circulation Free-Delivery Unit Coolers for Refrigeration
AHRI 450	(2007) Water-Cooled Refrigerant Condensers, Remote Type
AHRI 490 I-P	(2011) Performance Rating of Remote Mechanical-Draft Evaporatively-Cooled Refrigerant Condensers
AHRI 700	(2016) Specifications for Fluorocarbon Refrigerants
AHRI 710 I-P	(2009) Performance Rating of Liquid-Line Driers
AHRI 711	(2009) Performance Rating of Liquid-Line Driers
AHRI 720	(2002) Refrigerant Access Valves and Hose Connectors
AHRI 750 I-P	(2016) Performance Rating of Thermostatic Refrigerant Expansion Valves
AHRI 751 SI	(2016) Performance Rating of Thermostatic Refrigerant Expansion Valves
ANSI/AHRI 460	(2005) Performance Rating of Remote Mechanical-Draft Air-Cooled Refrigerant Condensers
ANSI/AHRI 495	(2005) Performance Rating of Refrigerant Liquid Receivers
ANSI/AHRI 510	(2006) Performance Rating of Positive Displacement Ammonia Compressors and Compressor Units
ANSI/AHRI 520	(2004) Performance Rating of Positive Displacement Condensing Units
ANSI/AHRI 760	(2007) Performance Rating of Solenoid Valves for Use With Volatile Refrigerants

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

ASHRAE 15 & 34	(2013) ASHRAE Standard 34-2016 Safety Standard for Refrigeration Systems/ASHRAE Standard 34-2016 Designation and Safety Classification of Refrigerants-ASHRAE Standard 34-2016
ASHRAE 17	(2015) Method of Testing Capacity of Thermostatic Refrigerant Expansion Valves
ASHRAE 23.1	(2010) Methods of Testing for Rating Positive Displacement Refrigerant Compressors and Condensing Units that Operate at Subcritical Temperatures of the Refrigerant
ASHRAE 64	(2011) Methods of Testing Remote Mechanical-Draft Evaporative Refrigerant Condensers

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME A13.1	(2020) Scheme for the Identification of Piping Systems
ASME B1.20.1	(2013; R 2018) Pipe Threads, General Purpose (Inch)
ASME B1.20.2M	(2006; R 2011) Pipe Threads, 60 Deg. General Purpose (Metric)
ASME B16.9	(2018) Factory-Made Wrought Buttwelding Fittings
ASME B16.11	(2016) Forged Fittings, Socket-Welding and Threaded
ASME B31.1	(2020) Power Piping
ASME B31.5	(2020) Refrigeration Piping and Heat Transfer Components
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments
ASME BPVC SEC IX	(2017; Errata 2018) BPVC Section IX-Welding, Brazing and Fusing Qualifications
ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

AMERICAN WELDING SOCIETY (AWS)

AWS A5.8/A5.8M	(2019) Specification for Filler Metals for Brazing and Braze Welding

AWS BRH	(2007; 5th Ed) Brazing Handbook
AWS D1.1/D1.1M	(2020) Structural Welding Code - Steel

ASTM INTERNATIONAL (ASTM)

ASTM A36/A36M	(2019) Standard Specification for Carbon Structural Steel
ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A105/A105M	(2018) Standard Specification for Carbon Steel Forgings for Piping Applications
ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A126	(2004; R 2019) Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
ASTM A153/A153M	(2016a) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A181/A181M	(2014; R 2020) Standard Specification for Carbon Steel Forgings, for General-Purpose Piping
ASTM A197/A197M	(2000; R 2019) Standard Specification for Cupola Malleable Iron
ASTM A234/A234M	(2019) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
ASTM A278/A278M	(2001; R 2020) Standard Specification for Gray Iron Castings for Pressure-Containing Parts for Temperatures Up to 650 degrees F (350 degrees C)
ASTM A307	(2014; E 2017) Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength
ASTM A334/A334M	(2004a; R 2016) Standard Specification for Seamless and Welded Carbon and Alloy-Steel Tubes for Low-Temperature Service
ASTM A653/A653M	(2020) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM B117	(2019) Standard Practice for Operating

	Salt Spray (Fog) Apparatus
ASTM B209	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B209M	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric)
ASTM B221	(2014) Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
ASTM B221M	(2013) Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes (Metric)
ASTM B280	(2020) Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service
ASTM C534/C534M	(2020a) Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
ASTM D520	(2000; R 2011) Zinc Dust Pigment
ASTM D3308	(2012; R 2017) Standard Specification for PTFE Resin Skived Tape
ASTM F104	(2011; R 2020) Standard Classification System for Nonmetallic Gasket Materials

INTERNATIONAL INSTITUTE OF AMMONIA REFRIGERATION (IIAR)

IIAR 2	(2008; ADD A 2010) American National Standard for Equipment, Design, and Installation of Ammonia Mechanical Refrigerating Systems

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

MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA MG 1	(2018) Motors and Generators
NEMA MG 2	(2014) Safety Standard for Construction and Guide for Selection, Installation and Use of Electric Motors and Generators

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-301-01 (2019) Structural Engineering

UNDERWRITERS LABORATORIES (UL)

UL 207 (2009; Reprint Jan 2020) Refrigerant-Containing Components and Accessories, Nonelectrical

1.2 SUBMITTALS

****

NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item, if the submittal is sufficiently important or complex in context of the project.

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

****

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Drawings; G[, [_____]]

SD-03 Product Data

Refrigeration System; G[, [_____]]
Spare Parts
Framed Instructions
Qualifying Procedures
Verification of Dimensions
Coil Corrosion Protection
Tests
Demonstrations; G[, [_____]]

SD-06 Test Reports

Tests

SD-07 Certificates

Refrigeration System
Service Organizations

1.3 QUALITY ASSURANCE

1.3.1 Qualifications

****
NOTE: If the need exists for more stringent requirements for weldments, delete the first bracketed statement; otherwise delete the second.
****

[Submit a letter listing the qualifying procedures for each welder including supporting data such as test procedures used, what was tested to, etc. and a list of the names of qualified welders and their identification symbols. 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. Notify the Contracting Officer 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.] [Welding and nondestructive testing procedures shall be as specified in Section 40 05 13.96 WELDING PROCESS PIPING.] Weld structural members in accordance with Section 05 05 23.16 STRUCTURAL WELDING.

1.3.2 Drawings

Investigate the plumbing, fire protection, electrical, structural and finish conditions that would affect the work to be performed and arrange such work accordingly, furnishing required offsets, fittings, and accessories to meet such conditions. Equipment, ductwork, and piping arrangements shall fit into space allotted and allow adequate acceptable clearances for installation, replacement, entry, servicing, and maintenance. Submit drawings providing adequate detail to demonstrate compliance with contract requirements and consisting of:

(1) Equipment layouts identifying assembly and installation details.

(2) Piping layouts which identify valves, fittings, pipe sizes, and pipe slopes. Clearly identify and explain any changes to the design.

(3) Plans and elevations which identify clearances required for maintenance and operation.

(4) Wiring diagrams which identify each component individually and interconnected or interlocked relationships between components.

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

(6) Details of supports, if other than those indicated, including loadings and type of frames, brackets, stanchions, or others.

(7) Automatic temperature control diagrams and control sequences.

(8) Installation details which include the amount of factory set superheat and corresponding refrigerant pressure/temperature.

1.3.3 Service Organizations

Submit a certified list of qualified permanent service organizations for the specified equipment, as specified. Include their addresses and qualifications, for support of the specified 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.

1.4 DELIVERY, STORAGE, AND HANDLING

Protect stored items from the weather and contamination. Proper protection and care of material before, during, and after installation is 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 MAINTENANCE

1.5.1 Operation Manual

Provide [six] [_____] complete copies of an operation manual in bound 216 by 279 mm 8-1/2 x 11 inch booklets listing step-by-step procedures required for system startup, operation, and shutdown. The booklets shall include the manufacturer's name, model number, parts list, and a brief description of all equipment and their basic operating features.

1.5.2 Maintenance Manual

Provide [six] [_____] complete copies of maintenance manual in bound 216 by 279 mm 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.

1.5.3 Extra Materials

Submit 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

PART 2 PRODUCTS

****

NOTE: Projects which include vapor-compression type refrigeration systems will comply with the safety standards defined in ASHRAE 15 & 34. Designers will be responsible for thoroughly researching and implementing the ASHRAE 15 & 34 safety requirements. For refrigerant-containing parts (excluding piping) located within an indoor space, a designer can use the following 6-step synopsis as a guide in determining "System Application Requirements" from ASHRAE 15 & 34.

Step 1. Identify the safety group classification of the refrigerant anticipated to be used in the new refrigeration equipment. Refrigerants R-22 and R-134a are considered Group A1 refrigerants. Refrigerant R-123 is considered a Group B1 refrigerant. Ammonia is considered a Group B2 refrigerant.

Step 2. Identify the occupancy classification of the facility which will house the new refrigerant equipment. Occupancies include institutional, public assembly, residential, commercial, large mercantile, industrial, and mixed types.

Step 3. Determine the system probability (high or low) of the new refrigeration equipment. Split system applications are typically considered high-probability systems according to ASHRAE 15 & 34.

Step 4. Estimate the quantity of refrigerant (grams or pounds) in the largest single refrigerant circuit of the new equipment. The designer will research catalog data from a minimum of 2 different manufacturers in order to get an approximation.

Step 5. Determine the volume (cubic meters or cubic feet) of the indoor space which is planned to house the new refrigeration equipment.

Step 6. Identify the "System Application Requirements" from the applicable table in ASHRAE 15 & 34 based upon the information identified in the previous steps (e.g., safety group, occupancy, system probability, refrigerant quantity, and indoor space volume). The "System Application Requirements" will dictate applicable refrigerant

limitations as well as occupied space or mechanical room requirements.

ASHRAE 15 & 34 refers to a mechanical room as a machinery room, however, the terms are synonymous. On mechanical room design, ASHRAE 15 & 34 touches on criteria concerning equipment placement, ventilation design, door and passageway restrictions, refrigerant monitoring, open-flame devices, pressure-relief and purge piping. In addition to mechanical room design, ASHRAE 15 & 34 also touches on criteria concerning refrigerant piping, signs, self-contained breathing apparatus (SCBA), and miscellaneous installation restrictions. (SCBAs cannot be considered MCA funded items and are therefore not included in this specification.)

****

2.1 STANDARD PRODUCTS

Provide materials and equipment which are standard products of a manufacturer regularly engaged in the manufacturing of such products, that are of a similar material, design and workmanship and that have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2 year use includes 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 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. Products shall be supported by a service organization. System components shall be environmentally suitable for the indicated locations.

2.2 NAMEPLATES

****

NOTE: In a salt water environment substitute acceptable non-corroding metal such as but not limited to nickel-copper, 304 stainless steel, or monel. Aluminum is unacceptable. Nomenclature (or system identification) should be established by the designer.

****

Major equipment including compressors, condensers, unit coolers, receivers, heat exchanges, 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] [stainless steel] [_____]. Plates shall be fixed in prominent locations with nonferrous screws or bolts.

2.3 ELECTRICAL WORK

****

NOTE: Where motor starters for mechanical equipment are provided in motor-control centers, the

references to motor starters shall be deleted.
****

Electrical equipment, motors, motor efficiencies, and wiring shall be in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Electrical motor driven equipment specified shall be provided complete with motors, motor starters, and controls. Electrical characteristics and enclosure type shall be as shown, and unless otherwise indicated, motors of 746 W 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 NEMA MG 2 and shall 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. Unit control panels and electrical components shall be mounted in a NEMA ICS 6, Type 1 or 3A enclosure.

2.4 MISCELLANEOUS MATERIALS

2.4.1 Refrigerant and Oil

****
NOTE: R-22, R-123 and R-134a all meet the ODP requirement of 0.05. References to ammonia and IIAR are made throughout this section. If ammonia is inapplicable, then delete these references.
****

Refrigerant shall be [one of the fluorocarbon gases. Refrigerants shall have number designations and safety classifications in accordance with ASHRAE 15 & 34. Refrigerants must meet the requirements of AHRI 700 as a minimum. Refrigerants shall have an Ozone Depletion Potential of less than or equal to 0.05] [ammonia in accordance with IIAR 2 and as defined herein.] Refrigerant systems shall be charged in accordance with manufacturer's recommendations, including types and quantities of refrigerant and lubricating oil. Except for factory sealed units, two complete charges of lubricating oil for each compressor crankcase shall be furnished. One charge shall be used during the system performance testing period. Following the satisfactory completion of the performance testing, the oil shall be drained and replaced with a second charge.

2.4.2 Gaskets

Gaskets shall conform to ASTM F104 classification for compressed sheet with nitrile binder and acrylic fibers for maximum 370 degrees C 700

degrees F service.

2.4.3 Bolts and Nuts

Bolts and nuts, except as required for piping applications, shall conform to ASTM A307. The bolt head shall be marked to identify the manufacturer and the standard with which the bolt complies, in accordance with ASTM A307.

2.4.4 Pipe Hangers, Inserts, and Supports

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

2.4.5 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.

2.4.6 Pressure and Vacuum Gauge

Gauge shall conform to ASME B40.100, Class 1, 2, or 3, Style X, Type I or III as required, 115 mm 4-1/2 inches in diameter with phenolic or metal case. Each gauge range shall be selected so that at normal operating pressure, the needle is within the middle third of the range.

2.4.7 Temperature Gauges

Industrial duty thermometers shall be provided for the required temperature range. Thermometers shall have a Fahrenheit scale on a white face. The pointer shall be adjustable.

2.4.7.1 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.

2.4.7.2 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.

2.4.7.3 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.

2.4.7.4 Thermal Well

Thermal well shall be identical size, 13 or 19 mm 1/2 or 3/4 inch NPT connection, brass or stainless steel. Where test wells are indicated, provide captive plug-fitted type 13 mm 1/2 inch NPT connection suitable for use with either engraved stem or standard separable socket thermometer or thermostat. Extended neck thermal wells shall be of sufficient length

to clear insulation thickness by 25 mm 1 inch.

2.4.8 Unicellular Plastic Foam

Unicellular plastic foam shall be in accordance with ASTM C534/C534M, Type I. Comply with EPA requirements in accordance with Section 01 33 29 SUSTAINABILITY REQUIREMENTS AND REPORTING.

2.4.9 Bird Screen

Screen shall be square mesh, plain weave, 2 by 2 mesh, 1.6 mm 0.063 inch diameter aluminum wire or 0.79 mm 0.031 inch diameter stainless steel wire.

2.4.10 Galvanized Steel Sheet

ASTM A653/A653M, Coating Class G-90, lockforming quality.

2.4.11 Galvanized Steel Shapes

ASTM A36/A36M to commercial weight of not less than 0.70 kg/square meter 2.3 ounces/square foot of single side surface.

2.4.12 Aluminum Sheets and Plates

ASTM B209M ASTM B209, Alloy 3003, H-14. Sheets shall be lockforming quality.

2.4.13 Aluminum Shapes

ASTM B221M ASTM B221, Alloy 6061, T-5 and T-6.

2.5 COMPRESSOR/CONDENSING UNITS

****
NOTE: Delete the last sentence if an ammonia system is not specified.
****

[Compressor] [Condensing] unit shall be factory fabricated, assembled, tested, packaged, and ready for full capacity operation after terminal point connection and field charging with operating fluids. Unit shall conform to ANSI/AHRI 520, ASHRAE 23.1, and ASHRAE 15 & 34. Ammonia systems shall also conform to IIAR 2 and ANSI/AHRI 510.

2.5.1 Compressor

Select compressors for maximum energy efficiency and operating reliability. Rotating parts shall be statically and dynamically balanced at the factory to eliminate vibration at both partial and full load conditions. Compressors shall be capable of continuous operation at lowest partial load. Compressor over 7.5 kW 10 hp shall start from rest unloaded. Compressor unloaders shall not be used when saturated suction temperatures are below minus 4 degrees C 25 degrees F.

2.5.1.1 Construction

Compressors 1.5 kW 2 hp and less shall be the accessible, sealed reciprocating type of either the open or hermetic design. Compressors above 1.5 kW 2 hp shall be the accessible hermetic, sealed reciprocating

type. Compressors shall have integrally cast housings of close-grained iron with an oil-level bull's eye, cast cylinder heads, cast aluminum or forged steel connecting rods, and cast iron or forged steel crankshafts. Main bearings shall be the sleeve-insert type. Ammonia service compressor cylinder blocks and heads shall be fitted with self-draining water- or refrigerant-cooled jackets where recommended by the manufacturer. Water jackets shall be freeze protected.

2.5.1.2 Lubrication System

The lubrication system on compressors 2.2 kW 3 hp or larger shall be the forced-feed, positive-displacement type with oil strainer. The oil pump shall be reversible. Lube oil pressure gauge and failure switch shall be provided for forced-feed lubrication type compressors. Compressor shall be provided with an adjustable oil level regulator with a shutoff valve on each inlet to allow removal of individual compressors without shutting down the entire system.

2.5.1.3 Motor

Compressor motors shall be of the constant-speed, squirrel-cage, induction, hermetically sealed, low-starting-current, high-torque type. Motors shall be furnished with magnetic NEMA across-the-line motor starters in general purpose enclosures.

2.5.1.4 Compressor Components

Compressor systems shall include, as a minimum, the following:

a. Compressors 1.1 kW 1-1/2 hp and larger shall be provided with double seated suction and discharge service valves each with gauge ports.

b. Compressors 3.7 kW 5 hp or larger shall have a solid state oil pressure safety switch with a manual reset with auxiliary alarm contacts. Time delay duration shall be as recommended by compressor manufacturer.

c. Each compressor shall have a single low-pressure control with automatic reset and adjustable cut-in and cut-out range. Braided steel lines shall be used.

d. Each compressor shall have a single high-pressure control with manual reset, adjustable set-point, and auxiliary alarm contact. Braided steel lines shall be used.

e. A compressor cooling fan shall be provided for each compressor which operates below minus 18 degrees C 0 degrees F saturated suction temperature.

f. Each compressor shall have a crankcase oil heater. Control of the heaters shall be as recommended by the compressor manufacturer.

g. When required by the compressor manufacturer, compressors shall be provided with a hot-gas muffler to reduce vibration and noise from pulsations.

2.5.2 Base Mounting

****

NOTE: Where condensing units or compressors are located on top of walk-in boxes, mount on spring vibration isolators. Mass of inertia block shall be an engineered solution accommodating site conditions.
****

Factory mount compressor and accommodating components on a rigid, steel [base,][rack,] where indicated. Mount the compressor assembly [with spring type vibration isolation mountings[. Place elastomer pads between the assembly base and the floor.][selected to limit transmissibility of imbalanced forces at lowest equipment rpm to 5 percent.]][on a concrete inertia block, fitted with spring type vibration isolation mountings. Mass of the concrete inertia block shall be [2.0][_____] times mass of supported assembly. Spring mountings shall be selected to limit transmissibility of imbalanced forces at lowest equipment rpm to 3 percent.]

2.5.3 Unit Accessories

[Integral] [Remote] condensers shall be in accordance with paragraph CONDENSER, [_____]. Accessories to be used in combination with each unit shall be provided as indicated and shall be in accordance with paragraph REFRIGERANT ACCESSORIES. Outdoor condensing units shall be provided with weather hoods.

2.5.4 Electrical Controls

****
NOTE: Verify that reverse-phase, and phase-imbalance protection provisions are available in sizes under 70 kW 20 tons. Check with manufacturers before specifying other than across-the-line starting. If the transmissibility of equipment vibration is critical, indicate the use of service-rated flexible connectors on all pipe, tubing, and conduit to the equipment.
****

Electrical controls for the unit shall be in accordance with paragraph ELECTRICAL WORK and include at a minimum main and branch circuit overload protective devices compensated for ambient temperatures as recommended by the manufacturer; status pilot lights; compressor safety, operating and capacity controls; defrost controls; local and remote audible and visual alarms with provisions to silence; short cycling control with lock-out timer; time delay for sequenced compressor starts; and remote component interface.

2.6 CONDENSER, AIR-COOLED

Unit shall be factory fabricated and tested, packaged, self-contained and ready for full capacity operation after terminal point connections. Unit shall conform to ANSI/AHRI 460. Split systems shall be manufacturer matched units. Fans shall be propeller or centrifugal type as specified in paragraph Fans. Fan motors shall have [open][dripproof][totally enclosed][explosion proof] enclosures. Electrical controls for the unit shall be in accordance with paragraph ELECTRICAL WORK shall include a control transformer and shall be capable of interfacing with local and remote components.

2.6.1 Unit Casing

Casing shall be weatherproof and enclose all unit components. Structural members and sheet metal for the unit casing shall be constructed of galvanized steel or aluminum. Casing shall be fitted with lifting provisions, access panels, removable legs, and fan and heat rejection coil guards and screens.

2.6.2 Condenser Coil

****

NOTE: When coils are located in a corrosive or salt-laden environment, require both the copper or aluminum tubes and the protective coating.

****

Coil shall have [nonferrous][copper or aluminum] tubes of 10 mm 3/8 inch minimum diameter with copper or aluminum fins that are mechanically bonded or soldered to the tubes. [Coil shall be protected in accordance with paragraph COIL CORROSION PROTECTION.] Casing shall be galvanized steel or aluminum. Contact of dissimilar metals shall be avoided. Coils shall be tested in accordance with ASHRAE 15 & 34 at the factory and shall be suitable for the working pressure of the installed system. Condenser may be used for refrigerant storage in lieu of separate receiver, provided that storage capacity is 20 percent in excess of fully charged system. Coil shall be dehydrated and sealed after testing and prior to evaluation and charging. Unit shall be provided with a factory operating charge of refrigerant and oil or a holding charge. Unit shipped with a holding charge shall be field charged. Separate expansion devices shall be provided for each compressor circuit.

2.7 CONDENSER, WATER-COOLED

Condenser shall be [remote mounted, tested and rated to AHRI 450][an integral component of a water-cooled condensing unit, be tested and rated to ANSI/AHRI 520]. Condensers shall have safety provisions conforming to ASHRAE 15 & 34. Coils shall conform to ASME BPVC SEC VIII D1 or UL 207, as applicable for maximum and minimum pressure or temperature encountered. Condenser heads shall be removable and have flanged side inlet pipe connections which permit access to or removal of the tubes. A separate condenser shall be provided for each compressor circuit. Fans shall be propeller or centrifugal type as specified in paragraph Fans. Fan motors shall have [open][dripproof][totally enclosed][explosion proof] enclosures.

2.7.1 Unit Casing

Casing shall be weatherproof and enclose all unit components. Structural members and sheet metal for the unit casing shall be constructed of galvanized steel or aluminum. Casing shall be fitted with lifting provisions, access panels, removable legs, and fan and heat rejection coil guards and screens.

2.7.2 Condenser Coil

****

NOTE: Normally 70/30 copper nickel performance is superior to 90/10 copper nickel in brackish water and salt water. Where conditions are not

detrimental to 90/10 copper nickel, incorporate same as an alternative acceptable material. Use the higher fouling factor for open systems.
****

Condensers shall be of the shell-and-tube type with the coolant in the tubes. Water-wetted metals shall be [copper][or][[90/10][or][70/30] copper-nickel], except that heads may be ferrous metal in systems with chemically treated recirculating water. Unit shall be rated for not less than 2758 kPa 400 psig refrigerant side and 860 kPa 125 psig water side pressure service at operating temperatures. Water supply, return and control system wetted parts shall be copper, bronze or stainless steel. Water supply, return connections and piping internal to unit shall be copper with brazed or threaded copper or bronze fittings, terminating in a threaded connection. Piping arrangement shall include valved access for recirculation of acidic scale removal chemicals and isolation pressure taps to determine pressure drop and water flow. Performance shall be based on an allowable water velocity not less than 0.9 m/s 3 fps nor more than 3 m/s 10 fps with a fouling factor of [0.0005][0.001]. The design pressure drop shall govern the number of passes. Control valve on the water supply line shall be [the automatic, self-contained type, controlled by condensing pressure which close bubble-tight when compressor is not operating.] [the modulating three-way type, controlled by pressure controller.]

2.8 CONDENSER, EVAPORATIVE

Each unit shall be the counter-flow blow-through design, with single-side air entry. The unit shall have fan assemblies built into the unit base, with all moving parts factory mounted and aligned. Primary construction of the pan section, the cabinet, etc. shall be not lighter than 1.6 mm (16 gauge) 16 gauge steel, protected against corrosion by a zinc coating. The zinc coating shall conform to ASTM A153/A153M and ASTM A123/A123M, as applicable and have an extra heavy coating of not less than 0.76 kg/square m 2-1/2 ounces per square foot of surface. Cut edges shall be given a protective coating of zinc-rich compound. After assembly, the manufacturer's standard zinc chromatized aluminum or epoxy paint finish shall be applied to the exterior of the unit. Unit shall be rated in accordance with AHRI 490 I-P and tested in accordance with ASHRAE 64.

2.8.1 Pan Section

The pan shall be watertight and shall be provided with drain, overflow, and make-up water connections. Standard pan accessories shall include access doors, a lift-out strainer of anti-vortexing design and a brass make-up valve with float ball.

2.8.2 Fan Section

Fan shall be the [centrifugal][propeller] type in accordance with paragraph Fans. Fan and fan motor shall not be located in the discharge airstream of the unit. Motors shall have [open][dripproof][totally enclosed][explosion proof] enclosure and shall be suitable for the indicated service. The condensing unit design shall prevent water from entering into the fan section.

2.8.3 Condensing Coil

****

NOTE: Delete the copper or aluminum tubes and the protective coating except in corrosive environments.
****

Coils shall have [nonferrous][copper or aluminum] tubes of 10 mm 3/8 inch minimum diameter without fins.[Coil shall be protected in accordance with paragraph COIL CORROSION PROTECTION.] Casing shall be galvanized steel or aluminum. Contact of dissimilar metals shall be avoided. Coils shall be tested in accordance with ASHRAE 15 & 34 at the factory and be suitable for the working pressure of the installed system. Each coil shall be dehydrated and sealed after testing and prior to evaluation and charging. Each unit shall be provided with a factory operating charge of refrigerant and oil or a holding charge. Unit shipped with a holding charge shall be field charged.

2.8.4 Water Distribution System

Water shall be distributed uniformly over the condensing coil to ensure complete wetting of the coil at all times. Spray nozzles shall be brass, stainless steel, or high-impact plastic. Nozzles shall be the cleanable, nonclogging, removable type. Nozzles shall be designed to permit easy disassembly and shall be arranged for easy access.

2.8.5 Water Pump

The water pump shall be the bronze-fitted centrifugal or turbine type, and may be mounted as an integral part of the evaporative condenser or remotely on a separate mounting pad. Pumps shall have cast iron casings. Impellers shall be bronze, and shafts shall be stainless steel with bronze casing wearing rings. Shaft seals shall be the mechanical type. Pump casing shall be factory coated with epoxy paint. Pump motors shall have [open][dripproof][totally enclosed][explosion proof] enclosures. A bleed line with a flow valve or fixed orifice shall be provided in the pump discharge line and shall be extended to the nearest drain for continuous discharge. Pump suction shall be fully submerged and provided with a galvanized steel or monel screened inlet.

2.8.6 Drift Eliminator

Eliminators shall be provided to limit drift loss to not over 0.005 percent of the specified water flow. Eliminators shall be constructed of zinc-coated steel or polyvinyl chloride (PVC). Eliminators shall prevent carry over into the unit's fan section.

2.9 UNIT COOLERS

****
NOTE: If it is more economical to use one big air handling unit instead of several unit coolers, use Section 23 30 00 HVAC AIR DISTRIBUTION to develop the requirements and delete the unit coolers. Use Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC to develop the control requirements for the air handling unit.
****

Unit shall be [forced circulation][free delivery] type, factory fabricated, assembled and tested, and packaged in accordance with AHRI 420. Ammonia systems shall conform to IIAR 2. Fan shall be the

[centrifugal][propeller] type in accordance with paragraph Fans. Motors shall have [open][dripproof][totally enclosed][explosion proof] enclosures.

2.9.1 Construction

****
NOTE: Coils for fluorocarbon systems will have copper tubes and aluminum fins. Coils for ammonia systems will be hot-dip galvanized steel or aluminum.
****

Casing shall be Type 300 stainless steel, aluminum, mill galvanized or hot-dip galvanized steel after fabrication. Zinc-coated carbon steel shall be protected in accordance with paragraph COIL CORROSION PROTECTION.. Coils shall [be hot-dip galvanized steel or aluminum.][have copper tubes and aluminum fins.] Drain pan shall be watertight, corrosion resistant. Drainage piping for units in spaces maintained at less than 2 degrees C 35 degrees F shall be insulated.

2.9.2 Defrosting

****
NOTE: Spaces maintained at 2 degrees C 35 degrees F will be defrosted with ambient air. Spaces below 2 degrees C 35 degrees F will use either a hot gas or electric heat defrosting system. For a defrosting system choose between a timer defrost controller or a demand defrost controller.
****

Unit shall be [defrosted with ambient space air.][fitted with a [hot gas][electric heat] defrosting system.][Defrost system shall be controlled by timer defrost controller adjustable for up to 6 defrost cycles per 24 hours, each of 5 to 120 minutes duration. Controller shall include an adjustable timer to control frequency of cycles; defrost initiating thermostat; adjustable program timer to control sequence of defrost cycle; defrost terminating thermostat; manual override switch; selector switch; and status pilot light.][Defrost system shall be controlled by demand defrost controller. Controller shall include an automatic, solid-state circuitry to initiate defrost cycle based on sensing adjustable temperature difference of air moving across coil in direct proportion to frost build-up; thermostat to terminate defrost; adjustable lockout to prevent initiation of defrost during pull-down after defrost cycle; manual override switch; and status pilot light.]

2.10 CONTROLS AND INSTRUMENTS

Refrigeration system controls, instruments and devices shall be industrial quality, and shall conform to applicable requirements of ASHRAE 15 & 34. Submit manufacturer's standard catalog data, prior to the purchase or installation of a particular component, highlighted to show brand name, model number, size, options, performance charts and curves, etc. in sufficient detail to demonstrate compliance with contract requirements.

a. Provide data for each specified component including manufacturer's recommended installation instructions and procedures. If vibration isolation is specified for a unit, include vibration isolator literature containing catalog cuts and certification that the isolation characteristics of the isolators provided meet the

manufacturer's recommendations.

b. Fluid containing surfaces shall be rated for the service and constructed of materials suitable for the fluid. Component electrical rating shall be 120 volt ac, unless otherwise indicated and shall be suitable for imposed loads.

c. Ammonia systems shall conform to IIAR 2. Copper, copper alloy and white metals, except aluminum, shall not be used for ammonia service.

d. Submit proof of compliance where the system, components, or equipment are specified to comply with requirements of AHRI, ASHRAE, ASME, or UL. The label or listing of the specified agency will 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.

e. When performance requirements of this project's drawings and specifications vary from standard AHRI rating conditions, computer printouts, catalog, or other application data certified by AHRI or a nationally recognized laboratory as described above shall be included. If AHRI does not have a current certification program that encompasses such application data, the manufacturer may self certify that its application data complies with project performance requirements in accordance with the specified test standards.

2.10.1 Refrigeration System Alarms

2.10.1.1 Audible Alarm

Audible alarm shall be surface-mounted, 100 mm 4 inch vibrating bell type suitable for indoor or outdoor service.

2.10.1.2 Visual Alarm

Visual alarm shall be pilot light type. Alarm shall be 100 watt, incandescent, vapor-tight fixture with cast metal guard and [red][green][amber] lens.

2.10.2 Controllers

2.10.2.1 Differential Pressure Controller

Differential pressure controller shall be provided with high and low pressure sensing ports and shall be direct or reverse acting with calibrated proportional band and set point adjustments. Controller output shall be [low voltage electric][pneumatic][4-20 mA dc], proportional to the pressure differential sensed. Local and remote set point adjustments shall be included. Range shall meet system requirements.

2.10.2.2 Differential Temperature Controller

Differential temperature controller shall be provided with two filled, remote sensing bulbs connected to the controller by [capillary][armored capillary] tubing. Controller shall be direct or reverse acting with calibrated proportional band and set point adjustments. Controller output shall be [low voltage electric][pneumatic][4-20 mA dc], proportional to

the temperature differential sensed. Provisions for local and remote set point adjustments shall be included. Range shall be as required to meet system requirements. For immersion service, thermal wells shall be provided.

2.10.3 Pilot Lights

Panel-mounted pilot lights shall be NEMA Class 12 oil-tight, push-to-test transformer for 6-8 Vac lamps. Lamps shall be replaceable by removal of color cap. Cap color shall be as indicated.

2.10.4 Programmer, Demand Control/Load

****

NOTE: Before application of energy management systems/load shedders to refrigeration systems, and related fans and pumps, the designer shall ascertain that application will be neither conducive to equipment damage nor counterproductive. Safety trips, compressor slugging, freeze-ups and reloading of circuits may occur.

****

Programmer shall be fully automatic, fail safe, field programmable, solid-state, demand control and load programmable for [_____][16] loads. Demand control portion shall monitor power consumption by[watt][or][current] transducers. Set point shall be field adjustable with adjustable dead band. Load shedding sequence time and differential time between load shedding shall be adjustable. Contacts shall store alarm condition. Meter readout shall indicate demand deviation from set point. Load profile recorder shall be strip-chart type with readily discernable event record. Load programmer shall permit programming of on/off time of each load for any time element within a week and shall equalize power demand over a preset time cycle. System shall include input override and time cycle accelerator for checkout. Alarm condition, status of all loads and time period shall be visually indicated and recorded. Each load shall include a H-O-A toggle switch. Alarm provisions shall include relay contacts for external, remote alarm functions and test provisions. Override [thermostat][pressure switch][timer] shall be provided to restore shedded loads indicated. Control panel enclosure shall be NEMA ICS 6, Type 1, surface mounted type with key lock. Load profile recorder shall be [surface][flush panel] mounted type. Load relays shall be plug-in type with critical load failure in "on" mode and contacts rated for pilot duty at 120 volt ac. Load shedding position switches shall shed loads on a first shed/last restore basis and remove loads from system logic for shedding cycle. Time clock shall be fitted with spring motor to maintain time in event of power failure.

2.10.5 Switches, Fluid Service

Switches shall be field adjustable SPDT type and shall have NEMA ICS 6, Type 1 enclosure with operating range specified or indicated. Circuits shall be as required for the applicable functions.

2.10.5.1 Air Flow Switch

Air flow switch shall have a service pressure range of 31 to 2542 Pa 0.12 to 10 inches wg.

2.10.5.2 Water-Flow Switch

Water flow switch shall have a body rating suitable for the service, field-adjustable activating flow rate, and a pressure drop not in excess of 13.8 kPa 2 psi at maximum flow rate.

2.10.5.3 Pressure Switch

Pressure switch shall be factory set, one or two stage as indicated, with adjustable operating and differential pressure. Bourdon tube inlet shall be fitted with damper screw adjustment.

2.10.5.4 Differential Pressure Switch

Differential pressure switch shall be factory set, provided with high and low sensing ports, one or two stages and adjustable differential range and pressure.

2.10.5.5 Temperature Switch

Temperature switch shall be factory set, provided with [capillary][armored capillary] tubing and filled sensing system, one or two stages as indicated, and operating adjustable differential range. For immersion service, thermal wells shall be provided.

2.10.5.6 Differential Temperature Switch

Differential temperature switch shall be factory set, provided with two [separate][separate armored] capillary systems, one or two stages, and adjustable differential range and temperature. For immersion service, thermal wells shall be provided.

2.10.6 Push-Button Stations

Stations shall be NEMA Class 12 oil-tight, momentary or maintained-contact type, as indicated. Start push-buttons shall have a fully guarded or flush black operator button. Stop push-buttons shall have an unguarded or extended red operator button.

2.10.7 Selector

Switches shall be NEMA Class 12 oil-tight, momentary or maintained contact type, as indicated, with standard operator.

2.11 HEAT RECOVERY DEVICES

2.11.1 Heat Recovery Coil, Air

****

NOTE: When coils are located in a corrosive or salt-laden environment, require both the copper or aluminum tubes and the protective coating.

****

Coil shall be compatible with the type of refrigerant used in the system. Coil shall have [nonferrous][copper or aluminum] tubes of 10 mm 3/8 inch minimum diameter with copper or aluminum fins that are mechanically bonded or soldered to the tubes.[Coil shall be protected in accordance with paragraph COIL CORROSION PROTECTION.] Casing shall be galvanized steel or

aluminum. Contact of dissimilar metals shall be avoided. Coils shall be tested in accordance with ASHRAE 15 & 34 at the factory and shall be suitable for the working pressure of the installed system. Coil shall be dehydrated and sealed after testing and prior to evaluation and charging. Unit shall be provided with a factory operating charge of refrigerant and oil or a holding charge. Unit shipped with a holding charge shall be field charged. Coil shall mount within a heat recovery, factory-fabricated, draw-through, central station type air conditioner in accordance with Section 23 30 00 HVAC AIR DISTRIBUTION.

2.11.2 Hot Water Reclaim

****

NOTE: Indicate on the drawings the size of the exchanger either as a percent of the total rated condenser load or as a percent of the superheated portion of the total rated condenser load. The refrigerant compressor head pressure control and the circulating pump can be deleted if inapplicable.

****

Unit shall be a double-wall, tube-within-tube heat exchanger type, complete with thermostatic control. Unit shall be constructed and refrigerant pressure/temperature rated in accordance with ASHRAE 15 & 34. Heat exchanger coil shall consist of an external refrigerant containing carbon steel tube and an internal, double-wall-in-metallic contact, convoluted, potable water containing copper tube. Cabinet shall be fabricated of zinc-protected steel and shall be internally insulated in coil space. The recovery device shall be provided with a refrigerant compressor head pressure control and an interlocked, potable water circulating pump. Pump and motor assembly shall be close-coupled, manufacturer's standard type with indicated head and capacity characteristics, and with brass, bronze, copper or stainless steel wetted parts. Pump shall be mounted [remotely][integral] to the exchanger and be rated for [115][208][230] volt ac power supply.

2.12 PURGE SYSTEM

****

NOTE: Refrigeration systems which operate below atmospheric pressure (i.e., R-123 machines) will require a refrigerant purge piping system. Indicate the routing of purge piping on the drawings. Require the Contractor to delete the piping if a purge system is not required for the type of refrigeration system that is to be provided. Indicate that it will be the Contractor's responsibility to size the piping based upon the recommendations of the refrigeration system's manufacturer. Purge discharge piping may be connected to the pressure-relief piping on the equipment side of the piping's vibration isolators.

****

Provide refrigeration systems, which operate at pressures below atmospheric pressure, with a purge system. Purge systems shall automatically remove air, water vapor, and non-condensable gases from the system's refrigerant. Purge systems shall condense, separate, and return all refrigerant back to the system. An oil separator shall be provided

with the purge system if required by the manufacturer. Purge system shall not discharge to occupied areas, or create a potential hazard to personnel. Purge system shall include a purge pressure gauge, number of starts counter, and an elapsed time meter. Purge system shall include lights or an alarm which indicate excessive purge or an abnormal air leakage into the system.

2.13 REFRIGERANT LEAK DETECTOR

****

NOTE: Refrigerant leak detectors will be provided as required by the "System Application Requirements" in ASHRAE 15 & 34.

When a detector is required, the location will be indicated on the drawings. Detectors are best located between the refrigeration system and the room exhaust. Sampling points from a detector will be located a maximum of 450 mm 18 inches above the finished floor since all commonly-used refrigerants are heavier than air.

As a rule of thumb, the distance between any refrigeration system and a refrigerant sampling point shouldn't exceed 15 m 50 feet. In order to meet the recommended 15 m 50 feet distance, a mechanical room can be provided with either multiple detectors each with single sampling points or with one detector that has the capability of monitoring at multiple sampling points. If multiple sampling points are required, enter the number in the appropriate blank below.

In accordance with ASHRAE 15 & 34, when a detector senses refrigerant it must activate an alarm and initiate the room ventilation system. In regards to alarms, as a minimum indicate that the detector will energize a light on or near the detector as well as a second light installed on the outside wall next to the mechanical room entrance. The exterior light will be provided with a sign that warns personnel entering the mechanical room of a refrigerant release and that a SCBA is required to enter. If applicable to the installation, include an audible alarm on the exterior of the mechanical room. Include the electrical design for the alarm system on the drawings.

As an additional item, ASHRAE 15 & 34 states that open-flame devices (i.e., boilers, etc.) cannot be installed in the same area as a refrigeration system, unless either combustion air for the open-flame device is ducted straight from outside to the device; or the alarm relay from the detector is used to automatically shutdown the combustion process in the event of refrigerant leakage. Indicate all applicable alarm controls on the drawings.

Delete the information in the last bracketed sentence if an EMCS is not applicable to the design.
****

Detector shall be the continuously-operating, halogen-specific type. Detector shall be appropriate for the refrigerant in use. Detector shall be specifically designed for area monitoring and shall include [a single sampling point][[_____] sampling points] installed where indicated. Detector design and construction shall be compatible with the temperature, humidity, barometric pressure and voltage fluctuations of the operating area. Detector shall have an adjustable sensitivity such that it can detect refrigerant at or above 3 parts per million (ppm). Detector shall be supplied factory-calibrated for the appropriate refrigerant. Detector shall be provided with an alarm relay output which energizes when the detector detects a refrigerant level at or above the TLV-TWA (or toxicity measurement consistent therewith) for the refrigerant in use. The detector's relay should be capable of initiating corresponding alarms and ventilation systems as indicated on the drawings. Detector shall be provided with a failure relay output that energizes when the monitor detects a fault in its operation.[Detector shall be compatible with the facility's energy management and control system (EMCS). The EMCS shall be capable of generating an electronic log of the refrigerant level in the operating area, monitoring for detector malfunctions, and monitoring for any refrigerant alarm conditions.]

2.14 REFRIGERANT RELIEF VALVE/RUPTURE DISC ASSEMBLY

****
NOTE: ASHRAE 15 & 34 requires refrigeration systems to be protected with a pressure-relief device that will safely relieve pressure due to fire or other abnormal conditions. A relief valve/rupture disc assembly is the optimum solution. The rupture disc will provide visual indication of a release while also providing immediate shutoff once a safe pressure is achieved.

Designer will indicate on the drawings the location of each new relief valve/rupture disc assembly as well as the routing and size of corresponding pressure-relief piping. The routing and size of new pressure-relief piping will be in accordance with ASHRAE 15 & 34.
****

The assembly shall be a combination pressure relief valve and rupture disc designed for refrigerant usage. The assembly shall be in accordance with ASME BPVC SEC IX and ASHRAE 15 & 34. The assembly shall be provided with a pressure gauge assembly which will provide local indication if a rupture disc is broken. Rupture disc shall be the non-fragmenting type.

2.15 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 13 mm 0.5 inches in height.

2.15.1 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.

2.15.2 Controls and Piping Identification

Provide refrigerant systems containing more than 50 kg 110 lb of refrigerant with refrigerant signs which designate the following as a minimum:

a. Valves or switches for controlling the refrigerant flow [, the ventilation system,] and the refrigerant compressor.

b. Pressure limiting device.

2.16 POWER TRANSMISSION COMPONENTS

Fan and open compressor drives shall be in accordance with the manufacturer's published recommendations, except as otherwise specified. Horsepower rating of V-belt drive shall be based on maximum pitch diameter of sheaves. Compressors shall be fitted with fixed sheaves and drives with a minimum service factor of [1.5][2.0]. Where the number of unit starts exceeds 8 per 24 hours, add 0.1 to the required drive service factor. Sheaves shall be statically and dynamically balanced, machined ferrous metal, bushing type, secured by key and keyway. Pitch diameter of fixed pitch sheaves and adjustable sheaves, when adjusted to specific limits, shall be not less than that recommended by NEMA MG 1. Adjustable sheaves shall be selected to provide the required operating speed with the sheave set at mid-point of its adjustment range. The adjustment range for various size and type belts shall be 16 percent minimum for classical section belts and 12 percent minimum for narrow section belts. Belt drive motors shall be provided with slide rail or equivalent adjustable motor bases. Direct drive couplings for motors rated less than 2.2 kW 3 hp shall be manufacturer's standard. Direct drive couplings for motors rated greater than 2.2 kW 3 hp shall be elastomer-in-shear type. Each drive shall be independent of any other drive. Drive bearings shall be protected with water slingers or shields. V-belt drives shall be fitted with guards where exposed to contact by personnel.

2.17 CONDENSER WATER SYSTEMS

****
NOTE: Delete this paragraph if inapplicable. Use Section 23 65 00 COOLING TOWER and 23 64 26 CHILLED AND CONDENSER WATER PIPING AND ACCESSORIES to develop the requirements for a condenser water system.
****

Cooling towers, condenser water pumps, condenser water treatment systems, condenser water piping, fittings, valves and accessories shall be in accordance with Sections 23 65 00 COOLING TOWER and 23 64 26 CHILLED, CHILLED-HOT, AND CONDENSER WATER PIPING SYSTEMS.

2.18 DRAIN AND MISCELLANEOUS PIPING

Piping, fittings, valves and accessories for drain and miscellaneous services shall be in accordance with Section 22 00 00 PLUMBING, GENERAL PURPOSE.

2.19 PIPING AND FITTINGS, FLUOROCARBONS

Piping, valves, fittings, and accessories shall conform to the requirements of ASHRAE 15 & 34and ASME B31.5, except as specified.

2.19.1 Steel Pipe

Steel pipe for fluorocarbon service shall conform to ASTM A53/A53M, Schedule 40, Type E or S, Grades A or B. Type F pipe shall not be used.

2.19.2 Steel Pipe Joints and Fittings

Joints and fittings shall be steel butt-welding, socket-welding, or malleable iron threaded type. Pipe shall be welded except that joints on lines 50 mm 2 inches and smaller may be threaded. Threads shall be tapered type conforming to ASME B1.20.2MASME B1.20.1. The malleable iron threaded type fitting shall be of a weight corresponding to adjacent pipe. Flanges and flange faces of fittings shall be tongue-and-groove type with gaskets suitable for the refrigerant used; size 25 mm 1 inch and smaller shall be oval, two-bolt type; size above 25 mm 1 inch, up to and including 100 mm 4 inch, shall be square four-bolt type; and sizes over 100 mm 4 inch shall be round.

2.19.3 Steel Tubing

Steel tubing for refrigeration service shall be in accordance with ASTM A334/A334M, Grade 1. Tubing with a nominal diameter of 10 mm 3/8 inch or 13 mm 1/2 inch shall have a wall thickness of 1.22 mm 0.049 inches. Tubing with a nominal diameter of 19 mm 3/4 inch through 50 mm 2 inches shall have a wall thickness of 1.62 mm 0.065 inches. Tubing with a nominal diameter of 65 through 100 mm 2-1/2 through 4 inches shall have a wall thickness of 2.4 mm 0.095 inches. Steel tubing shall be cold-rolled, electric-forged, welded-steel. One end of the tubing shall be provided with a socket. Steel tubing shall be cleaned, dehydrated, and capped.

2.19.4 Steel Tubing Joints and Fittings

Joints and fittings shall be socket type provided by the steel tubing manufacturer.

2.19.5 Copper Tubing

Copper tubing shall conform to ASTM B280 annealed or hard drawn as required. Copper tubing shall be soft annealed where bending is required and hard drawn where no bending is required. Soft annealed copper tubing shall not be used in sizes larger than 35 mm 1-3/8 inches. Joints shall be brazed except that joints on lines 22 mm 7/8 inch and smaller may be flared.

2.19.6 Copper Tube Joints and Fittings

Copper tube joints and fittings shall be flare joint type with short-shank

flare, or solder-joint pressure type. Joints and fittings for brazed joint shall be wrought-copper or forged-brass sweat fittings. Cast sweat-type joints and fittings will not be allowed for brazed joints.

2.20 PIPING AND FITTINGS, AMMONIA

At system application conditions to minus 6.7 degrees C 20 degrees F piping system components including but not limited to piping, flanges, fittings, valves, and all accessories including flange bolts, nuts, and bolt patterns shall conform to ASME B31.5. Unions shall not be used in this piping system. Other requirements are as follows:

2.20.1 Pipe, Black Carbon Steel

ASTM A53/A53M, Type E or S, Grade A or B, Schedule 40, standard weight, or Schedule 80, or extra strong as required.

2.20.2 Fittings, Threaded

ASTM A105/A105M or ASTM A181/A181M and ASME B16.11, 2.07 MPa 3000 psig WOG, forged steel.

2.20.3 Fittings, Welding

In sizes 25 mm 1 inch and under, ASTM A105/A105M or ASTM A181/A181M, and ASME B16.11, 2.07 MPa 3000 psig WOG, forged steel, socket weld, bored to match pipe wall thickness. Sizes exceeding 25 mm 1 inch shall be wrought carbon steel, long radius, butt-weld, to match pipe wall thickness, conforming to ASTM A234/A234M and ASME B16.9.

2.20.4 Fittings, Flanged

High strength gray cast iron conforming to ASTM A126, Class B, or ASTM A278/A278M, Class 40, or malleable iron conforming to ASTM A197/A197M, manufacturer's standard long radius. Flange configuration shall be as specified for flanges.

2.20.5 Flanges

Forged carbon steel conforming to ASTM A181/A181M, with industry standard tongue and groove face finish, 2-bolt oval shape in sizes 19 mm 3/4 inch and under; 4-bolt square shape in sizes 25 mm 1 inch through 100 mm 4 inches; round shape in sizes 127 mm 5 inches and larger; weld neck, except in sizes 50 mm 2 inches and under socket weld is acceptable. Threaded connection flanges are not acceptable. Flange template dimensional and shape criteria shall be identical and/or interchangeable with valve flanges specified in paragraph VALVES, AMMONIA AND FLUOROCARBON.

2.21 VALVES, AMMONIA AND FLUOROCARBON

****

NOTE: Construction of valves for ammonia service should be stainless steel or ferrous based only.

****

Valves shall be pressure and temperature rated for contained refrigerant service and shall comply with ASME B31.1. Metals of construction shall be of Type 300 stainless steel, or [ferrous or copper][ferrous] based. Atmosphere exposed valve stems shall be stainless steel or corrosion

resistant metal plated carbon steel. Valve body connections shall be brazed or welded socket, flanged or combination thereof. Threaded connections shall not be used, except in pilot pressure or gauge lines where maintenance disassembly is required and welded flanges cannot be used. Valves shall be suitable for or fitted with extended copper ends for brazing in-place without disassembly. Ferrous body valves shall be fitted with factory fabricated and brazed copper transitions. To minimize system pressure drops, where practicable, globe valves shall be angle body type, and straight line valves shall be full port ball type. Control valve inlets shall be fitted with integral or adapted strainer or filter where recommended or required by manufacturer. Valves shall be cleaned and sealed moisture-tight.

2.21.1 Refrigerant-Stop Valves

Stop valves shall be designed for use with the refrigerant used and shall have pressure ratings compatible with system working pressures encountered. Gate valves will not be acceptable.

2.21.1.1 Fluorocarbon Service

Valves 16 mm 5/8 inch and smaller shall be handwheel operated, straight or angle, packless diaphragm globe type with back-seating stem, brazed ends, except where SAE flare or retained seal cap connections are required. Valves larger than 16 mm 5/8 inch shall be globe or angle type, wrench operated with ground-finish stems, or ball valves, packed especially for refrigerant service, back seated, and provided with seal caps. Refrigerant isolation and shutoff valves shall have retained or captive spindles and facilities for tightening or replacement of the gland packing under line pressure as applicable. Stop valves shall have back-seating plated steel stem, bolted bonnet in sizes 25 mm 1 inch OD and larger, integral or flanged transition brazed socket. Valves, in sizes through 65 mm 2-1/2 inches shall be end-entry body assembly, full-port, floating ball type, with equalizing orifice fitted chrome plated ball, seats and seals of tetrafluoroethylene, chrome plated or stainless steel stem, and seal cap. In sizes 100 mm 4 inch IPS and larger, and in smaller sizes where carbon steel piping is used, valve bodies shall be tongue and groove flanged and complete with mating flange, gaskets and bolting for socket or butt-weld connection. Purge, charge and receiver valves shall be of manufacturer's standard configuration.

2.21.1.2 Ammonia Service

Valves shall be straight or angle, packed, rising stem/handwheel fitted, globe type. Stem shall be back-seating type, fitted with non-rotating, self-aligning, retained lead alloy seat disc. In sizes 19 mm 3/4 inch IPS and larger, bonnets shall be bolted and body end connections shall be buttweld or tongue and groove flanged and furnished with mating flange, gaskets, and fasteners. Mating flange shall be socket or buttweld connection type. In sizes under 19 mm 3/4 inch IPS, threaded ends will be acceptable. Ball valves constructed specifically for ammonia refrigeration service are acceptable.

2.21.2 Check Valve

Valve shall be designed for service application, spring-loaded type where required, with resilient seat and with flanged body in sizes 13 mm 1/2 inch and larger. Valve shall provide positive shutoff at [10.3][13.8][20.7] kPa [1-1/2][2][3] psi differential pressure.

2.21.3 Liquid Solenoid Valves

Valves shall comply with ANSI/AHRI 760 and shall be suitable for continuous duty with applied voltages 15 percent under and 5 percent over nominal rated voltage at maximum and minimum encountered pressure and temperature service conditions. Valves shall be direct-acting or pilot-operating type, packless, except that packed stem, seal capped, manual lifting provisions shall be furnished. Solenoid coils shall be moistureproof, UL approved, totally encapsulated or encapsulated and metal jacketed as required. Valves shall have safe working pressure of 2758 kPa 400 psi and a maximum operating pressure differential of at least 1380 kPa 200 psi at 85 percent rated voltage. Valves shall have an operating pressure differential suitable for the refrigerant used.

2.21.4 Expansion Valves

****

NOTE: Choose AHRI 751 SI AHRI 750 I-P for fluorocarbon service and ASHRAE 17 for ammonia service.

****

Expansion valves shall conform to the requirements of [AHRI 751 SI AHRI 750 I-P][ASHRAE 17]. Valve shall be of the diaphragm and spring type with internal or external equalizers, and bulb and capillary tubing. Valve shall be provided with an external superheat adjustment along with a seal cap. Internal equalizers may be utilized where flowing refrigerant pressure drop between outlet of the valve and inlet to the evaporator coil is negligible and pressure drop across the evaporator is less than the pressure difference corresponding to 1 degree C 2 degrees F of saturated suction temperature at evaporator conditions. Bulb charge shall be determined by the manufacturer for the application and liquid shall remain in the bulb at all operating conditions. Gas limited liquid charged valves and other valve devices for limiting evaporator pressure shall not be used without a distributor or discharge tube or effective means to prevent loss of control when bulb becomes warmer than valve body. Pilot-operated valves shall have a characterized plug to provide required modulating control. A de-energized solenoid valve may be used in the pilot line to close the main valve in lieu of a solenoid valve in the main liquid line. An isolatable pressure gauge shall be provided in the pilot line, at the main valve. Automatic pressure reducing or constant pressure regulating expansion valves may be used only where indicated or for constant evaporator loads. In direct-expansion unit cooler applications, thermostatic expansion valve discharge shall be through distributor and distributing tubes or through a single tube outlet leading to an orificed header provided by the unit cooler manufacturer, supplying an evaporator coil with not more than four circuits. Distributor orifices shall be sized for application conditions and distributor shall be provided by the thermostatic expansion valve manufacturer as a matched combination to suit evaporator coil circuitry. Where indicated, distributor tube shall be fitted with side inlet for hot gas bypass or defrosting. In single compressor/evaporator combinations, where compressor capacity control is only by on-off cycling, and if recommended by the compressor manufacturer, thermostatic expansion valve shall be furnished with a small bleed passage between inlet and outlet to facilitate equalization of high and low side during off cycle.

2.21.5 Safety Relief Valve

****
NOTE: Three way valves should be used on ammonia vessels and equipment.
****

Valve shall be the [two-way][three-way] type. Single type valves shall be used only where indicated. Valve shall bear the ASME code symbol. Valve capacity shall be certified by the National Board of Boiler and Pressure Vessel Inspectors. Valve shall be of an automatically reseating design after activation.

2.21.6 Evaporator Pressure Regulators, Direct-Acting

Valve shall include a diaphragm/spring power assembly, external pressure adjustment with seal cap, and pressure gauge port. Valve shall maintain a constant inlet pressure by balancing inlet pressure on diaphragm against an adjustable spring load. Pressure drop at system design load shall not exceed the pressure difference corresponding to a 1 degree C 2 degrees F change in saturated refrigerant temperature at evaporator operating suction temperature. Spring shall be selected for indicated maximum allowable suction pressure range.

2.21.7 Refrigerant Access Valves

Refrigerant access valves and hose connections shall conform to AHRI 720.

2.21.8 Service Gauge Fittings

Fittings shall be designed for connecting a pressure gauge with a hose fitting. These fittings shall be provided in the suction pipe at each unit cooler.

2.22 REFRIGERANT ACCESSORIES

2.22.1 Fans

Fan wheel shafts shall be supported by either maintenance-accessible lubricated anti-friction block-type bearings, or permanently lubricated ball bearings. Unit fans shall be selected to produce the air flow required at the fan total pressure. Thermal overload protection shall be of the manual or automatic-reset type. Fan wheels or propellers shall be constructed of aluminum or galvanized steel. Centrifugal fan wheel housings shall be of galvanized steel, and both centrifugal and propeller fan casings shall be constructed of aluminum or galvanized steel. Steel elements of fans, except fan shafts, shall be hot-dipped galvanized after fabrication or fabricated of mill galvanized steel. Mill-galvanized steel surfaces and edges damaged or cut during fabrication by forming, punching, drilling, welding, or cutting shall be recoated with an approved zinc-rich compound. Fan wheels or propellers shall be statically and dynamically balanced. Forward curved fan wheels shall be limited to [_____] mm inches. Direct-drive fan motors shall be of the multiple-speed variety. Centrifugal scroll-type fans shall be provided with streamlined orifice inlet and V-belt drive. Each drive shall be independent of any other drive. Propeller fans shall be [direct-drive][V-belt] drive type with [adjustable][fixed] pitch blades. V-belt driven fans shall be mounted on a corrosion protected drive shaft supported by either maintenance-accessible lubricated anti-friction block-type bearings, or

permanently lubricated ball bearings.

2.22.2 Pressure Vessels

Pressure vessels shall conform to ASME BPVC SEC VIII D1 or UL 207, as applicable for maximum and minimum pressure or temperature encountered. Where referenced publications do not apply, pressure components shall be tested at 1-1/2 times design working pressure. Refrigerant wetted carbon steel surfaces shall be pickled or abrasive blasted free of mill scale, cleaned, dried, charged, and sealed. Where service temperatures below minus 6.7 degrees C 20 degrees F are encountered, materials of construction shall be low temperature alloy carbon steel.

2.22.2.1 Hot Gas Muffler

Unit shall be selected by the manufacturer for maximum noise attenuation. Units rated for 105.5 kW 30 tons capacity and under may be field tunable type.

2.22.2.2 Liquid Receiver

****

NOTE: Delete the last sentence if inapplicable. Insulation may be required if the room where the receiver is located can reach a higher temperature than the saturation temperature of the refrigerant. Insulation is generally not needed in most applications.

****

Receiver shall be designed, filled, and rated in accordance with the recommendations of ANSI/AHRI 495, except as modified herein. Receiver shall be sized so that it is never filled beyond 80 percent of its total capacity. The remaining 20 percent shall allow for liquid expansion. Receiver shall be provided with a relief valve of capacity and setting in accordance with ASHRAE 15 & 34. Receiver shall be fitted to include an inlet pipe; an outlet drop pipe with oil seal and oil drain where necessary; two bulls-eye liquid level sight glass in same vertical plane, 90 degrees apart and perpendicular to axis of receiver or external gauge glass with metal guard and automatic stop valves;[a thermal well for thermostat;][a float switch column;][external float switches;] purge, charge, equalizing, pressurizing, plugged drain and service valves on the inlet and outlet connections. Receiver shall be factory insulated with not less than 25 mm 1 inch thick, 100 percent adhesive bonded, vaportight, flexible, closed-cell elastomer and finished with two coats of solvent base PVC protective coating or 0.41 mm 0.016 inch thick aluminum jacket.

2.22.2.3 Oil Separator

****

NOTE: An oil separator may be required if a system has very low evaporator temperatures (minus 18 degrees C 0 degrees F or less), or very long runs of piping, or multiple compressors. Use ASHRAE Handbook, Refrigeration Systems and Applications for further guidance. Note that the inclusion of oil separators will not decrease the need for using proper pipe sizing and layout/sloping techniques to ensure oil return.

****

Separator shall be the high efficiency type, provided with removable flanged head for ease in removing float assembly and removable screen cartridge assembly. Pressure drop through a separator shall not exceed [69 kPa 10 psi][_____] during the removal of hot gas entrained oil. Connections to compressor shall be as recommended by the compressor manufacturer. Separator shall be provided with an oil float valve assembly or needle valve and orifice assembly, drain line shutoff valve, sight glass,[filter for removal of all particulate sized 0.01 mm and larger,][thermometer and low temperature thermostat fitted to thermal well,][immersion heater,][external float valve fitted with three-valve bypass,] and strainer.

2.22.2.4 Oil Reservoir

Reservoir capacity shall equal one charge of all connected compressors. Reservoir shall be provided with an external liquid gauge glass, plugged drain, and isolation valves. Vent piping between the reservoir and the suction header shall be provided with a 34.5 kPa 5 psi pressure differential relief valve. Reservoir shall be provided with the manufacturer's standard filter on the oil return line to the oil level regulators.

2.22.3 Condenser and Head Pressure Control

Unit shall be capable of automatically operating without daily or seasonal adjustments in ambient temperature of [_____] degrees C degrees F. Control shall be set for refrigerant condensing temperature of [_____] degrees C degrees F. Controls shall permit proper operation of system with proper differential pressure across the thermostatic expansion valve. Control system shall be based on sensing of actual condensing pressure in conjunction with manufacturer's standard method of subcooling the saturated refrigerant. Controls shall be set to produce a minimum [_____] degrees C degrees F subcooling. Subcooling circuit shall be liquid sealed. Air volume control will not be acceptable for ambient conditions below 2 degrees C 35 degrees F. Necessary accessories shall be provided to maintain safe compressor discharge temperatures for low temperature systems.

2.22.4 Filter Driers

Driers shall conform to AHRI 711AHRI 710 I-P. Sizes 16 mm 5/8 inch and larger shall be the full flow, replaceable core type. Sizes 13 mm 1/2 inch and smaller shall be the sealed type. Cores shall be of suitable desiccant that will not plug, cake, dust, channel, or break down, and shall remove water, acid, and foreign material from the refrigerant. Filter driers shall be constructed so that none of the desiccant will pass into the refrigerant lines. Minimum bursting pressure shall be 10 MPa 1,500 psig.

2.22.5 Sight Glass and Liquid Level Indicator

2.22.5.1 Assembly and Components

Assembly shall be pressure- and temperature-rated and constructed of materials suitable for the service. Glass shall be borosilicate type. Ferrous components subject to condensation shall be electro-galvanized.

2.22.5.2 Gauge Glass

Gauge glass shall include top and bottom isolation valves fitted with automatic checks, and packing followers; red-line or green-line gauge glass; elastomer or polymer packing to suit the service; and gauge glass guard.

2.22.5.3 Bulls-Eye and Inline Sight Glass Reflex Lens

Bulls-eye and inline sight glass reflex lens shall be provided for dead-end liquid service. For pipe line mounting, two plain lenses in one body suitable for backlighted viewing shall be provided.

2.22.5.4 Moisture Indicator

Indicator shall be a self-reversible action, moisture reactive, color changing media. Indicator shall be furnished with full-color-printing tag containing color, moisture and temperature criteria. Unless otherwise indicated, the moisture indicator shall be an integral part of each corresponding sight glass.

2.22.6 Flexible Pipe Connectors

Connector shall be pressure and temperature rated for the service in accordance with ASHRAE 15 & 34 and ASME B31.5. Connector shall be a composite of interior corrugated phosphor bronze or Type 300 series stainless steel, as required for fluid service, with exterior reinforcement of bronze, stainless steel or monel wire braid. Assembly shall be constructed with a safety factor of not less than 4 at 150 degrees C 300 degrees F. Unless otherwise indicated, the length of a flexible connector shall be as recommended by the manufacturer for the service intended.

2.22.7 Strainers

Strainers used in refrigerant service shall have brass or cast iron body, Y or angle pattern, cleanable, not less than 60-mesh noncorroding screen of an area to provide net free area not less than 10 times the pipe diameter with pressure rating compatible with the refrigerant service. Screens shall be stainless steel or monel and reinforced spring-loaded where necessary for bypass-proof construction.

2.22.8 Brazing Materials

Brazing materials for refrigerant piping shall be in accordance with AWS A5.8/A5.8M, Classification BCuP-5.

2.22.9 Liquid and Suction Headers

Liquid and suction headers shall be provided on each multi-compressor system. Headers shall be sized according to manufacturer's recommendations. Each header shall be provided with service valves to permit servicing each unit cooler and forced circulation air coil. Each service valve shall have a gauge port which can be closed by back-seating the valve and a front seat which can close off the line connected to the manifold. Each service valve shall be provided with a removable, protective valve stem cap or cover.

2.22.10 Suction Accumulators

****

NOTE: Delete this paragraph if other means are taken to prevent liquid carry-over and to assure oil return to the compressors.

****

Accumulator shall be designed and installed within each suction header to provide a positive trap for liquid carry-over and to assure oil return to the compressors. An accumulator's internal liquid holding volume shall be at least [_____] cubic meters feet. Design shall ensure that oil is not trapped in the accumulator.

2.23 FACTORY FINISHES

2.23.1 Coil Corrosion Protection

****

NOTE: Research local conditions to determine the corrosiveness of the environment. Where condenser or evaporator coils are to be installed in highly corrosive atmospheres, carefully consider the coil and fin combinations specified. Standard coil construction is typically copper tubes with aluminum fins. For excessively corrosive atmospheres, either copper tubes with copper fins or aluminum tubes with aluminum fins should be considered.

For maximum coil protection, include the requirements of this paragraph. This paragraph addresses phenolic, vinyl, and epoxy type coatings. For coils with relatively close fin spacing the phenolic or epoxy coating are the preferred types as these have less tendency to bridge across the fins than vinyl. In addition, the phenolic and epoxy type coatings can typically provide better thermal conductivity than vinyl.

If coatings are specified, note that a coil's heat transfer capacity can be reduced anywhere between 1 to 5 percent; total unit capacity may have to be increased as a result.

****

Provide coil with a uniformly applied [epoxy electrodeposition] [phenolic] [vinyl] [epoxy electrodeposition, phenolic, or vinyl] type coating to all coil surface areas without material bridging between fins. Submit product data on the type coating selected, the coating thickness, the application process used, the estimated heat transfer loss of the coil, and verification of conformance with the salt spray test requirement. Coating shall be applied at either the coil or coating manufacturer's factory. Coating process shall ensure complete coil encapsulation. Coating shall be capable of withstanding a minimum 1,000 hours exposure to the salt spray test specified in ASTM B117 using a 5 percent sodium chloride solution.

2.23.2 Equipment and Components

****
NOTE: A salt fog test should be required for all outdoor equipment. Specify a 125-hour test in noncorrosive environments and a 500-hour test in corrosive environments.
****

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] [500] hours exposure to the salt spray test specified in ASTM B117 using a 25 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 1/8 inch 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 D520, Type I.

2.23.3 Color Coding

****
NOTE: Color coding for piping identification required by the using agency will be developed and inserted in the "Color Code Schedule" in Section 09 90 00 PAINTS AND COATINGS. For Air Force Installations, piping will be color-coded in accordance with Attachment 4 of AFM 88-15.
****

Color coding for piping identification is specified in Section 09 90 00 PAINTS AND COATINGS.

2.23.4 Color Coding Scheme

****
NOTE: Color Coding Scheme may be deleted in accordance with Notes in Section 22 00 00 PLUMBING, GENERAL PURPOSE.
****

A color coding scheme for locating hidden piping shall be in accordance with [Section 22 00 00 PLUMBING, GENERAL PURPOSE][Section 22 00 70 PLUMBING, HEALTHCARE FACILITIES].

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, perform verification of dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work. Submit a letter, at least 2 weeks prior to beginning construction, including the date the site was visited, confirmation of existing conditions, and any discrepancies found.

3.2 INSTALLATION

Perform the work in accordance with the manufacturer's published diagrams, recommendations, and equipment warranty requirements. The design, fabrication, and installation of the system shall conform to ASME BPVC SEC VIII D1 and ASME BPVC SEC IX as applicable. Where applicable, perform work in accordance with ASHRAE 15 & 34 and IIAR 2 for ammonia systems.

3.2.1 Equipment

****

NOTE: Determine in the initial stages of design the approximate distances required for maintenance clearances of all new equipment. The maintenance clearances will be used in determining the final layout of the equipment.

****

Equipment shall be properly leveled, aligned, and secured in place in accordance with manufacturer's instructions. Provide necessary supports for all equipment, appurtenances, and pipe as required, including frames or supports for compressors, pumps and similar items. Compressors shall be isolated from the building structure. Isolators shall be selected and sized based on load-bearing requirements and the lowest frequency of vibration to be isolated. Foundation drawings, bolt-setting information, and foundation bolts shall be furnished prior to concrete foundation construction for equipment indicated or required to have concrete foundations. Concrete for foundations shall be as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.2.2 Mechanical Room Ventilation

****

NOTE: For mechanical rooms which are intended to house refrigeration equipment, designers will use ASHRAE 15 & 34 to determine applicable design criteria. Delete this paragraph if a mechanical room is not applicable to the design.

In summary, ASHRAE 15 & 34 allows the use of either natural or mechanical ventilation systems, however natural ventilation is allowed only in certain limited applications. Natural ventilation is allowed only when "a refrigerant system is located outdoors more than 6 m 20 feet from building openings and is enclosed by a penthouse, lean-to or other open structure", otherwise mechanical ventilation is required.

The amount of ventilation air required for a mechanical room will be determined based upon the ventilation equations in ASHRAE 15 & 34. In order to use these equations, a designer must approximate the mass of refrigerant (kgs or lbs) expected in the largest system located in the mechanical room. Refrigerant quantities will be determined based upon a minimum of 2 different system manufacturers.

a. For a natural ventilation system, ASHRAE 15 & 34 provides an equation for sizing the amount of free opening area required.

b. For a mechanical ventilation system, ASHRAE 15 & 34 requires both normal and alarm ventilation. Normal ventilation will be sized to cover personnel ventilation requirements (2.5 1/s/m2 or 0.5 cfm/ft2) and heat buildup requirements if applicable. Alarm ventilation will be sized based upon the equations in ASHRAE 15 & 34. Both the normal and alarm ventilation rates can be achieved using the same ventilation system (e.g., multi-speed exhaust fans), however, individual systems are preferred. For the alarm ventilation, exhaust intakes will be located near the equipment and close to the finished floor. Most commonly used refrigerants are heavier-than-air and subsequently sink to the floor. Also as prescribed in ASHRAE 15 & 34, air supply and exhaust ducts to the mechanical room will serve no other area within a facility. Discharge air from a mechanical ventilation system will be to the outdoors.

****

Mechanical ventilation systems shall be in accordance with Section 23 30 00 HVAC AIR DISTRIBUTION.

3.2.3 Building Surface Penetrations

Sleeves in nonload bearing surfaces shall be galvanized sheet metal, conforming to ASTM A653/A653M, Coating Class G-90, 1 mm (20 gauge) 20 gauge. Sleeves in load bearing surfaces shall be uncoated carbon steel pipe, conforming to ASTM A53/A53M, [Schedule 30][Schedule 20][Standard weight]. Sealants shall be applied to moisture and oil-free surfaces and elastomers to not less than 13 mm 1/2 inch depth. Sleeves shall not be installed in structural members.

3.2.3.1 Refrigerated Space

Refrigerated space building surface penetrations shall be fitted with sleeves fabricated from hand-lay-up or helically wound, fibrous glass reinforced polyester or epoxy resin with a minimum thickness equal to equivalent size Schedule 40 steel pipe. Sleeves shall be constructed with integral collar or cold side shall be fitted with a bonded slip-on flange or extended collar. In the case of masonry penetrations where sleeve is not cast-in, voids shall be filled with latex mixed mortar cast to shape of sleeve, and flange/external collar type sleeve shall be assembled with butyl elastomer vapor barrier sealant through penetration to cold side surface vapor barrier overlap and fastened to surface with masonry anchors. Integral cast-in collar type sleeve shall be flashed [as indicated.] [with not less than 100 mm 4 inches of cold side vapor barrier overlap of sleeve surface.] Normally noninsulated penetrating round surfaces shall be sealed to sleeve bore with mechanically expandable seals in vapor tight manner and remaining warm and cold side sleeve depth shall be insulated with not less than [100][_____] mm [4][_____] inches of foamed-in-place rigid polyurethane or foamed-in-place silicone elastomer. Vapor barrier sealant shall be applied to finish warm side insulation surface. Warm side of penetrating surface shall be insulated beyond vapor

barrier sealed sleeve insulation for a distance which prevents condensation. Wires in refrigerated space surface penetrating conduit shall be sealed with vapor barrier plugs or compound to prevent moisture migration through conduit and condensation therein.

3.2.3.2 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 provide a minimum of 6 mm 1/4 inch 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 07 92 00 JOINT SEALANTS.

3.2.3.3 Waterproof Penetrations

Pipes passing through roof or floor waterproofing membrane shall be installed through a 0.48 kg 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 8 inches from the pipe and shall 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 2 inches 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.

3.2.3.3.1 Waterproof Clamping Flange

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. Waterproofing membrane shall be clamped into place and sealant shall be placed in the caulking recess.

3.2.3.3.2 Modular Mechanical Type Sealing Assembly

In lieu of a waterproof 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 the 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 diameter.

3.2.3.4 Fire-Rated Penetrations

Penetration of fire-rated walls, partitions, and floors shall be sealed as specified in Section 07 84 00 FIRESTOPPING.

3.2.3.5 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.

3.2.4 Access Panels

Access panels shall be provided for 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 08 31 00 ACCESS DOORS AND PANELS.

3.2.5 Refrigeration Piping

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NOTE: For the design of a refrigerant piping system a designer has basically two options:

1) Perform the design of the entire system including pipe sizes and layout/slopes based on guidance from ASHRAE. On the drawings indicate that it will be the Contractor's responsibility to coordinate the pipe sizes and layout/slopes with the equipment and piping configurations to be provided.

2) For small systems (systems with 1 or 2 compressors and 1 or 2 coolers; 1 compressor for each cooler), the designer may elect to show only the individual components and their relative layout or schematic with no pipe sizes or slopes. For these types of systems, it will be the Contractor's responsibility to submit shop drawings and calculations to completely define the entire system based on the equipment to be provided.

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Unless otherwise specified, pipe and fittings installation shall conform to the requirements of ASME B31.5. Pipe shall be cut accurately to the measurements established at the jobsite and worked into place without springing or forcing. Cutting or otherwise weakening of the building structure to facilitate piping installation will not be permitted without written approval. Pipes shall be cut square, shall have burrs removed by reaming, and be installed in a manner to permit free expansion and contraction without damage to joints or hangers. Filings, dust, or dirt shall be wiped from interior of pipe before connections are made.

3.2.5.1 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-sweep bends are formed. The centerline radius of bends shall not be less than 6 diameters of the pipe. Bent pipe showing kinks, wrinkles, or other malformations will not be accepted.

3.2.5.2 Functional Requirements

Piping shall be sloped 13 mm/3 m 1/2 inch/10 feet of pipe in the direction of flow to ensure adequate oil drainage. Open ends of refrigerant lines or equipment shall be properly capped or plugged during installation to keep moisture, dirt, or other foreign material out of the system. Piping shall remain capped until installation. Equipment piping shall be in accordance with the equipment manufacturer's recommendations and the contract drawings.

3.2.5.3 Brazed Joints

Perform brazing in accordance with AWS BRH, 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. Tubing shall be protected against oxidation during brazing by continuous purging of the inside of the piping using nitrogen. Piping shall be supported prior to brazing and shall not be sprung or forced.

3.2.5.4 Threaded Joints

Threaded joints shall be made with tapered threads and made tight with PTFE tape complying with ASTM D3308 or equivalent thread-joint compound applied to the male threads only. Not more than three threads shall show after the joint is made.

3.2.5.5 Welded Joints

Welded joints in steel refrigerant piping shall be fusion welded. Changes in direction of piping shall be made with welded fittings only; mitering or notching pipe or other similar construction to form elbows or tees will not be permitted. Branch connections shall be made with welding tees or forged welding branch outlets. Steel 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 a pressure regulated 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/D1.1M or as recommended by the manufacturer. Electrodes that have been wetted or that have lost any of their coating shall not be used.

3.2.5.6 Flanged Joints

Flanged joints shall be assembled square and tight with matched flanges, gaskets, and bolts. Gaskets shall be suitable for use with the refrigerants to be handled. When steel refrigerant piping is used, union or flange joints shall be provided in each line immediately preceding the connection to each piece of equipment requiring maintenance, such as compressors, coils, refrigeration equipment, control valves, and other similar items.

3.2.5.7 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.

3.2.6 Piping Supports

Refrigerant pipe supports shall conform to ASME B31.5. 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.

3.2.6.1 Seismic Requirements

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NOTE: Provide seismic requirements for piping and related equipment supports , if a Government designer is the Engineer of Record, and show on the drawings. Delete the inappropriate bracketed phrase. Sections 13 48 73 and 23 05 48.19, properly edited, must be included in the contract documents.
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Support and brace piping and attached valves to resist seismic loads [as specified in UFC 3-301-01 and Sections 13 48 73SEISMIC CONTROL FOR MECHANICAL EQUIPMENT[and 23 05 48.19 [SEISMIC] BRACING FOR HVAC]] [as indicated]. Provide structural steel, required for reinforcement, to properly support piping, headers, and equipment but not shown. Material used for support shall be as specified in Section 05 12 00 STRUCTURAL STEEL.

3.2.6.2 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. Material used for support shall be as specified in Section 05 12 00 STRUCTURAL STEEL.

3.2.7 Pipe Hangers, Inserts, and Supports

Pipe hangers, inserts, and supports shall conform to MSS SP-58, except as modified herein. Pipe hanger types 5, 12, and 26 shall not be used.

3.2.7.1 Hangers

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

3.2.7.2 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.

3.2.7.3 C-Clamps

Type 19 and 23 C-clamps shall be torqued in accordance with MSS SP-58 and have both locknuts and retaining devices, furnished by the manufacturer. Field-fabricated C-clamp bodies or retaining devices are not acceptable.

3.2.7.4 Angle Attachments

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

3.2.7.5 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 60 degrees F 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 60 degrees F. A high density insulation insert of cellular glass shall be used under the Type 40 shield for piping 50 mm 2 inches and larger.

3.2.7.6 Horizontal Pipe Supports

Horizontal pipe supports shall be spaced as specified in MSS SP-58. A support shall be installed not over 300 mm 12 inches from the pipe fitting joint at each change in direction of the piping. Pipe supports shall be spaced not over 1525 mm 5 feet apart at valves. Pipe hanger loads suspended from steel joist with hanger loads between panel points in excess of 23 kg 50 pounds shall have the excess hanger loads suspended from panel points.

3.2.7.7 Vertical Pipe Supports

Vertical pipe shall be supported at each floor, except at slab-on-grade, and at intervals of not more than 4570 mm 15 feet, not more than 2440 mm 8 feet from end of risers, and at vent terminations.

3.2.7.8 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.

3.2.7.9 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.

3.2.7.10 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 4 inches, or by an amount adequate for the insulation, whichever is greater.

3.2.7.11 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.

3.2.8 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 1525 mm 5 feet on each side of each expansion joint, and in lines 100 mm 4 inches or smaller not more than 610 mm 2 feet on each side of the joint.

3.2.9 Pipe Anchors

Provide anchors 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.

3.2.10 Piping Identification

Each piping system and direction of fluid flow shall be identified in accordance with applicable provisions of ASME A13.1 with color coded, water, moisture and broad-spectrum temperature resistant, plastic labels.

3.2.11 Manual Valves

Install stop valves on each side of each piece of equipment such as compressors, condensers, evaporators, receivers, and other similar items in multiple-unit installation, to provide partial system isolation as required for maintenance or repair. Angle and globe valves shall be installed with stems horizontal unless otherwise indicated. Ball valves shall be installed with stems positioned to facilitate operation and maintenance. Isolating valves for pressure gauges and switches shall be external to thermal insulation. Safety switches shall not be fitted with isolation valves. Thermal wells for insertion thermometers and thermostats shall extend beyond thermal insulation surface not less than 25 mm 1 inch. Filter dryers having access ports may be considered a point of isolation. Purge valves shall be provided at all points of systems where accumulated noncondensable gases would prevent proper system

operation. Valves shall be furnished to match line size, unless otherwise indicated or approved. Drain valves shall be provided in bottom of risers and low points of ammonia piping.

3.2.12 Expansion Valves

Expansion valves shall be installed with the thermostatic expansion valve bulb located on top of the suction line when the suction line is less than 50 mm 2 inches in diameter and at the 4 o'clock or 8 o'clock position on lines larger than 50 mm 2 inches. The bulb shall be securely fastened with two clamps. The bulb shall be insulated. The bulb shall be installed in a horizontal portion of the suction line, if possible, with the pigtail on the bottom. If the bulb is installed in a vertical line, the bulb tubing shall be facing up.

3.2.13 Valve Identification

Each system valve, including those which are part of a factory assembly, shall be tagged. Tags shall be in alphanumeric sequence, progressing in direction of fluid flow. Tags shall be embossed, engraved, or stamped plastic or nonferrous metal of various shapes, sized approximately 35 mm 1-3/8 inch diameter, or equivalent dimension, substantially attached to a component or immediately adjacent thereto. Tags shall be attached with nonferrous, heavy duty, bead or link chain, 14 gauge 14 gauge annealed wire, nylon cable bands or as approved. Tag numbers shall be referenced in Operation and Maintenance Manuals and system diagrams.

3.2.14 Strainers

Strainers shall be provided immediately ahead of solenoid valves and expansion devices and where indicated. Strainers may be an integral part of the expansion valve.

3.2.15 Filter Dryer

A liquid line filter dryer shall be provided on each refrigerant circuit located so that all liquid refrigerant passes through a filter dryer. Dryers shall be sized in accordance with the manufacturer's recommendations. A dryer shall be installed so that it can be isolated from the system, the isolated portion of the system evacuated, and the filter dryer replaced. Dryers shall be installed in the horizontal position except replaceable core filter dryers may be installed in the vertical position with the access flange on the bottom.

3.2.16 Sight Glass

A moisture indicating sight glass shall be installed in refrigerant circuits down stream of filter dryers and where indicated. Sight glass shall be full line size.

3.2.17 Thermometers

Thermometers shall be fitted with thermal well. Mercury shall not be used in thermometers. Where test thermometer locations are indicated, only plugged thermal well shall be provided. Thermometers located within 1525 mm 5 feet of floor may be rigid stem type. Where thermal well is located above 1525 mm 5 feetabove floor, thermometer shall be universal adjustable angle type or remote element type to 2135 mm 7 feet above floor and remote element type where thermal well is 2135 mm 7 feet or more above floor.

Thermometers shall be located in coolant supply and return or waste lines at each heat exchanger, at each automatic temperature control device without an integral thermometer, refrigerant liquid line leaving receiver, refrigerant suction line at each unit cooler, and where indicated or required for proper operation of equipment.

3.2.18 Flexible Connectors

Flexible metallic connectors shall be installed perpendicular to line of motion being isolated. Piping for equipment with bidirectional motion shall be fitted with two flexible connectors, in perpendicular planes. Reinforced elastomer flexible connectors shall be installed in accordance with manufacturer's instructions. Piping guides and restraints related to flexible connectors shall be provided as required. Connectors shall be provided in the suction and discharge lines on spring mounted compressors. Connectors shall be anchored firmly at the upstream end on the suction line and the downstream end in the discharge line.

3.2.19 Power Transmission Components Adjustment

V-belts and sheaves shall be properly aligned and tensioned preliminary to operation and after 72 hours of operation at final speed. Belts on drive side shall be uniformly loaded, not bouncing. Alignment of direct-drive couplings shall be to within 50 percent of manufacturer's maximum allowable range of misalignment.

3.2.20 Unit Cooler Drainage

Drain lines from product storage spaces maintained at 2 degrees C 35 degrees F or lower shall be fitted with NSF approved connections and cleanout tee; shall be short as possible; shall not be trapped; and shall not be combined, unless all combined units are defrosted simultaneously and are controlled by a single timer. Drain lines may be combined in spaces maintained at nonfreezing temperatures after individual trapping. Drain lines shall be heat traced and insulated starting with drain pan fitting through the surface penetration into a nonfreezing space, a distance sufficient to ensure freedom from ice during defrost cycle. Drain line size shall be not less than drain pan outlet size. Drain line shall be pitched as shown, and not less than 6 mm/300 mm 1/4 inch/foot where not shown. Drain line heat tracing shall be[electric][and][hot gas] as indicated.[Hot gas supply line to the unit cooler shall be routed in contact with the drain line by banding with all stainless steel worm drive hose clamps on not more than 300 mm 12 inch centers and heat transfer area shall be increased by continuous tangential fillets of heat conducting paste.][Electrically heat traced drain lines shall utilize external or internal to drain line heating elements, applied to produce watt-density and temperature recommended by the manufacturer. Where metallic sheathed heat tracer is used in contact with metallic drain line or internal thereto, sheath material shall be stainless steel. External metallic sheathing shall be installed by banding on not more than 300 mm 12 inch centers with all stainless steel worm drive hose clamps and heat transfer area shall be increased by continuous tangential fillets of heat conducting paste. Electric heat tracing power supply shall be as indicated.]

3.2.21 Field Applied Insulation

Field applied insulation shall be as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

3.2.22 Factory Applied Insulation

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NOTE: Include or delete items requiring factory applied insulation as applicable.

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Suction headers, liquid receivers, oil separators, and oil reservoirs shall be insulated with not less than 19 mm 3/4 inch thick unicellular plastic foam as a standard manufacturer's process.

3.2.23 Framed Instructions

Submit framed instructions for posting, at least 2 weeks prior to construction completion. Framed instructions shall be framed under glass or laminated plastic and posted where directed. Instructions shall include 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 instructions shall be posted before acceptance testing of the system.

3.3 TESTS

Submit a letter, at least [10] [_____] working days in advance of each test, advising the Contracting Officer of the test. Submit individual letters for the refrigerant system, the system performance, and the acceptance tests. Each letter shall identify the date, time, and location for each test. Conduct tests in the presence of the Contracting Officer. Utilities for testing shall be provided as specified in the SPECIAL CONTRACT REQUIREMENTS. Water and electricity required for the tests will be furnished by the Government. Provide material, equipment, instruments, and personnel required for the test.

a. The services of a qualified technician shall be provided as required to perform tests and procedures indicated. Field tests shall be coordinated with Section 23 05 93 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS.

b. Submit [6] [_____] copies of each test containing the information described below in bound 216 by 279 mm 8-1/2 by 11 inch booklets. Submit individual reports for the refrigerant system, the system performance, and the acceptance tests.

   (1) The dates the tests were started and completed.
   (2) A list of equipment used, with calibration certifications.
   (3) Initial test summaries.
   (4) Repairs/adjustments performed.
   (5) Final test results and comments.

3.3.1 Refrigerant System

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NOTE: Where applicable condensing temperature is over 55 degrees C 130 degrees F, equipment and piping will be capable of withstanding leak pressure tests at not less than the design pressure

corresponding to the condensing pressure during the higher ambient conditions. (Refer to ASHRAE 15 & 34.)
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After all components of the refrigerant system have been installed and connected, the entire refrigeration system shall be subjected to a pneumatic test as specified.

3.3.1.1 Preliminary Procedures

Prior to pneumatic testing, equipment which has been factory tested and refrigerant charged as well as equipment which could be damaged or cause personnel injury by imposed test pressure, positive or negative, shall be isolated from the test pressure or removed from the system. Safety relief valves and rupture discs, where not part of factory sealed systems, shall be removed and openings capped or plugged.

3.3.1.2 Pneumatic Test

Pressure control and excess pressure protection shall be provided at the source of test pressure. Valves shall be wide open, except those leading to the atmosphere. Test gas shall be dry nitrogen, with minus 56.7 degrees C minus 70 degree F dewpoint and less than 5 ppm oil. Test pressure shall be applied in two stages before any refrigerant pipe is insulated or covered. First stage test shall be at 69 kPa 10 psig with every joint being tested with a thick soap or color indicating solution. Second stage tests shall raise the system to the minimum refrigerant leakage test pressure specified in ASHRAE 15 & 34 or IIAR 2 with a maximum test pressure of 25 percent greater than specified. Ammonia unloading lines shall be tested at 2415 kPa 350 psig. Pressure above 690 kPa 100 psigshall be raised in 10 percent increments with a pressure acclimatizing period between increments. The initial test pressure shall be recorded along with the ambient temperature to which the system is exposed. Final test pressures of the second stage shall be maintained on the system for a minimum of 24 hours. At the end of the 24 hour period, the system pressure shall be recorded along with the ambient temperature to which the system is exposed. A correction factor of 2 kPa 0.3 psi will be allowed for each degree change between test space initial and final ambient temperature, plus for increase and minus for a decrease. If the corrected system pressure is not exactly equal to the initial system test pressure, the system shall be investigated for leaking joints. To repair leaks, the joint shall be taken apart, thoroughly cleaned, and reconstructed as a new joint. Joints repaired by caulking, remelting, or back-welding/brazing will not be acceptable. Following repair, the entire system shall be retested using the pneumatic tests described above. The entire system shall be reassembled once the pneumatic tests are satisfactorily completed.

3.3.1.3 Evacuation Test

Following satisfactory completion of the pneumatic tests, the pressure shall be relieved and the entire system shall be evacuated to an absolute pressure of 300 microns. During evacuation of the system, the ambient temperature shall be higher than 2 degrees C 35 degrees F. No more than one system shall be evacuated at one time by one vacuum pump. Once the desired vacuum has been reached, the vacuum line shall be closed and the system shall stand for 1 hour. If the pressure rises over 500 microns after the 1 hour period, the system shall be evacuated again down to 300 microns and let set for another 1 hour period. The system shall not be

charged until a vacuum of at least 500 microns is maintained for a period of 1 hour without the assistance of a vacuum line. If, during the testing, the pressure continues to rise, the system shall be checked for leaks, repaired as required, and the evacuation procedure repeated. During evacuation, pressures shall be recorded by a thermocouple type, electronic type, or a calibrated-micron type gauge.

3.3.1.4 System Charging and Startup Test

Following satisfactory completion of the evacuation tests, the system shall be charged with the required amount of refrigerant by raising pressure to normal operating pressure, and in accordance with manufacturer's procedures. Following charging, the system shall operate with high-side and low-side pressures and corresponding refrigerant temperatures, at design or improved values. The entire system shall be tested for leaks. Fluorocarbon systems shall be tested with halide torch or electronic leak detectors. Ammonia systems shall be tested with sulphur tapers. When charging and testing with ammonia under pressure, gas masks shall be provided.

3.3.1.5 Refrigerant Leakage

If a refrigerant leak is discovered after the system has been charged, the leaking portion of the system shall immediately be isolated from the remainder of the system and the refrigerant pumped into the system receiver or other suitable container. The refrigerant shall not be discharged into the atmosphere.

3.3.1.6 Contractor's Responsibility

Take steps to prevent the release of refrigerants into the atmosphere at all times during the installation and testing of the refrigeration system. The steps shall include, but not be limited to, procedures which will minimize the release of refrigerants to the atmosphere and the use of refrigerant recovery devices to remove refrigerant from the system and store the refrigerant for reuse or reclaim. No more than 85 grams 3 ounces of refrigerant shall be released to the atmosphere in any one occurrence. System leaks within the first year shall be repaired in accordance with the requirements herein at no cost to the Government, including material, labor, and refrigerant, if the leak is the result of defective equipment, material, or installation.

3.3.2 System Performance

After the foregoing tests have been completed and 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 startup representative experienced in system startup and testing, at such times as directed. Tests shall cover a period of not less than [_____] days for each system and 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. Any refrigerant lost during the system startup shall be replaced. During the system performance tests, a report shall be maintained to document compliance with the specified performance criteria upon completion and testing of the system. The report shall include the following information at a minimum 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) Ambient, condensing and coolant temperatures.
   (5) Running current, voltage and proper phase sequence for each phase of all motors.

c. The actual onsite setting of operating and safety controls.

d. Thermostatic expansion valve superheat-value as determined by field test.

e. Subcooling.

f. High and low refrigerant temperature switch set-points.

g. Low oil pressure switch set-point.

h. Defrost system timer and thermostat set-points.

i. Moisture content.

j. Capacity control set-points.

k. Field data and adjustments which affect unit performance and energy consumption.

l. Field adjustments and settings which were not permanently marked as an integral part of a device.

3.4 DEMONSTRATIONS

Conduct demonstrations for the operating staff as designated by the Contracting Officer. Submit a letter, at least 14 working days prior to the date of the proposed demonstrations, identifying the date, time, and location for the demonstrations which shall start after the system is functionally completed but prior to final acceptance tests. Demonstrations shall be under the direction of a registered professional engineer who shall attest to installed systems and equipment compliance with the requirements of the contract documents. Demonstrations shall include operation of systems equipment and controls through normal ranges and sequences and simulation of abnormal conditions. Each device shall be caused to function manually and automatically in accordance with its purpose. The field instructions shall cover the items contained in the Operation and Maintenance Manuals as well as demonstrations of routine maintenance operations.

3.5 ACCEPTANCE TESTS

Upon completion and prior to acceptance of the work, perform pre-operational checkout, calibration and adjustment of system components to ensure and demonstrate stable, accurate, reproducible, energy efficient operation and optimum performance. Operate systems for [48][_____] hours after all major corrections have been made. If tests do not demonstrate

satisfactory system performance, deficiencies shall be corrected and system shall be retested. Prior to acceptance, service valve seal caps and blanks over gauge points shall be installed and tightened.

3.6 FIELD PAINTING

Painting required for surfaces not otherwise specified, and finish painting of items only primed at the factory are specified in Section 09 90 00 PAINTS AND COATINGS.

3.7 CLEANING AND ADJUSTING

Equipment shall be wiped clean, with all traces of oil, dust, dirt, or paint spots removed. 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.

-- End of Section --