
USACE / NAVFAC / AFCEA / NASA UFGS-42 22 13 (August 2008)

Preparing Activity: NASA Superseding
UFGS-42 22 13.00 40 (April 2008)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated April 2009

SECTION TABLE OF CONTENTS

DIVISION 42 - PROCESS HEATING, COOLING, AND DRYING EQUIPMENT

SECTION 42 22 13

CENTRIFUGAL PROCESS CHILLERS AND COOLERS

08/08

PART 1 GENERAL

- 1.1 REFERENCES
- 1.2 SUBMITTALS
- 1.3 GENERAL REQUIREMENTS

PART 2 PRODUCTS

- 2.1 CENTRIFUGAL WATER-CHILLER PACKAGE
- 2.2 COMPRESSOR
- 2.3 CONDENSER
- 2.4 COOLER (REFRIGERANT EVAPORATOR)
- 2.5 PURGE SYSTEM
- 2.6 CONTROL AND CONTROL PANELS
- 2.7 MOTORS
- 2.8 INSULATION
- 2.9 VIBRATION ISOLATION
- 2.10 SPECIAL TOOLS

PART 3 EXECUTION

- 3.1 INSTALLATION
- 3.2 MANUFACTURER'S REPRESENTATIVE
- 3.3 REFRIGERANT AND OIL CHARGE
- 3.4 ALIGNMENT
- 3.5 FIELD TESTING

-- End of Section Table of Contents --

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CENTRIFUGAL PROCESS CHILLERS AND COOLERS 08/08

NOTE: This specification covers the requirements for packaged self-contained hermetic compressor units. Rewrite if unit is not self-contained per definition.

Drawings or schedule shall include capacity, capacity conditions, pressure drops, control diagrams, and refrigerant used.

Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable items(s) or insert appropriate information.

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

Comments and suggestions on this guide specification are welcome and should be directed to the technical proponent of the specification. A listing of technical proponents, including their organization designation and telephone number, is on the Internet.

Submit recommended changes to a UFGS as a Criteria Change Request (CCR).

PART 1 GENERAL

1.1 REFERENCES

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 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 480 (2007) Standard for Refrigerant-Cooled Liquid Coolers, Remote Type
- AHRI 520 (2004) Performance Rating of Positive Displacement Condensing Units
- AHRI 550/590 (2003) Standard for Water-Chilling Packages Using the Vapor Compression Cycle

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

- ASHRAE EQUIP SI HDBK (2004) Handbook, HVAC Systems and Equipment (SI Edition)

ASME INTERNATIONAL (ASME)

- ASME BPVC SEC VIII D1 (2007; Addenda 2008) Boiler and Pressure Vessel Code; Section VIII, Pressure Vessels Division 1 - Basic Coverage

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

- ISO 1940-1 (2003; Corrigendum 2005) Mechanical Vibration - Balance Quality Requirements for Rotors in a Constant (Rigid) State - Part 1: Specification and Verification of Balance Tolerance - International Restrictions

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

- NEMA 250 (2008) Enclosures for Electrical Equipment (1000 Volts Maximum)
- NEMA MG 1 (2007; Errata 2008) Standard for Motors and Generators

U.S. DEPARTMENT OF ENERGY (DOE)

- DOE CE-2 (2000) How to Buy an Energy-Efficient Water-Cooled Electric Chiller

1.2 SUBMITTALS

NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project. Keep submittals to the minimum required for adequate quality control.

A "G" following a submittal item indicates that the submittal requires Government approval. Some submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation 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.

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

SD-01 Preconstruction Submittals

Submit [Material, Equipment, and Fixture Lists](#) for centrifugal chiller systems in accordance with paragraph entitled, "General Requirements," of this section.

SD-02 Shop Drawings

Submit connection diagrams indicating the relations and connections of the following items. Drawings shall indicate the physical layout of all controls, and internal tubing and wiring details.

Centrifugal Water Chiller
Compressor
Condenser
Cooler
Purge System
Motors
Control and Control Panels

Submit [Control Diagrams](#) for centrifugal chiller units in accordance with paragraph entitled, "General Requirements," of this section.

Submit installation drawings for centrifugal chiller systems in accordance with the paragraph entitled, "Installation," of this section. Drawings shall indicate overall physical features, dimensions, ratings, service requirements, and equipment weights.

Submit [Record Drawings](#) for centrifugal chiller units in accordance with paragraph entitled, "General Requirements," of this section.

SD-03 Product Data

Submit [Equipment Foundation Data](#) for the following items in accordance with paragraph entitled, "General Requirements," of this section.

Centrifugal Water Chiller
Compressor
Condenser
Cooler
Purge System
Motors

Submit [Equipment and Performance Data](#) for centrifugal water chillers in accordance with paragraph entitled, "General Requirements," of this section.

Submit manufacturer's catalog data for the following items:

Centrifugal Water Chiller
Compressor
Condenser
Cooler
Purge System
Motors
Control and Control Panels
Insulation
Vibration Isolation
Special Tools
Spare Parts

SD-04 Samples

Submit [Manufacturer's Standard Color Chart](#) in accordance with paragraph entitled, "General Requirements," of this section.

SD-05 Design Data

Submit [Design Analysis and Calculations](#) in accordance with paragraph entitled, "General Requirements," of this section.

SD-06 Test Reports

Submit [Test Reports](#) for chiller units indicating the results of performance tests performed in accordance with the paragraph entitled, "Field Testing," of this section.

SD-07 Certificates

Submit [Listing of Product Installation](#) for centrifugal chiller units in accordance with paragraph entitled, "Installation," of this section.

Submit certificates for following items showing conformance with the referenced standards contained in this section.

[Centrifugal Water Chiller](#)
[Compressor](#)
[Condenser](#)
[Cooler](#)
[Purge System](#)
[Motors](#)
[Control and Control Panels](#)
[Insulation](#)
[Vibration Isolation](#)
[Special Tools](#)
[Spare Parts](#)

SD-10 Operation and Maintenance Data

Submit [Operation and Maintenance Manuals](#) in accordance with paragraph entitled, "Manufacturer's Representative," of this section.

1.3 GENERAL REQUIREMENTS

NOTE: If Section [23 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEMS](#) is not included in the project specification, applicable requirements therefrom should be inserted and the following paragraph deleted. If Section [23 05 48 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT](#) is not included in the project specification, applicable requirements therefrom should be inserted and the second paragraph deleted. If Section [26 60 13.00 40 LOW-VOLTAGE MOTORS](#) is not included in the project specification, applicable requirements therefrom should be inserted and the third paragraph deleted.

[Section [23 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEMS](#) applies to work specified in this section.]

[Section [23 05 48 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT](#) applies to work specified in this section.]

[Section 26 60 13.00 40 LOW-VOLTAGE MOTORS applies to this section.]

Submit [Control Diagrams](#) for centrifugal chiller units showing the physical and functional relationship of equipment. Electrical diagrams shall show the size, type, and capacity of the system.

Submit [Record Drawings](#) for centrifugal chiller units providing current factual information including deviations from, and amendments to, the drawings and concealed and visible changes in the work.

Submit [Material, Equipment, and Fixture Lists](#) for centrifugal chiller systems including manufacturer's style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site information.

Submit [Equipment and Performance Data](#) for centrifugal water chillers indicating the guaranteed maximum brake power at 75-, 50-, 25-, and 10-percent points of full compressor capacity at design condenser water temperature. Develop this information from data specified herein.

Submit [Equipment Foundation Data](#) including equipment weight and operating loads, location and projection of anchor bolts, and horizontal and vertical clearances for installation, operation, and maintenance. Data shall also include dimensions of foundations and relative elevations, and installation requirements such as noise abatement, vibration isolation, and utility services.

[Manufacturer's Standard Color Chart](#) shall indicate the manufacturer's standard color selections and finishes for chiller units.

Submit [Design Analysis and Calculations](#) for centrifugal chillers indicating the manufacturer's recommended power ratings, rotational speeds, and piston speeds.

PART 2 PRODUCTS

NOTE: Pump and Motor balance shall conform to ISO 1940-1 - (1986) Balance Quality Requirements of Rigid Rotors - Determination of Permissible Residual Unbalance unless otherwise noted. Motor vibration levels shall conform to NEMA Specification MG-1, Motors and Generators, Part 7 unless otherwise noted.

NOTE: All rotating machinery shall be capable of having shaft alignment and machine balance following installation. This requirement shall include "skid-mounted" and "self-contained" units.

NOTE: Balance is the process of improving the mass distribution of the pump components in order to minimize damaging centrifugal forces. No component can be perfectly balanced. There will always be some remaining unbalance. The minimum recommended

balance grade is ISO grade 2.5. Select an ISO grade or insert a standard.

2.1 CENTRIFUGAL WATER-CHILLER PACKAGE

Ensure centrifugal water-chiller assembly is packaged and self-contained, and includes compressor-condenser, cooler (refrigerant evaporator) accessories, control panel, and intercomponent piping and wiring ready for field-terminal connections.

Unit and spare parts shall conform to the applicable requirements of AHRI 550/590, AHRI 480, and specified requirements. Energy efficiency ratings shall meet or exceed the full-load efficiency and the integrated part-load value (IPLV) efficiency ratings as described in AHRI 550/590 and the recommended levels specified in DOE CE-2 and DOE CE-6.

2.2 COMPRESSOR

NOTE: At higher than 3,600 rpm speeds, reevaluate 0.025 millimeter vibration limit. Do not use compressor that will operate at 20,000 or higher rpm.

Compressor shall be [single] [multistage], [direct] [gear-driven] centrifugal type, with hermetically sealed, compressor-motor assembly. Motor windings shall be [refrigerant] [water-cooled]. Rotor assembly shall be statically and dynamically balanced to ISO 1940-1 -1986, [G6.3] [G2.5] [G1.0] [_____]. Shaft main bearings shall be replaceable sleeve-insert type.

Lubrication system shall be of the forced-feed type with oil sump, hermetically sealed motor-driven positive displacement pump, oil filter, and strainer. Oil temperature shall be thermostatically controlled. Provide a mechanically operated oil supply to the bearings during spin down in event of power interruption. A differential oil-pressure cutout shall be interlocked with starting equipment and shall allow the compressor to operate only when the required oil pressure is available at the bearings.

Provide compressor with temperature-actuated capacity reduction and of the multiple radial blade or butterfly-damper type Variable Frequency Drive (VFD) compressor motor control to provide automatic capacity regulation from 100 percent to 10 percent of capacity. Provide automatic hot-gas bypass if required to maintain stable operation. Control system shall include automatic stopping, when load falls below 10 percent capacity point, and automatic unloaded restarting on load demand. Capacity modulation shall be controlled by the temperature of the water leaving the cooler. Unit controller shall be able to maintain leaving-water temperature at plus or minus 0.25 degrees C 0.5 degree F of the set point.

2.3 CONDENSER

Condenser shall be of the shell-and-tube cleanable-type construction. Condenser shall comply with ASHRAE EQUIP SI HDBK, Chapter 13, and ASME BPVC SEC VIII D1 regarding quality of materials used, methods of construction, design of components, and testing of materials, assemblies, connections, and appurtenances. Minimum water-side working pressure shall be 1050 kilopascal 150 psig, and minimum refrigerant-side working pressure

shall be saturation pressure of refrigerant used at 29 degrees C 85 degrees F. Spaces not subject to ASME code due to size or other limitations shall be pneumatically tested at 1-1/2 times working pressure or 310 kilopascal 45 psig, whichever is greater.

Tubes shall be seamless copper tubing with integral fins and individually removable from either end of shell. Tubes shall be rolled or brazed into tube sheet. Provide intermediate tube supports so that distance between supports does not exceed approximately 900 millimeter 3 feet. Supports shall be fitted to the tubes in a manner that will preclude corrosion, vibration, and abrasion.

Fit and arrange water boxes or removable elbows to permit cleaning of tubes without disturbing piping beyond elbows. Elbows shall be flanged- or grooved-coupling type. End bells shall be hinged-mounted.

NOTE: R-12 is designated as a restricted material.
Use available substitutes as apply to specifier's
application. CFC's shall be phased out. No new
designs using CFC's allowed.

Design the unit to permit pump-down and isolation of the entire refrigerant charge within 80 percent of available condenser volume. If the unit condenser does not have sufficient pump-down capacity, provide a separate pump-out tank.

NOTE: Many present-day nonchromate water treatment
chemicals degrade at temperatures as low as 100 to
135 degrees F 38 to 57 degrees C and tend to
severely foul heat-transfer surfaces. The
difference between a fouling factor of 0.0005 and
0.001 could approximate 7 percent of machine
capacity. Cost of unit with 0.001 fouling factor
will be higher and may be restrictive.

Limiting water velocity to 2 meter per second 7 feet
per second (fps) could force selection of next
larger size machine.

Tube protectors are usually required at velocities
in excess of 2 meter per second 7 fps.

Select one of the following two paragraphs.
Normally, select the first paragraph.

Base the condenser performance on a maximum water velocity of 3 meter per second 10 feet per second (fps) and a fouling factor of 0.001. Design and construction provisions shall preclude tube failure due to erosion.

Base the condenser performance on a maximum water velocity of 2 meter per second 7 fps and a fouling factor of 0.001.

2.4 COOLER (REFRIGERANT EVAPORATOR)

Cooler shall conform to the requirements specified herein in paragraph

entitled, "Condenser," and the following:

Base the cooler capacity on refrigerant suction temperature in excess of 0 degrees C 32 degrees F and a fouling factor of 0.0005.

Provide a frangible safety relief device. Device to be piped to building exterior.

2.5 PURGE SYSTEM

NOTE: R-11 and R-113 are restricted materials.
Purge system applies only to existing units and
modifications. An available substitute should be
found and incorporated immediately.

When HCFC-123 refrigerant is used, provide and connect a high efficiency purge system to the main refrigeration system. When in operation, the purge system shall function to automatically remove air, water vapor, and noncondensable gases from the refrigeration system and to condense, separate, and return to the system any refrigerant present therein. Purge system shall be manually or automatically started and stopped and shall be assembled as a compact unit. Purge system shall be complete with operating and safety devices and with an oil separator if recommended by the manufacturer. When a positive-pressure refrigerant is used by the manufacturer in the basic liquid chiller unit, a purge system will not be required. Units shall purge no more than 0.045 kg 0.1 pounds of non-condensable.

2.6 CONTROL AND CONTROL PANELS

NOTE: Select the following paragraph only after
checking control panel sizes and numbers to be sure
they can be unit mounted. Some or all starters may
be mounted in motor control center and unit will not
be totally self-contained.

Coordinate with Section 23 09 33.00 40 ELECTRIC AND
ELECTRONIC CONTROL SYSTEM FOR HVAC and electrical
requirements.

Provide water-chilling unit with one or more control panels containing safety and operating devices and intercomponent piping and wiring for field terminal connection and fully automatic operation.

Coordinate the controls with automatic temperature controls systems and electrical work specified and indicated. Control panel shall contain control equipment specified, and control equipment normally furnished and recommended by the manufacturer for optimum operation of the system. Control panel items shall be permanently identified, including at least the following:

NOTE: The following are manufacturer's standard
items. If the last two listed items, motor
controllers and NEMA 1 enclosures, are specified

elsewhere, delete from this paragraph.

Refrigerant suction and discharge pressure gages

Oil-pressure gages

Purge-drum pressure gage

Refrigerant low-temperature or low-pressure cutout

Refrigerant high-pressure cutout

Time delay relays

Motor high-temperature cutout

Lubricating-oil high-temperature cutout if required by equipment

Oil differential-pressure interlock

Interlock relays and reset button

Manual/automatic selector switches and controls for purge pumps

Pilot lights indicating position of safety controls

System start/stop provisions with condition-indicating lights

Load-limiting device to operate capacity-control mechanism

Cooler refrigerant thermometer with well

Main circuit protective and interruptive device

Transformers for any other source-voltage requirements

Terminals for field-installed equipment

Motor controllers

NEMA 250, Type 1 enclosures

Provide the following items as part of the installation:

NOTE: Coordinate with drawings. Select, delete, or supplement. These are normally field-installed by the Contractor.

Audible-alarm bell, 100 millimeter 4-inch diameter

Chilled-water and condenser supply-and-return thermometers with wells

Indicating-type chilled-water thermostat with well

Chilled-water low-temperature cutout

2.7 MOTORS

Hermetically sealed motors shall conform to NEMA MG 1 AHRI 520 and to requirements for motors as specified herein.

Bearings shall be [oil-lubricated, replaceable-sleeve, insertable type] [permanently lubricated, rolling element type].

NOTE: Normally delete the following paragraph.
Review. Limit percent of full-load amperes at which
motor controller overload will trip (105 percent,
trane), gas pressure differential, pumps, sprays,
unit capacity, or other. Coordinate with motor
controller specification and drawings.

Motor shall have two manually resettable thermal-overload protective devices located within windings.

NOTE: Coordinate the following with the following
motor controller specification and drawings.
Rewrite as necessary to suit designed size and type
equipment.

If water-chilled unit or any component could be damaged by reverse motor operation, and when proposed water-chiller unit contains a mechanically driven lubricating-oil pump, the manufacturer's responsibility shall include:

Providing reverse-phase rotation protection, if motor controllers are provided as part of package.

Indicating in shop drawings that reverse-phase rotation protection is necessary if motor controllers are in a motor-control center not provided by the manufacturer.

2.8 INSULATION

NOTE: Select the following paragraphs only when
specified equipment is to be provided with factory
insulation. Normally provide for field insulation
of cooler headers.

Cooler shell and suction piping between evaporator and first stage of each compressor unit shall be insulated and vapor-sealed. Insulate the water boxes to provide for ease of access to heads for inspection and repair. Where motors are the gas-cooled type, provide insulation and vapor seal on the cold-gas inlet connection to the motor.

Vapor-seal material shall be manufacturer's standard color elastomeric unicellular foam of 25 millimeter 1 inch minimum thickness to preclude condensation of ambient moisture on any surface under site-operating conditions. If unicellular material is black or is otherwise coated, only use polyvinylchloride lacquer for coating. Remove and replace any coating

that cracks when unicellular material is compressed with specified coating at no additional expense to the Government.

2.9 VIBRATION ISOLATION

Vibration isolation provisions shall conform to requirements specified in Section 23 05 48 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT.

2.10 SPECIAL TOOLS

One complete set of special tools, as recommended by the manufacturer, shall be provided for field maintenance of the system. Tools shall be contained in a locked toolbox. Provide two keys to the Contracting Officer.

PART 3 EXECUTION

3.1 INSTALLATION

Install equipment as specified, and in accordance with manufacturer's recommendations.

Submit Listing of Product Installation for centrifugal chiller units showing at least 5 installed units, similar to those proposed for use, that have been in successful service for a minimum period of 5 years. List shall include purchaser, address of installation, service organization, and date of installation.

3.2 MANUFACTURER'S REPRESENTATIVE

Services of a competent factory-trained representative shall be provided to supervise the assembly, charging, testing, and startup of equipment; in addition, Government personnel shall receive 8 hours of instructions in proper operation and maintenance procedures. A factory performance test will be conducted on every chiller in accordance with AHRI 550/590. Test will be witnessed by Government and Contractor.

Contractor shall submit [6] [_____] copies of the Operation and Maintenance Manuals 30 calendar days prior to testing the centrifugal chiller system. Update and resubmit data for final approval no later than 30 calendar days prior to contract completion.

3.3 REFRIGERANT AND OIL CHARGE

Completely charge unit(s) with refrigerant and oil before operation.

3.4 ALIGNMENT

Before attempting alignment, the contractor will demonstrate that the pump does not have any load/force imposed by the piping system. Minimum alignment values (below) are for pump and driver at normal running temperatures. Ensure values are compensated for thermal growth. Ensure limited movement of the pump or driver (commonly known as bolt-bound) is corrected to ensure alignment capability. Hold down bolts shall not be undercut in order to perform adjustment.

Shims shall be commercially die-cut, without seams or folds, and be made of corrosion resistant stainless steel. Use no more than four shims at any single point.

Units with drive motor over [7.5][10][15][20][25] hp shall have alignment jack bolts installed.

Pump and driver may have an intermediate shaft, spacer, or spool piece (sometimes called a jackshaft) Based on the motor nominal operating speed, the Pump and driver shall be aligned to the following minimum specifications:

Speed(RPM)	Close-Coupled Offset (mils)	Close-Coupled Angle(mils/in.)	Spool Piece Angle (mils/in. @ coupling pt.)
600	6.0	2.0	3.0
900	5.0	1.5	2.0
1200	4.0	1.0	1.5
1800	3.0	0.5	1.0
3600	1.5	0.4	0.5
7200	1.0	0.3	0.4

Perform pump alignment under the direction of the manufacturer's representative.

Provide final alignment settings as part of the final test data.

3.5 FIELD TESTING

Prior to final acceptance, vibration analysis shall verify pump and motor conformance to specifications. Vibration levels shall not be more than .075 in/sec at 1 times run speed and at pump frequency, and .04 in/sec at other multiples of run speed.

Contractor shall use an Fast Fourier Transformer (FFT) analyzer to measure vibration levels. It shall have the following characteristics: A dynamic range greater than 70 dB; a minimum of 400 line resolution; a frequency response range of 5 Hz-10 KHz(300-600000 cpm); the capacity to perform ensemble averaging, the capability to use a Hanning window; auto-ranging frequency amplitude; a minimum amplitude accuracy over the selected frequency range of plus or minus 20 percent or plus or minus 1.5 dB. An accelerometer, either stud-mounted or mounted using a rare earth, low mass magnet and sound disk(or finished surface) shall be used with the FFT analyzer to collect data. The mass of the accelerometer and its mounting shall have minimal influence on the frequency response of the system over the selected measurement range.

Upon completion of the installation, and within 60 calendar days after the date of initial operation, performance tests shall be conducted in the presence of the Contracting Officer. Conduct these tests until the performance of the system is proven, with 8 hours of successful operation as a minimum period. Any equipment defects or performance deficiencies shall be corrected, and the tests repeated until performance is fully satisfactory. Determine the water flows from pressure-drop across chiller and condenser, and from pump curves. Provide calibrated test instruments. Government will provide load.

Ensure each unit is tested for leaks under pressure and evacuated and dehydrated to 2 degrees C 35 degrees F wet bulb, or an absolute pressure of not over 813 pascal 0.24 inch of mercury

Provide final test reports to the Contracting Officer. Reports shall have

a cover letter/sheet clearly marked with the System name, Date, and the words "Final Test Reports - Forward to the Systems Engineer/Condition Monitoring Office/Predictive Testing Group for inclusion in the Maintenance Database."

-- End of Section --