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UFGS-42 22 13.00 40 (February 2011)
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UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2016

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DIVISION 42 - PROCESS HEATING, COOLING, AND DRYING EQUIPMENT

SECTION 42 22 13.00 40

CENTRIFUGAL PROCESS CHILLERS AND COOLERS

08/14

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CENTRIFUGAL PROCESS CHILLERS AND COOLERS 08/14

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

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 items(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

NOTE: Include in drawings or schedule capacity, capacity conditions, pressure drops, control diagrams, and refrigerant used.

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 48.00 40 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 48.00 40 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.

]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 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 480 (2007) Refrigerant-Cooled Liquid Coolers, Remote Type

AHRI 550/590 I-P (2011; Addendum 1 2012; Addendum 2-3 2013) Performance Rating Of Water-Chilling and Heat Pump Water-Heating Packages Using the Vapor Compression Cycle

ANSI/AHRI 520 (2004) Performance Rating of Positive Displacement Condensing Units

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

ASHRAE EQUIP SI HDBK (2012) Handbook, HVAC Systems and

Equipment (SI Edition)

ASME INTERNATIONAL (ASME)

ASME BPVC SEC VIII D1 (2010) BPVC Section VIII-Rules for
Construction of Pressure Vessels Division 1

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

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

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250 (2014) Enclosures for Electrical Equipment
(1000 Volts Maximum)

NEMA MG 1 (2014) Motors and Generators

U.S. DEPARTMENT OF ENERGY (DOE)

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

DOE CE-6 (2000) How to Buy an Energy-Efficient
Air-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.

The Guide Specification technical editors have
designated 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 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.

Use the "S" Classification only in SD-11 Closeout Submittals. An "S" following a submittal item indicates that the submittal is required for the Sustainability Notebook to fulfill federally mandated sustainable requirements in accordance with Section 01 33 29 SUSTAINABILITY REPORTING.

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.] Submittals with an "S" are for inclusion in the Sustainability Notebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Material, Equipment, and Fixture Lists[; G[, [____]]]

SD-02 Shop Drawings

Connection Diagrams[; G[, [____]]]

Control Diagrams[; G[, [____]]]

Installation Drawings[; G[, [____]]]

SD-03 Product Data

Centrifugal Water-Chiller[; G[, [____]]]

Compressor[; G[, [____]]]

Condenser[; G[, [____]]]

Control and Control Panels[; G[, [____]]]

Cooler[; G[, [____]]]

Equipment Foundation Data[; G[, [____]]]

Equipment and Performance Data[; G[, [____]]]

Insulation[; G[, [____]]]

Motors[; G[, [____]]]

Purge System[; G[, [____]]]

Spare Parts[; G[, [____]]]

Special Tools[; G[, [____]]]

Vibration Isolation[; G[, [____]]]

SD-04 Samples

Manufacturer's Standard Color Chart[; G[, [____]]]

SD-05 Design Data

Design Analysis and Calculations[; G[, [____]]]

SD-06 Test Reports

Test Reports[; G[, [____]]]

SD-07 Certificates

Listing of Product Installation[; G[, [____]]]

Referenced Standards Certificates[; G[, [____]]]

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals[; G[, [____]]]

SD-11 Closeout Submittals

Record Drawings[; G[, [____]]]

1.3 QUALITY CONTROL

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. Include purchaser name, address of installation, service organization, and date of installation.

1.3.1 Equipment and Performance Data

Submit equipment and performance data for centrifugal water chiller system for the following:

- a. Centrifugal Water Chiller
- b. Compressor
- c. Condenser
- d. Cooler
- e. Purge System
- f. Motors
- g. Control and Control Panels
- h. Insulation
- i. Vibration Isolation

- j. Special Tools

- k. Spare Parts

1.3.2 Referenced Standards Certificates

Submit certificates for following items showing conformance with referenced standards in this section:

- a. Centrifugal Water Chiller

- b. Compressor

- c. Condenser

- d. Cooler

- e. Purge System

- f. Motors

- g. Control and Control Panels

- h. Insulation

- i. Vibration Isolation

- j. Special Tools

- k. Spare Parts

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

2.1.1 Equipment and Performance Data

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.

Ensure manufacturer's standard color chart indicates the manufacturer's standard color selections and finishes for chiller units.

2.1.2 Required Drawings and Diagrams

Submit shop drawings of connection diagrams indicating the physical layout of all controls, internal tubing and wiring details, and the relations and connections of the following items:

- a. Centrifugal Water Chiller

- b. Compressor

- c. Condenser
- d. Cooler
- e. Purge System
- f. Motors
- g. Control and Control Panels

Submit design analysis and calculations for centrifugal chillers indicating the manufacturer's recommended power ratings, rotational speeds, and piston speeds.

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. Also include dimensions of foundations and relative elevations, and installation requirements such as noise abatement, vibration isolation, physical features, dimensions, ratings, equipment weights and utility services. Include foundation data for the following:

- a. Centrifugal Water Chiller
- b. Compressor
- c. Condenser
- d. Cooler
- e. Purge System
- f. Motors

Submit control diagrams for centrifugal chiller units showing the physical and functional relationship of equipment. Show on electrical diagrams the size, type, and capacity of the system.

[2.1.3 Design Requirements

2.1.3.1 Vibration Isolation

Provide vibration isolation conforming to requirements specified in Section 23 05 48.00 40 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT.

]2.2 COMPONENTS

NOTE: Ensure Pump and Motor balance conforms to ISO 1940-1 - (2003) Balance Quality Requirements of Rigid Rotors - Determination of Permissible Residual Unbalance unless otherwise noted. Ensure Motor vibration levels conform to NEMA Specification MG-1, Motors and Generators, Part 7 unless otherwise noted.

NOTE: Specify all rotating machinery is capable of

having shaft alignment and machine balance following installation. This requirement includes "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.

2.2.1 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.

Provide unit and spare parts conforming to the applicable requirements of AHRI 550/590 I-P, AHRI 480, and specified requirements. Ensure Energy Efficiency Ratings (EER) meets or exceeds the full-load efficiency and the integrated part-load value (IPLV) efficiency ratings as described in AHRI 550/590 I-P and the recommended levels specified in DOE CE-2 and DOE CE-6.

2.2.2 Compressor

NOTE: At higher than 3,600 rpm speeds, reevaluate 0.025 millimeter 0.001 inch vibration limit. Do not use compressor that will operate at 20,000 or higher rpm.

Provide [single] [multistage], [direct] [gear-driven] centrifugal type compressor, with hermetically sealed, compressor-motor assembly. Provide with [refrigerant] [water-cooled] motor windings. Ensure rotor assembly is statically and dynamically balanced to ISO 1940-1, [G6.3] [G2.5] [G1.0] [____], with replaceable sleeve-insert type shaft main bearings.

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

Provide compressor with temperature-actuated capacity reduction. Select a 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, with the control system including automatic stopping, when load falls below 10 percent capacity point, and automatic unloaded restarting on load demand. Ensure capacity

modulation is controlled by the temperature of the water leaving the cooler, with unit controller capable of maintaining leaving-water temperature at plus or minus 0.25 degrees C 0.5 degree F of the set point.

2.2.3 Condenser

Provide shell-and-tube cleanable-type condenser, complying 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. Ensure minimum water-side working pressure is 1050 kilopascal 150 psig. Minimum refrigerant-side working pressure is saturation pressure of refrigerant used at 29 degrees C 85 degrees F. Pneumatically test spaces not subject to ASME code due to size or other limitations at 1-1/2 times working pressure or 310 kilopascal 45 psig, whichever is greater.

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

Fit and arrange water boxes or removable elbows to permit cleaning of tubes without disturbing piping beyond elbows, with flanged- or grooved-coupling type elbows, and hinged-mounted end bells.

NOTE: R-12 is designated as a restricted material.
Use available substitutes as apply to specified's
application. CFC's are being phased out. No new
designs using CFC's are 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 38 to 57
degrees C 100 to 135 degrees F 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. Ensure design and construction provisions 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.

2.2.4 Cooler (Refrigerant Evaporator)

Provide cooler conforming to the requirements specified herein in paragraph 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.

2.2.5 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 a positive-pressure refrigerant is used by the manufacturer in the basic liquid chiller unit, a purge system is not required.

Ensure when in operation, the purge system functions automatically to remove air, water vapor, and noncondensable gases from the refrigeration system and condenses, separates, and returns any refrigerant present therein to the system. Ensure purge system manually or automatically starts and stops and is assembled as a compact unit. Verify purge system is complete with operating and safety devices, with an oil separator if recommended by the manufacturer. Ensure units purge no more than 0.045 kg 0.1 pounds of non-condensable.

2.2.6 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. Provide control panel containing

control equipment specified, and control equipment normally furnished and recommended by the manufacturer for optimum operation of the system. Permanently identify control panel items, 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.

- a. Refrigerant suction and discharge pressure gages
- b. Oil-pressure gages
- c. Purge-drum pressure gage
- d. Refrigerant low-temperature or low-pressure cutout
- e. Refrigerant high-pressure cutout
- f. Time delay relays
- g. Motor high-temperature cutout
- h. Lubricating-oil high-temperature cutout if required by equipment
- i. Oil differential-pressure interlock
- j. Interlock relays and reset button
- k. Manual/automatic selector switches and controls for purge pumps
- l. Pilot lights indicating position of safety controls
- m. System start/stop provisions with condition-indicating lights
- n. Load-limiting device to operate capacity-control mechanism
- o. Cooler refrigerant thermometer with well
- p. Main circuit protective and interruptive device
- q. Transformers for any other source-voltage requirements
- r. Terminals for field-installed equipment
- [s. Motor controllers
-]t. 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.

- a. Audible-alarm bell, 100 millimeter 4-inch diameter
- b. Chilled-water and condenser supply-and-return thermometers with wells
- c. Indicating-type chilled-water thermostat with well
- d. Chilled-water low-temperature cutout

2.2.7 Motors

Provide hermetically sealed motors conforming to NEMA MG 1, ANSI/AHRI 520 and requirements for motors as specified herein.

Provide with [oil-lubricated, replaceable-sleeve, insertable type]
[permanently lubricated, rolling element type] bearings.

**NOTE: Limit percent of full-load amperes at which
 motor controller overload will trip, gas pressure
 differential, pumps, sprays, unit capacity, or
 other. Coordinate with motor controller
 specification and drawings.**

[Provide motor with 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 includes:

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

[2.2.8 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.**

Insulate and vapor seal cooler shell and suction piping between evaporator and first stage of each compressor unit. Insulate the water boxes, allowing 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.

Provide manufacturer's standard color elastomeric unicellular foam vapor seal material 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.

]PART 3 EXECUTION

3.1 INSTALLATION

Install equipment as specified, and in accordance with manufacturer's installation drawings and written instructions, including ratings and service requirements.

3.1.1 Alignment

Before attempting alignment, 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. Do not undercut hold down bolts in order to perform adjustment.

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

Provide installed alignment jack bolts on all units with a drive motor over [7.5][10][15][20][25] hp.

Provide pump and driver with an intermediate shaft, spacer, or spool piece (sometimes called a jackshaft). Based on the motor nominal operating speed, align the pump and driver to the following minimum specifications:

Speed(RPM)	Close-Coupled Offset (mils)	Close-Coupled Angle (mils/in)	Spool Piece Angle @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

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

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

3.2 FIELD QUALITY CONTROL

3.2.1 Inspection and Testing

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

Prior to final acceptance, verify pump and motor conformance to specifications using vibration analysis, with vibration levels not exceeding .075 in/sec at 1 times run speed and at pump frequency, and .04 in/sec at other multiples of run speed.

Use a Fast Fourier Transformer (FFT) analyzer to measure vibration levels, having the following characteristics:

- a. Dynamic range greater than 70 dB;
- b. A minimum line resolution of 400;
- c. A frequency response range of 5 Hz-10 KHz(300-600000 cpm);
- d. The capacity to perform ensemble averaging;
- e. The capability to use a Hanning window;
- f. Auto ranging frequency amplitude;
- g. A minimum amplitude accuracy over the selected frequency range of plus or minus 20 percent or plus or minus 1.5 dB.
- h. An accelerometer, either stud-mounted or mounted using a rare earth, a low mass magnet and sound disk(or finished surface) used with the FFT analyzer to collect data.

Ensure the mass of the accelerometer and its mounting 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, conduct performance tests 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. Correct any equipment defects or performance deficiencies, and repeat the tests until performance is fully accepted by the Contracting Officer. Determine the water flows from the 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. Provide reports with 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."

3.2.2 Manufacturer's Representative

Provide the services of a competent factory-trained representative to supervise the assembly, charging, testing, and startup of equipment. Provide documentation that a factory performance test has been conducted on every chiller in accordance with AHRI 550/590 I-P, witnessed by Government and Contractor.

3.3 CLOSEOUT ACTIVITIES

Provide [one] [_____] complete set[s] of special tools, as recommended by the manufacturer, for field maintenance of the system, in a locked toolbox. Provide two [sets of]keys to the Contracting Officer.

Make provisions for Government personnel to receive [8][_____] hours of instructions in proper operation and maintenance procedures.

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.

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.

-- End of Section --