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USACE / NAVFAC / AFCESA / NASA **UFGS-23 71 19 (April 2006)**

Preparing Activity: USACE **Replacing without change UFGS-15848 (April 2005)**

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated 18 July 2006

Latest change indicated by CHG tags
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SECTION TABLE OF CONTENTS

DIVISION 23 - HEATING, VENTILATING, AND AIR CONDITIONING

SECTION 23 71 19

THERMAL ENERGY STORAGE SYSTEM: ICE-ON-COIL

04/06

-- End of Section Table of Contents --

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SECTION 23 71 19

THERMAL ENERGY STORAGE SYSTEM: ICE-ON-COIL
04/06

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NOTE: This guide specification covers the requirement for ice-on-coil type thermal energy storage systems, including the system refrigeration, controls, piping and electrical work.

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.

Recommended changes to a UFGS should be submitted as a Criteria Change Request (CCR).

Use of electronic communication is encouraged.

Brackets are used in the text to indicate designer choices or locations where text must be supplied by the designer.
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PART 1 GENERAL

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NOTE: The use of this specification will be coordinated with other sections as appropriate in order to specify a complete thermal energy storage system. The designer should be familiar with ASHRAE's Design Guide for Cool Thermal Storage and ARI Guideline T before preparing the design. Note that this first edition is tailored for ice-on-coil systems. This specification will be a document that develops further based on the needs of our customers and changing technology.

For Army projects, reference the UFGS specifications approved for use by the Army; for Navy projects, reference the UFGS specifications approved for use

by the Navy. Sections ending in "A" are for Army projects. Sections ending in "N" are for Navy projects. Sections without an "A" or "N" are true UFGS, and should be used for both Army and Navy projects.

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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 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.

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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.

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2003; R 2004) Motors and Generators
NEMA MG 11	(1977; R 1997; R 2001) Energy Management Guide for Selection and Use of Single Phase Motors

1.2 MODIFICATION OF REFERENCES

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction", or words of similar meaning, to mean the Contracting Officer.

1.3 SUBMITTALS

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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. Submittals should be kept 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.

Quantity and submission requirements for Operation and Maintenance Data are identified in Section 01 33 00 for Navy projects. Select bracketed quantity and submission requirements for Operation and Maintenance Data for Army projects only.

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

SD-02 Shop Drawings

Installation Drawings[; G][; G, [_____]]

Drawings consisting of equipment layout including assembly and installation details and electrical connection diagrams; layout and installation details of thermal storage units including support structure, thermal storage system circulation pumps, distribution manifolds and all piping, including support structure for system piping and points of connection to storage units and to piping specified in related sections. Drawings shall include any information required to demonstrate that the system has been coordinated and will properly function within the HVAC system and shall show equipment relationship to other parts of the work, including clearances required for operation and maintenance.

SD-03 Product Data

Equipment and Installation[; G][; G, [_____]]

Manufacturer's catalog data included with the detail drawings for the following items. The data shall be highlighted to show model, size, options, etc., that are intended for consideration. Data shall be adequate to demonstrate compliance with contract requirements for the following:

a. Controls.

b. Storage Units (including heat exchanger).

c. Maximum charge and discharge rates and latent cooling capacity of each unit.

d. Type of glycol recommended for use by both the refrigeration system and the storage system manufacturers. Information shall be provided that lists the latent storage capacity and overall APLV of the refrigeration and storage systems based on their combined operating characteristics using varying glycol concentrations. The recommended concentration of glycol for optimal performance based on the system capacity profile at the specified design conditions shall be highlighted.

Test Procedures[; G][; G, [_____]]

Proposed test procedures for performance tests of systems, at least 2 weeks prior to the start of related testing.

System Diagrams[; G][; G, [_____]]

Proposed diagrams, at least 2 weeks prior to start of related testing and as specified.

Manufacturer's Representative[; G][; G, [_____]]

A letter from the system manufacturer, at least 2 weeks prior to the start of work, listing the experience and training of the Manufacturer's Representative.

Testing, Adjusting, and Balancing[; G][; G, [_____]]

Proposed test schedules for Capacity Test and Performance Test, at least 2 weeks prior to the start of related testing.

Field Training[; G][; G, [_____]]

Proposed schedule for field training submitted at least 2 weeks prior to the start of related training.

SD-06 Test Reports

Factory Tests[; G][; G, [_____]]
Performance Tests[; G][; G, [_____]]

Test reports for the factory tests and performance tests in booklet form, upon completion of testing. Reports shall document all phases of tests performed including initial test summary, all corrections and adjustments made, and final test results.

SD-07 Certificates

Installation Drawings[; G][; G, [_____]]

Concurrent with installation drawings, manufacturer's certification of installation drawings.

SD-10 Operation and Maintenance Data

Thermal Energy Storage System[; G][; G, [_____]]

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

[[Six] [_____] manuals at least 2 weeks prior to field training.] Submit Data Package 3 and data complying with the requirements specified in Section 01 78 23 OPERATION AND MAINTENANCE DATA.

1.4 MANUFACTURER'S REPRESENTATIVE

Performance testing work specified in this section shall be performed under the supervision of and certified by the Manufacturer's Representative. Certification shall be provided for installation drawings, test procedures, and test results. The Manufacturer's Representative shall have no less than 3 continuous years of experience directly involved in the design and installation of thermal energy storage systems, and shall have served in similar capacity on no fewer than five projects of similar size and scope during that period.

1.5 STANDARD PRODUCTS

The Thermal Energy Storage System shall be designed and assembled by a manufacturer regularly engaged in the manufacturing of systems that are of a similar design, workmanship, capacity, and operation. The manufacturer shall be responsible for the selection of the major components of the thermal energy storage system. The major components of the thermal energy storage system include ice storage units, liquid chillers, and system controls. Systems of similar design and capacity shall have been in satisfactory commercial or industrial use for 2 years before bid opening. The 2 years must be satisfactorily completed by a system which has been sold or is offered for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures. Systems having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation, for not less than 6000 hours exclusive of the manufacturer's factory tests, can be shown. The system shall be supported by a service organization certified by the system manufacturer.

PART 2 PRODUCTS

2.1 SYSTEM OPERATION CHARACTERISTICS

****
NOTE: Designers will include all energy efficient applications that optimize the complete thermal storage system, and are technically feasible and life cycle cost effective. The installation's capability to operate and maintain proposed systems will be a primary consideration in the life cycle cost analyses. Possible energy saving measures include cool storage with provisions for heat reclamation for preheating domestic hot water, or, in instances where both heating and cooling are required during the heating season, rejected heat from the cool storage system can be used to offset heating loads.
****

The system shall be of the "[internal] [or] [external] melt ice-on-coil" storage system as described in the ASHRAE Design Guide for Cool Thermal Storage. System performance shall be based on operation with a glycol solution (type and concentration) that is recommended by both the refrigeration system manufacturer and the storage system manufacturer to meet the system capacity profile at the specified design conditions. All system components that are in contact with glycol solution shall be designed for use with the solution.

2.1.1 Refrigeration System

****
NOTE: Section 23 64 00.00 10 LIQUID CHILLERS or 23 66 00.00 20 CENTRAL REFRIGERATION EQUIPMENT FOR AIR CONDITIONING must be specifically tailored to fit the needs of the type of storage system specified. The appropriate Application Part-Load Value (APLV) for ice making conditions should be included when specifying the chiller. Note that the APLV for ice making system shall include chillers and all auxiliary items such as storage system circulation pumps and bubblers required for operation of ice making. One typical example of conditions for ice making temperatures with which to specify an APLV is a glycol solution return temperature to the chiller of minus 0.5 degrees C (31 degrees F) and a glycol supply temperature from the chiller of minus 4.5 degrees C (24 degrees F).
****

In addition to meeting the capacity requirements specified herein and on the drawings, the refrigeration system shall be as specified in Section [23 64 00.00 10 LIQUID CHILLERS][23 66 00.00 20 CENTRAL REFRIGERATION EQUIPMENT FOR AIR CONDITIONING].

2.1.2 System Capacity Profile

****
NOTE: It is critical that the hourly design day

requirements listed below be adequate to meet anticipated loads, otherwise unwanted consequences such as uncomfortable conditions, insufficient cooling for critical functions, or the use of refrigeration equipment during periods that increase demand charges could occur. The system capacity should typically be optimized with respect to the installation electrical demand rather than that of the building for which the system is being installed.

The designer should coordinate with the customer as to which demand profile (installation or building) should be used to determine system operation. Note that the design conditions for the refrigeration system should be determined in accordance with the ASHRAE Design Guide for Cool Thermal Storage. The design conditions in most cases should not be less than 1 percent dry bulb temperature and the 1 percent wet bulb temperature for cooling towers, otherwise the 1 percent mean coincident wet bulb temperature.

****

The system shall provide the hourly capacity shown below in Table 1 at the design conditions listed for the refrigeration system. The flow supplied to the load, the maximum supply temperature delivered to the load, the return temperature from the load, and the system total latent capacity shall be as indicated on the drawings. Factory system capacity test results from proto-type testing shall be provided that demonstrate that system performance meets or exceeds these requirements. The manufacturer shall provide calculations with the factory system capacity test that demonstrate compliance with the system profile when installed as proposed at the specified design conditions. The losses shall include the following where applicable: maximum solar heat gain, heat gains from soil, and equipment room temperatures of 5.5 degrees C 10 degrees F above the refrigeration system design dry bulb temperature.

TABLE 1

SYSTEM PROFILE

Hour	A	B	C	D	E
1:00					
2:00					
3:00					
4:00					
5:00					
6:00					
7:00					
8:00					

TABLE 1

SYSTEM PROFILE

Hour	A	B	C	D	E
9:00					
10:00					
11:00					
12:00					
13:00					
14:00					
15:00					
16:00					
17:00					
18:00					
19:00					
20:00					
21:00					
22:00					
23:00					
24:00					

Legend:

A: System operating mode:

1. I - Chiller charging ice storage unit.

2. F - Storage discharging to serve load; chiller idle.

3. C - Combination of chiller operating and storage discharging to serve load.

4. N - Combination of chiller charging storage unit and serving the load.

B: Tonnage of cooling supplied to load by thermal energy storage system.

C: Chiller output.

D: Amount of item C used to charge storage.

E: Total amount of latent cooling stored.

2.2 CONTROLS

****
NOTE: The sequence of control for the thermal energy storage system should be shown on the drawings in text as a performance sequence so that the system manufacturer's standard controls can be used. The designer should investigate the requirement for connection of the thermal storage system to the installation's Utility Monitoring Control System (UMCS).
****

Controls for the thermal energy storage system shall be coordinated and integrated with the refrigeration system controls package specified in Section [23 64 00.00 10 LIQUID CHILLERS][23 66 00.00 20 CENTRAL REFRIGERATION EQUIPMENT FOR AIR CONDITIONING]. Thermal energy storage system shall be designed in accordance with the manufacturer's recommendations and to comply with the sequence of controls shown on the drawings. Controls, control strategies, storage system configuration, piping, and all ancillary equipment will be designed to ensure that the system performs as specified during partial, peak, and intermittent loading. The controls for the thermal energy storage system shall continuously measure the ice inventory of storage unit and relay this to the refrigeration controls package. The controls shall relay an alarm when; (a) any chiller fails to switch to the operating mode specified in the system capacity profile at any hourly interval; or (b) the total ice inventory falls [20] [_____] percent below the latent cooling storage specified in the system capacity profile at any hourly interval. The controls shall relay alarm and initiate system shutdown when the total ice inventory falls below [40] [_____] percent below the latent cooling storage specified in the system capacity profile at any hourly interval.

2.3 ICE STORAGE UNITS

****
NOTE: The number and size of storage units should be based on the size of the load, the sequence of operations, the space available for storage units, and any reliability requirements that are applicable. The designer should identify the space available for installation and maintenance of storage units and necessary auxiliaries on the drawings.
****

Ice storage units shall be designed and constructed for [above] [or] [below] ground installation. Units shall be externally insulated with system manufacturer's standard material. The insulated unit shall be weatherproof. Standby energy loss of insulated storage units shall not exceed 1 percent of total stored capacity over a period of 24 hours in ambient air of 30 degrees C. 85 degrees F. Bubblers or agitators shall be provided by the thermal storage unit manufacturer where required in order to meet performance specified. Where bubblers are required, dual bubblers shall be installed in each tank. Bubblers shall use intake air from inside

the storage units. Unit covers shall be suitable for burial beneath up to 0.6 m two feet of soil. Unit covers shall be in sections not exceeding 90 kg. 200 pounds. Each section shall be equipped with smoothed edges or handles and shall be designed for removal by two individuals [Ground] [Floor loading] shall not exceed [20 kPa 400 psf] [_____]. Each storage unit shall include either an integral thermally isolated expansion chamber or an insulated external expansion tank. Expansion chamber or tank shall be sized by the ice storage unit manufacturer to prevent formation of ice caps that reduce storage capacity. Each storage unit shall be equipped with both an inventory sensor that transmits the ice inventory level to the refrigeration system controls specified in paragraph CONTROLS and an visible ice inventory indicator mounted on the storage unit. The temperature drop of the glycol solution across the heat exchanger in the charging mode shall be large enough to permit full flow through the refrigeration system chillers. Heat exchangers shall be designed for an operating pressure 1035 kPa 150 psi and shall be certified to have a burst pressure of not less than 2070 kPa.300 psi. Additionally, each heat exchanger shall be factory tested at a minimum of 1550 kPa. 225 psi.

2.4 ASBESTOS PROHIBITION

Asbestos and asbestos-containing products shall not be used.

2.5 NAMEPLATES

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

2.6 SPECIAL TOOLS AND SPARE PARTS

One set of special tools, calibration devices, and instruments required for operation, calibration, and maintenance of the equipment shall be provided. In addition, a two year supply of all spare parts required for system operation shall be furnished.

2.7 EQUIPMENT GUARDS AND ACCESS

****
NOTE: Catwalks, ladders, and guardrails may be required. If so, select the applicable item and indicate on drawings. If not applicable, delete the entire last sentence.
****

Belts, pulleys, chains, gears, couplings, projecting setscrews, keys, and other rotating parts exposed to personnel contact shall be fully enclosed or guarded according to OSHA requirements. High temperature equipment and piping exposed to contact by personnel or where it creates a potential fire hazard shall be properly guarded or covered with insulation of a type specified. The requirements for catwalks, operating platforms, ladders, and guardrails are specified in Section 05 50 00 METAL: MISCELLANEOUS AND FABRICATIONS.

2.8 PIPING COMPONENTS

Piping components shall be as specified in Sections 23 64 26 CHILLED, CHILLED-HOT, AND CONDENSER WATER PIPING SYSTEMS and 23 23 00 REFRIGERANT PIPING.

2.9 ELECTRICAL WORK

****

NOTE: Show the electrical characteristics, motor starter type(s), enclosure type, and maximum rpm on the drawings in the equipment schedules.

Where reduced-voltage motor starters are recommended by the manufacturer or required otherwise, specify and coordinate the type(s) required in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Reduced-voltage starting is required when full voltage starting will interfere with other electrical equipment and circuits and when recommended by the manufacturer. Where adjustable speed drives (SD) are specified, reference Section 26 29 23 VARIABLE FREQUENCY DRIVE SYSTEMS UNDER 600 VOLTS. The methods for calculating the economy of using an adjustable speed drive is described in UFC 3-520-01 INTERIOR ELECTRICAL SYSTEMS.

****

Provide motors, controllers, integral disconnects, contactors, and controls with their respective pieces of equipment, except controllers indicated as part of motor control centers. Provide electrical equipment, including motors and wiring, as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Manual or automatic control and protective or signal devices required for the operation specified and control wiring required for controls and devices specified, but not shown, shall be provided. For packaged equipment, the manufacturer shall provide controllers including the required monitors and timed restart.

a. For single-phase motors, provide high-efficiency type, fractional-horsepower alternating-current motors, including motors that are part of a system, in accordance with NEMA MG 11

b. For polyphase motors, provide squirrel-cage medium induction motors, including motors that are part of a system, that meet the efficiency ratings for premium efficiency motors in accordance with NEMA MG 1.

c. Provide motors in accordance with NEMA MG 1 and of sufficient size to drive the load at the specified capacity without exceeding the nameplate rating of the motor. Motors shall be rated for continuous duty with the enclosure specified. Motor duty requirements shall allow for maximum frequency start-stop operation and minimum encountered interval between start and stop. 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. Provide motor starters complete with thermal overload protection and other necessary appurtenances. Motor bearings shall be fitted with grease supply fittings and grease relief to outside of the enclosure.

d. [Where two-speed or variable-speed motors are indicated, solid-state variable-speed controllers may be provided to accomplish the same function. Use solid-state variable-speed controllers for motors rated 7.45 kW (10 hp) or less and adjustable frequency drives for larger motors.] [Provide variable frequency drives for motors as

specified in Section 26 29 23 VARIABLE FREQUENCY DRIVE SYSTEMS UNDER 600 VOLTS.]

2.10 FACTORY PAINTING

New equipment shall be coated with a manufacturer's factory-applied finish that meets the following requirements:

a. The finish system designed for the equipment shall have been tested in accordance with Federal Test Method Standard No. 141 (Method 6061) and passed the 125-hour salt-spray fog test of that standard, except that equipment located outdoors shall have passed the 500-hour salt-spray fog test of that standard.

b. The film thickness of the factory painting system applied on the equipment shall not be less than the film thickness used on the successful test specimens.

c. If manufacturer's standard factory painting system is being proposed for use on surfaces subject to temperatures above 50 degrees C 120 degrees F, the factory painting system shall be designed for the temperature service.

PART 3 EXECUTION

3.1 INSTALLATION

Work shall be installed as shown and according to the manufacturer's system diagrams and recommendations, including space required for maintenance.

3.1.1 Piping

Piping installation shall be as specified in Section 23 64 26 CHILLED, CHILLED-HOT, AND CONDENSER WATER PIPING SYSTEMS.

3.1.2 Equipment and Installation

****
NOTE: Provide seismic requirements, if a Government designer (either Corps office or A/E) is the Engineer of Record, and show on the drawings. Delete the bracketed phrase if seismic details are not provided. Sections 13 48 00 and 13 48 00.00 10, properly edited, must be included in the contract documents.
****

All equipment shall be installed within the space allotted on the drawings. The layout shall include adequate space to accomodate the maintenance requirements as recommended by the manufacturer. Floor-mounted equipment, unless otherwise indicated, shall be set on not less than 150 mm 6 inch thick concrete pads or curbs doweled in place. Concrete foundations for equipment shall be heavy enough to minimize the intensity of the vibrations transmitted to attached piping, equipment, or the surrounding structure, as recommended by the equipment manufacturer. In lieu of a concrete pad foundation, a concrete pedestal block with isolators placed between the pedestal block and the floor may be provided. The concrete foundation or concrete pedestal block shall be of a mass not less than three times the weight of the components to be supported. Piping connections to equipment

mounted on pedestal blocks and piping connections to storage units shall be provided with flexible connectors. Foundation drawings, boltsetting information, and foundation bolts shall be furnished prior to concrete foundation construction for all equipment indicated or required to have concrete foundations. Concrete for all foundations shall be as specified in Section [03 31 00.00 10 CAST-IN-PLACE STRUCTURAL CONCRETE] [03 30 00.00 20 CAST-IN-PLACE CONCRETE]. In addition, the installation of tanks, compressors, pumps, valves, heat exchangers, and other similar items shall be as specified under Sections 13 48 00 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT and [13 48 00.00 10 SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT] [22 05 48.00 20 MECHANICAL SOUND, VIBRATION, AND SEISMIC CONTROL] [as shown on the drawings]. Structural steel required for reinforcement to properly support piping, headers, and equipment but not shown shall be provided under this section. Material used for support shall be as specified under Section [05 21 02.00 10 STEEL JOISTS] [05 21 00.00 20 STEEL JOISTS [AND JOIST GIRDERS]]. The method of anchoring and fastening shall be in accordance with manufacturer's instructions unless otherwise indicated.

3.1.3 Access Panels

Access panels shall be provided for all concealed valves, vents, controls, and items requiring inspection or maintenance. Access panels shall be of sufficient size and located so that the concealed items may be serviced and maintained or completely removed and replaced. Access panels shall be as specified in Section 05 50 00 METAL: MISCELLANEOUS AND FABRICATIONS.

3.1.4 Insulation

Unless otherwise specified, thickness and application of insulation materials for piping and equipment shall be according to Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

3.1.5 Special Requirements

The manufacturer's special requirements and recommendations, including field-applied insulation and vapor barriers, storage tank installation, distribution and air agitation system, clearances, materials, appurtenances, and all other necessary features shall be installed to provide a complete and operational thermal storage system.

3.2 FIELD PAINTING

Finish painting of items only primed at the factory or surfaces not specifically noted otherwise shall be as specified in Section 09 90 00 PAINTS AND COATINGS.

3.3 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. Fans shall be adjusted to the speed indicated by the manufacturer to meet specified conditions.

3.4 TESTING, ADJUSTING, AND BALANCING

The requirements for testing, adjusting, and balancing are specified in Section [23 05 93.00 10 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS] [23 08 00.00 20 HVAC TESTING/ADJUSTING/BALANCING]. Testing, adjusting, and balancing shall begin only when the entire HVAC system, including controls, has been completed with the exception of performance tests. The thermal energy storage system shall be charged with premixed glycol solution (type and concentration as specified by the manufacturers of both the refrigeration and storage systems) prior to testing, adjusting, and balancing.

3.5 PERFORMANCE TESTS

After testing, adjusting, and balancing has been completed as specified, the system shall be tested as a whole to see that all items perform as integral parts of the system and that operation is as specified. Corrections and adjustments shall be made as necessary to produce the conditions indicated or specified, and test(s) repeated in entirety until results are satisfactory. Tests shall be conducted by the thermal energy storage system manufacturer's representative. All instruments required for tests shall be furnished by the Contractor. The accuracy of test instruments shall be as specified in Section [23 05 93.00 10 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS] [23 08 00.00 20 HVAC TESTING/ADJUSTING/BALANCING]. Tests shall be performed as follows:

3.5.1 Operational Test

Test shall demonstrate that the entire system is functioning according to the specifications. The operational test shall cover a period of not less than [72] [_____] continuous hours of operation using only system controls in normal mode and specified sequence of operation. Ice inventory recordings in each storage unit shall be made at hourly intervals for the duration of the time period. In addition, weather controls, including the ambient temperature and humidity in a shaded and weather protected area shall be recorded at hourly intervals along with ice inventory. The results will be supplemented by calculations that demonstrate that the system will provide the capacity specified when operating during peak design conditions as specified in paragraph SYSTEM OPERATION CHARACTERISTICS.

3.5.2 Capacity Test

The storage units shall be filled with water at the return temperature specified from the load on the drawings. The storage units will then be charged to the manufacturer's design latent capacity using the refrigeration capacity that will be used during normal charging operations. The inlet and outlet temperature at and the flow rate through each storage unit and chiller shall be recorded on an hourly basis. The time, total refrigeration, and the total energy consumption required to charge all storage units to the latent capacity specified shall be recorded. When charging is complete, the chillers shall be shut down and the cooling from the storage units shall be supplied to the load until the specified maximum supply temperature to the load is exceeded. The inlet and outlet temperature at and the flow rate through each storage unit shall be recorded on an hourly basis. The time, total cooling capacity, and the total energy consumption during the period that the load is supplied by the storage units only shall be recorded. Ice inventory recordings in each storage unit shall be made at hourly intervals during the Capacity Test.

In addition, weather conditions, including ambient temperature and humidity in a shaded and weather protected area and all other pertinent temperatures and weather conditions shall be recorded at hourly intervals along with ice inventory.

3.6 FIELD TRAINING

****
NOTE: The number of hours of instruction should be determined based of the number and complexity of the systems specified.
****

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

3.6.1 Video Recording

Provide to the Contracting Officer two copies of the training course in VHS or DVD video recording. The recording shall record in video and audio all instructors' training presentations including question and answer periods with the trainees.

3.6.2 Unresolved Questions From Trainees

If, at the end of the training course, there are questions from trainees that remain unresolved, the instructor shall send the answer, in writing, to the Contracting Officer for transmittal to the trainees.

-- End of Section --