****
USACE / NAVFAC / AFCEC / NASA **UFGS-23 71 19 (May 2018)**

Preparing Activity: USACE **Superseding**
UFGS-23 71 19 (January 2008)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2022
****

SECTION TABLE OF CONTENTS

DIVISION 23 - HEATING, VENTILATING, AND AIR CONDITIONING (HVAC)

SECTION 23 71 19

THERMAL ENERGY STORAGE SYSTEM: ICE-ON-COIL

05/18

-- End of Section Table of Contents --

****
USACE / NAVFAC / AFCEC / NASA **UFGS-23 71 19 (May 2018)**

Preparing Activity: USACE **Superseding**
UFGS-23 71 19 (January 2008)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2022
****

SECTION 23 71 19

THERMAL ENERGY STORAGE SYSTEM: ICE-ON-COIL
05/18

****
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.

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

****
NOTE: The use of this specification will be coordinated with other sections as appropriate in order to specify a complete thermal energy storage system. These other sections include UFGS 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC; UFGS 23 64 10 WATER CHILLERS, VAPRO COMPRESSION TYPE; UFGS 01 91 00.15 10 and UFGS 01 91 00.15 20, TOTAL BUILDING COMMISSIONING. The designer should be familiar with ASHRAE's Design Guide for Cool Thermal Storage and AHRI Guideline T before preparing the design. Note that this 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.

****

1.1 MODIFICATION OF REFERENCES

In each of the publications referred to herein, interpret references to the "authority having jurisdiction", or words of similar meaning, to mean the Contracting Officer.

1.2 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.

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

ASHRAE 150	(2000; R 2014) Method of Testing the Performance of Cool Storage Systems
ASHRAE HVAC APP IP HDBK	(2016) HVAC Applications Handbook, I-P Edition
ASHRAE HVAC APP SI HDBK	(2019) HVAC Applications Handbook, SI Edition

ASTM INTERNATIONAL (ASTM)

ASTM D638	(2014) Standard Test Method for Tensile Properties of Plastics

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts

0, 1, 7, 12, 30, and 31

NEMA MG 11	(1977; R 2012) Energy Management Guide for Selection and Use of Single Phase Motors

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; ERTA 20-3 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4; TIA 20-5; TIA 20-6; TIA 20-7; TIA 20-8; TIA 20-9; TIA 20-10; TIA 20-11; TIA 20-12; TIA 20-13; TIA 20-14; TIA 20-15; TIA 20-16; ERTA 20-4 2022) National Electrical Code

1.3 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.

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.

****

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

Graphic layouts for dashboards; G[, [_____]]

Controls sequence of operation; G[, [_____]]

Point-to-point wiring diagrams; G[, [_____]]

Installation Drawings; G[, [_____]]

Table C1; G[, [_____]]

Table C2; G[, [_____]]

Table 1; G[, [_____]]

SD-03 Product Data

Equipment and Installation; G[, [_____]]

Test Procedures; G[, [_____]]

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

System Diagrams; G[, [_____]]

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

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

Field Training; G[, [_____]]

Control Valves; G[, [_____]]

Sensors; G[, [_____]]

Motors; G[, [_____]]

Integral disconnects; G[, [_____]]

Paint; G[, [_____]]

Glycol; G[, [_____]]

Glycol management system; G[, [_____]]

Ice Inventory System; G[, [_____]]

Controls; G[, [_____]]

Ice Storage Units; G[, [_____]]

Liquid Chillers; G[, [_____]]

SD-06 Test Reports

System Performance Tests Report; G[, [_____]]

SD-07 Certificates

Installation Drawings; G[, [_____]]

SD-10 Operation and Maintenance Data

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

Training Schedule and Content; G[, [_____]]

1.4 QUALITY ASSURANCE

1.4.1 Manufacturer's Representative

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

a. 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.

b. Installation 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, controls sequence of operation, point-to-point wiring diagrams, graphic layouts for dashboards and schematic controls diagram. Include on the drawings any information required to demonstrate that the system has been coordinated and will function properly within the HVAC system, and show equipment relationship to other parts of the work, including clearances required for operation and maintenance. Concurrent with installation drawings, submit manufacturer's certification of installation drawings.

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

1.4.2 Asbestos Prohibition

Do not use asbestos and asbestos-containing products.

1.5 EXTRA MATERIALS

Provide one set of special tools, calibration devices, and instruments required for operation, calibration, and maintenance of the equipment. In addition, furnish a two year supply of all spare parts required for system operation.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Provide a closed circuit, single source Thermal Energy Storage System designed and assembled by a manufacturer located in the United States and regularly engaged in the manufacturing of systems that are of a similar design, workmanship, capacity, and operation. The system must be installed by the system manufacturer or a service organization certified by the system manufacturer. The manufacturer is responsible for the selection and full integration 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 must have been in satisfactory commercial [or industrial] use for 3 years before bid opening. The 3 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 3-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.

2.2 EQUIPMENT

2.2.1 Nameplates

Provide a nameplate on all equipment that identifies the manufacturer's name, address, type or style, model or serial number, and catalog number.

2.2.2 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.

****

Fully enclose or guard belts, pulleys, chains, gears, couplings, projecting setscrews, keys, and other rotating parts exposed to personnel contact according to OSHA requirements. Provide guards or cover high temperature equipment and piping exposed to contact by personnel or where it creates a potential fire hazard with insulation of a type specified. The requirements for catwalks, operating platforms, ladders, and guardrails are specified in Section [08 31 00 ACCESS DOORS AND PANELS][05 51 33 METAL LADDERS]

2.3 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.

Ice on coil internal melt systems are typically used on HVAC applications such as administrative buildings, schools, day care facilities, and stores where cooling requirements are relatively constant over a minimum 6 hour period and operating control systems need to be simple. Ice-on-coil external melt systems are typically used on applications such as process cooling where cooling requirements change rapidly and for short on-peak demand periods of 2 to 6 hours. External melt systems require more complex controls and air agitation pumps.

****

Provide a system of the [internal][or][external] melt ice-on-coil storage system type as described in the ASHRAE HVAC APP SI HDBK ASHRAE HVAC APP IP HDBK chapter on Thermal Storage. Base the system performance 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. Design all system components that are in contact with glycol solution for use with the solution.

2.3.1 Refrigeration System

****

NOTE: Section 23 64 10 WATER CHILLERS, VAPOR COMPRESSION TYPE must be specifically tailored to fit the needs of the type of storage system specified. Designer should obtain detailed efficiency data for water chillers at design operating conditions to specify minimum energy performance standards for the chiller. Typically air-cooled chillers are used for this application. A table, such as the one below, should be filled in and located with the chiller specification to specify minimum efficiency.

CHILLER DESIGNATION	MODE	
	ICE BUILD MODE	ICE MELT MODE
Evaporator Fluid Type		

CHILLER DESIGNATION	**MODE**	
	ICE BUILD MODE	**ICE MELT MODE**
Evaporator Fluid Concentration percentage		
Efficiently (EER)		
Integrated Part Load Value (IPLV) EER		**N/A**
Non-Standard Part Load Value (NPLV) EER	**N/A**	
Evaporator Leaving Temperature (Degrees C) (Degrees F)		
Evaporator Entering Temperature (Degrees C) (Degrees F)		
Evaporator Flow Rate (L/sec) (GPM)		
Ambient Temperature (Degrees C) (Degrees F)		

****

In addition to meeting the capacity requirements specified herein and on the drawings, the refrigeration system must be as specified in Section 23 64 10 WATER CHILLERS, VAPOR COMPRESSION TYPE.

2.3.2 Designer Specified Application Rate

****

NOTE: Designer of Record to complete Table C1 and C2. These tables come from AHRI Guideline T

****

Table C1. Specification Information		
Discharge Fluid used to define the following design data		
	Supply Temperature to Load at peak conditions, T1, Degrees C F	
	Return Temperature from Load at peak conditions, T2, Degrees C F	
	Flow rate to Load at peak conditions, L/sec gpm	
	Maximum allowable pressure drop through storage device, kPa psi	
System Schematic (shown on drawings)		
Charge Fluid		

Table C1. Specification Information		
Maximum time and minimum temperature available to charge Thermal Storage Device from fully discharged condition (Initial Charge Cycle), h and Degrees C F		
*Design Heat Sink Rejection Temperature Degrees C F		
* denotes optional data for this table		

Table C2. User-specified Data

Hour	Thermal Storage System Load kW Tons	*Supply Temp to Load, T1, Degrees C F	*Return Temp from Load, T2, Degrees C F	*Flow Rate to Load, L/s gpm	*Heat Sink Rejection Temp (Wet-Bulb or Dry-Bulb), Degrees C F	Thermal Storage Refrigeration Equipment Use during this hour (Charge / Partial Cooling / Off
0-1						
1-2						
2-3						
3-4						
4-5						
5-6						
6-7						
7-8						
8-9						
9-10						
10-11						
11-12						
12-13						
13-14						

Table C2. User-specified Data						
Hour	Thermal Storage System Load kW Tons	*Supply Temp to Load, T1, Degrees C F	*Return Temp from Load, T2, Degrees C F	*Flow Rate to Load, L/s gpm	*Heat Sink Rejection Temp (Wet-Bulb or Dry-Bulb), Degrees C F	Thermal Storage Refrigeration Equipment Use during this hour (Charge / Partial Cooling / Off
0-1						
14-15						
15-16						
16-17						
17-18						
18-19						
19-20						
20-21						
21-22						
22-23						
23-0						
Totals						
* denotes optional data for this table						

2.3.3 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 HVAC APP SI HDBK ASHRAE HVAC APP IP HDBK chapter on 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 manufacturer must provide the data in Table 1 below at the design day conditions listed for the refrigeration system. The system must meet both system performance and minimum scheduled equipment capacities to meet the design requirements.[Factory system capacity test results from proto-type testing must be provided that demonstrate that system performance meets or exceeds these requirements. The manufacturer must provide calculations with the factory system capacity test that demonstrate compliance with the system profile when installed as proposed at the specified design conditions.] Include the following ambient load losses 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>
<tr><td colspan="2">Design Day ([_____]DB Degrees C F / [_____]WB Degrees C F)</td></tr>
<tr><td colspan="2">Net Usable Storage Capacity: [_____] kWh Ton-Hours (Total Column D)</td></tr>
<tr><td colspan="2">Heat Transfer Fluid: [_____]</td></tr>
<tr><td>Specific Gravity: [_____]
@ [_____] Degrees C F</td><td>Hours to Recharge from Fully Discharged Condition: [_____] hours</td></tr>
<tr><td>Specific Heat Calorie/gm/Degrees C Btu/lb/Degrees F [_____]:
@ [_____] Degrees C F</td><td>Hours to Recharge on Design Day:
[_____] hours</td></tr>
</table>

Table 1. Thermal Energy Storage System Data

Hour	A Thermal Storage System Load kW tons	B Refrigeration Equipment Load kW tons	C Storage Device Charge Rate kW tons	D Storage Device Discharge Rate1 kW tons	E Parasitic and Accessory Heat Load into Storage Device kW tons	F Ambient Heat Load into Storage Device kW tons
0-1						
1-2						
2-3						

Table 1. Thermal Energy Storage System Data						
3-4						
4-5						
5-6						
6-7						
7-8						
8-9						
9-10						
10-11						
11-12						
12-13						
13-14						
14-15						
15-16						
16-17						
17-18						
18-19						
19-20						
20-21						
21-22						
22-23						
23-0						
Totals						
Notes:						
1.	Greater Discharge Rates may not be possible at defined discharge temperature (T4).					
2.	Totals for Column B must be greater than or equal to the sum of totals for Columns A, E and F.					

Table 1. Thermal Energy Storage System Data (continued)						
Hour	G Net Storage Inventory2 kW-hour ton-hours	H Supply Temperature to Load, T1 Degrees C F	I Return Temperature from Load, T2 Degrees C F	J Flow Rate to Load L/s gpm	K Fluid Temperature Entering Storage Device T3 Degrees C F	L Fluid Temperature Leaving Storage Device T4 Degrees C F
0-1						
1-2						
2-3						
3-4						
4-5						
5-6						
6-7						
7-8						
8-9						
9-10						
10-11						
11-12						
12-13						
13-14						
14-15						
15-16						
16-17						
17-18						
18-19						
19-20						
20-21						

Table 1. Thermal Energy Storage System Data (continued)						
21-22						
22-23						
23-0						
Totals						
Notes:						
3.	Net Storage Inventory values are not available for instantaneous discharge.					
4.	The values in Column I must always be less than maximum temperature defined on the "User-Specified Data" Sheet.					

Table 1. Thermal Energy Storage System Data (continued)					
Hour	M Flow Rate through Storage Device L/s gpm	N Pressure Drop for Service Device kPa psi	O Storage Device Refrigeration Energy Input, kWh (electric chiller) or kWh kBtu (gas-fired chiller)	P Saturated Suction Temperature5 Degrees C F	Q Storage Device Parasitics Electrical Input
0-1					
1-2					
2-3					
3-4					
4-5					
5-6					
6-7					
7-8					
8-9					
9-10					
10-11					

Table 1. Thermal Energy Storage System Data (continued)					
11-12					
12-13					
13-14					
14-15					
15-16					
16-17					
17-18					
18-19					
19-20					
20-21					
21-22					
22-23					
23-0					
Totals					
Notes:					
5.	Applicable where refrigerant is the charge fluid.				

2.4 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).
****

Coordinate and integrate controls for the thermal energy storage system with the refrigeration system controls package specified in Section 23 64 10 WATER CHILLERS, VAPOR COMPRESSION TYPE. Design thermal energy storage system in accordance with the manufacturer's recommendations and to comply with the sequence of controls indicated. Design controls, control strategies, storage system configuration, piping, sensors and all ancillary equipment to ensure that the system performs as specified during partial, peak, and intermittent loading.

The controls for the thermal energy storage system must continuously measure the ice inventory of storage unit and relay this to the refrigeration controls package.

a. The controls must 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.

b. The controls must 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.

2.4.1 Communicating System Controller

A fully programmed [LonWorks] [BACnet] compatible communicating system controller must be furnished by the thermal energy storage manufacturer to provide completely integrated control of the thermal storage system for 24 hour system performance.

a. Provide digital application controllers capable of advanced preprogrammed functions with all memory and clock backed up for minimum 72 hours without data loss. Interface with chiller microprocessor to provide lead-lag operation and partial loading as required to meet hourly load profile for the building.

b. Provide graphical software that shows all equipment, temperatures and system modes/status. Provide software for automatic, schedule based, and manual operator control system. System must include preprogrammed control sequences, operator graphics reports, and drawings. Preprogrammed sequences must include one chiller, no heat exchanger; two chillers, no heat exchanger; one chiller with heat exchanger and two distribution pumps; and two chillers with heat exchanger and two distribution pumps.

c. System must include the following control functions: system scheduling; at least six modes of operation including off; chiller only - single and multiple chillers; ice only; chiller and ice; make ice; and make ice and cool.

d. Control system must have system mode determination; chiller plan demand limiting; ice inventory system management; chilled fluid system control; chiller/ice sequencing and control; color graphic based chiller and plant status screens; system and chiller diagnostic messages; system and chiller reporting; [and] failure modes and recovery; [heat exchanger sequencing and control;] [and pump control for water loops].

e. System must automatically switch between full ice storage mode on cool days, partial storage ice priority on warm days, and partial storage chiller priority on hot humid days as required to maintain indoor design temperature and relative humidity.

f. Graphical dashboards must indicate real time kW tons capacity, KW usage by chillers and pumps, ice inventory and melt rate.

g. System must have logging and trending capability to monitor various control points, status points, setpoints, and monitoring points.

2.4.2 Custom Color Graphics

Provide all information to show custom color graphics of all system components and schematic piping with temperature, pressure and diagnostics and status. Graphics include, but are not limited to:

2.4.2.1 System Schematic

Include temperature, setpoints, valve positions, tank status and ice inventory, key system operating parameters and hot links to other graphics pages.

2.4.2.2 Trends and Gauges

Dashboard style graphical representation of chiller, tank and system temperatures with override hot links, gauges showing instantaneous real time load on chiller, tanks, and building, with links to 7-day history

2.4.2.3 Savings Summary

Graphs showing kW demand, and kW usage savings, including present day, month to date and year to date.

2.4.2.4 Mode Chart

Printable matrix indication of modes as described above and position/status of pumps, chillers, and valves, with present values indicated and with present operating mode highlighted.

2.4.2.5 Strategic Data

Recap of thermal storage performance, including tons and kW, KWh and dollar savings, with hot links to the following trend logs and graphs. Take data at 15 minute intervals:

a. Building load

b. Chiller load

c. Ice inventory

d. Ice melt rate

e. Ice freeze cycle

f. Ice tank status

g. Chiller kW

h. End of day ice charge

i. kW shifted

2.5 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.

Tanks specified below are constructed of plastic and have a capacity range of [_____] kWh 50 to 500 ton hours each. These can be manifolded together to increase capacity. These are internal melt type storage units.
****

Each ice storage unit must have a net usable capacity of [____] kWh ton-hours. Design the ice storage tanks for a minimum 25 year service life and construct solely of corrosion-resistant materials, consisting basically of a cylindrical container, spiral tubular heat exchanger and supply and return headers. Each tank must have factory rated and published charge and discharge performance curves. The tanks must be suitable as standard for [installation above ground] [partially buried as shown in partially buried specifications] [fully buried as shown in fully buried specifications] and must produce a floor loading of no more than [____] kg/m2 pounds per square foot.

Each tank must be capable of being individually isolated from the thermal storage system so that each may be serviced without interrupting the operation of the total system. Provide factory rated and published charge and discharge performance curves for each tank that clearly indicate usable ton-hours of storage at the system design temperatures shown in the plans and specifications. Show usable kWh ton-hours on these curves and submit with the submittal package. Average charging ethylene glycol temperature (average over ice making hours) and final charging temperature must meet minimum scheduled performance as listed.

[2.5.1 Polyethylene Ice Storage Unit

2.5.1.1 Tank Container

Provide a cylindrical container constructed of polyethylene with an average thickness of 9.5 mm 3/8 inch and a minimum ultimate strength of 18,000 kPa 2600 psi in accordance with ASTM D638. The tank must be able to withstand total freezing of the water within it through repeated cycles without damage. Insulate the bottom and sides of the tank with a minimum R-factor of [9] [_____] and insulate the top with a minimum R-factor of [16] [_____]. Standby losses must not exceed 1 percent of the total stored capacity over an 29 Degrees C 85 Degrees F day. Cover the sides of the tank with 0.8 mm 0.032 inch textured aluminum sheet; weighing no more than 113 kg 250 pounds, with smoothed edges or handles for easy and safe gripping. Design tanks to withstand, without damage or distortion, repeated cycles of total freezing of all water within it due to control malfunctions or ambient temperatures for warranty period. Warrant the tank container for a period of 10 years.

2.5.1.2 Tank Heat Exchanger

Provide tank of welded polyethylene construction. The tank must contain a spiral-wound, mat-type heat exchanger consisting of polyethylene tubing arranged in multiple parallel circuits with opposite direction of flow in adjoining tubes. The heat exchanger must be capable of operating up to a 620 kPa 90 psi maximum pressure and have a minimum burst pressure rated for 4 times the maximum operating pressure. Factory hydrostatically pressure test each ice tank heat exchanger and its associated piping to a minimum of 1724 kPa 250 psi after tank insertion, not prior.

][2.5.2 Steel Ice Storage Unit

****

NOTE: Steel tanks are used for larger capacity thermal storage systems. They are available in either internal melt (primarily for HVAC applications) or external melt systems (primarily for process applications)

****

The ice storage units must be modular in design. Unit design must allow units of different sizes to be installed in order to optimize unit selection and minimize space requirements. Assure internal piping arrangements that create a balanced flow due to uniform pressure drop through the coil circuits allow mixed tank sizes.

2.5.2.1 Tank Container

Construct the tank of heavy-gauge galvanized steel panels and include double brake flanges for structural strength. Provide the tank walls with a minimum of 114 mm 4-1/2 inches of insulation that provides a total insulating value of R-18. Utilize multiple liners: the primary liner, which forms the interior of the unit, must be of single piece construction and be suitable for low temperature applications; the secondary liner/vapor barrier must be separated from the primary liner by 38 mm 1-1/2 inches of extruded polystyrene insulation. Insulate the tank bottom must be insulated with 50 mm 2 inches of expanded polystyrene insulation and 25 mm 1 inch of extruded polystyrene insulation.

Provide the ice storage unit with watertight, sectional covers constructed of hot-dip galvanized steel. Insulate the covers with a minimum of 50 mm 2 inches of expanded polystyrene insulation.

2.5.2.2 Tank Heat Exchanger

Contained within the tank must be a steel heat exchanger that is constructed of 27 mm 1.05 inch O.D., all prime surface serpentine steel tubing encased in a steel framework. Pneumatically test the coil, which is hot-dip galvanized after fabrication, at 1310 kPa 190 psig and rated for 1034 kPa 150 psig operating pressure. Configure the coil circuits to provide maximum storage capacity. Provide the galvanized steel coil connections on the unit that are grooved for mechanical coupling.

2.5.2.3 Sight Tube

Provide each ice storage unit with a sight tube. Fabricate the sight tube from clear plastic pipe to display the tank water level and corresponding ice inventory.

]2.6 PIPING COMPONENTS

Provide piping components as specified in Sections 23 64 26 CHILLED,

CHILLED-HOT, AND CONDENSER WATER PIPING SYSTEMS and 23 23 00 REFRIGERANT PIPING. Provide all heat tracing tape required for inventory meters, site glasses, and connections.

2.7 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 ADJUSTABLE SPEED DRIVE SYSTEMS UNDER 600 VOLTS.

****

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 and in accordance with NFPA 70. Provide 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. For packaged equipment, the manufacturer must 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 must be rated for continuous duty with the enclosure specified. Motor duty requirements must allow for maximum frequency start-stop operation and minimum encountered interval between start and stop. Motor torque must 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. Fit motor bearings 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 ADJUSTABLE SPEED DRIVE SYSTEMS UNDER 600 VOLTS.]

2.8 FACTORY FINISH SYSTEM

Coat new equipment with a manufacturer's factory-applied finish that meets the following requirements:

a. The [factory paint system] [galvanized metal] finish system designed for the equipment must 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 must have passed the 500-hour salt-spray fog test of that standard. [Equipment located in a sea coast environment must withstand 3,000 hours in a salt-spray fog test.]

b. The film thickness of the factory painting system applied on the equipment must 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 must be designed for the temperature service.

2.9 GLYCOL

Provide a fully formulated, inhibited ethylene, or propylene glycol-based, industrial heat transfer fluid specifically designed for use in HVAC and ice storage systems. The fluid must contain a complete package of corrosion inhibitors, buffers (reserve alkalinity), antifoam agent to lessen pitting and erosion, and a fluorescent dye to help detect leaks.

[2.10 GLYCOL TO WATER PLATE AND FRAME HEAT EXCHANGER

****
NOTE: Choose either this option or the next subpart option.
****

Provide heat exchanger consisting of embossed (pressed) plates with V-shaped herringbone pattern. Build the exchanger for design operating pressure, temperatures, capacities and fluids. Heat exchanger must be produced and supplied by thermal energy storage system manufacturer. The heat exchanger construction must consist of a frame, plate pack, fixed head, moveable follower, carrying bar, guiding bar, support column and tightening bolts. Construct plates of cold formed 316 stainless steel. Gaskets must be single piece molded design of Nitrile Rubber (NBR), EPDM or Viton. Glue gaskets to keep gasket in place during opening and closing. Arrange the plates and gaskets to ensure that the fluids do not intermix and any leaks are to the outside of the heat exchanger.

][2.11 GLYCOL MANAGEMENT SYSTEM

****
NOTE: Choose either this option or the previous subpart option.
****

Glycol management system must pressurize system to maintain proper volume of liquid in the building circulating loop, monitor the system pressure, and add fluid from a reservoir to the system when the pressure drops below the set point. The liquid pressurization system must be factory engineered and tested as a complete unit. Provide a unit approved for outdoor use using a TEFC pump motor and hot-dipped galvanized frame. Include a minimum 225 L 60 gallon covered, vented, reservoir with 30 L 10 gallon graduations. Provide system with an adjustable pressure relief valve which protects against accidental over-pressurization by the management system; and a check valve between building and filling system along with a service valve between reservoir and pump. Provide alarms with both visual indicating lights and remote contact points indicating the following conditions: low system pressure, low liquid level in reservoir, high liquid level, loss of power and low solution level. The minimum pumping capacity must be 0.2 L per second 3 gallons per minute at 550 kPa 80 psig.

]2.12 ICE INVENTORY METER

Provide an ice inventory meter to measure the quantity of ice in the thermal storage tank and provide both a visual indication and an electronic signal (4-20mA) suitable for remote monitoring. The inventory meter must consist of a weather resistant control box, air pump, tank probe and twin tubing. Supply [115V] [230V] power to the control box and draw less than one amp. Provide meter with an analog magnehelic type visual indicator factory calibrated at 0 to 100 percent and the 4-20mA signal must also be factory adjusted to the same range. Avoid requiring field adjustment of the analog meter or electronic transducer. Mount and position the measurement probe (air supply tube) in a thermal storage tank cover in accordance with manufacturer's instructions.[Provide special adaptors as required for buried thermal storage tank.] Include factory supplied twin tubing to connect it to tank probe. Instrument must be accurate to within plus or minus 5 percent and provide data required to determine remaining ice inventory. Do not use the instrument to indicate full charge for the purpose of terminating the ice building process.

2.13 SOURCE QUALITY CONTROL

Submit test reports for the factory tests in booklet form, upon completion of testing. Document all phases of tests performed including initial test summary, all corrections and adjustments made, and final test results.

PART 3 EXECUTION

3.1 INSTALLATION

Installed as indicated and according to the manufacturer's system diagrams and recommendations, including space required for maintenance. Submit proposed diagrams, at least 2 weeks prior to start of related testing and as specified.

3.1.1 Piping

Install piping as specified in Section 23 64 26 CHILLED, CHILLED-HOT, AND CONDENSER WATER PIPING SYSTEMS. Arrange piping for easy dismantling to permit tube cleaning.

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. Pertinent portions of Sections 13 48 73, 23 05 48.19, 22 05 48.00 20 properly edited, must be included in the contract documents.
****

Install all equipment within the space allotted on the drawings. Include adequate space in the layout to accommodate the maintenance requirements as recommended by the manufacturer. Set floor-mounted equipment, unless otherwise indicated, on not less than 150 mm 6 inch thick concrete pads or curbs doweled in place. Concrete foundations for equipment must 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 must be of a mass not less than three times the weight of the components to be supported.

a. Provide piping connections to equipment mounted on pedestal blocks and piping connections to storage units with flexible connectors. Furnish foundation drawings, bolt setting information, and foundation bolts prior to concrete foundation construction for all equipment indicated or required to have concrete foundations.

b. Provide concrete for all foundations as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE. [In addition, install tanks, compressors, pumps, valves, heat exchangers, and other similar items as specified under [Section 13 48 73 SEISMIC CONTROL FOR MECHANICAL EQUIPMENT,] [23 05 48.19 [SEISMIC] BRACING FOR HVZC,] [22 05 48.00 20 MECHANICAL SOUND, VIBRATION, AND SEISMIC CONTROL,] [and as shown on the drawings].]

c. Provide structural steel required for reinforcement to properly support piping, headers, and equipment but not shown under this section. Material used for support must be as specified under Section 05 21 00 STEEL JOIST FRAMING. The method of anchoring and fastening must be in accordance with manufacturer's instructions unless otherwise indicated.

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

e. Submit manufacturer's catalog data included with the detail drawings for the following items. Highlight the data to show model, size, options, etc., that are intended for consideration. Provide adequate data to demonstrate compliance with contract requirements for the following:

(1) Controls.

(2) Storage Units (including heat exchanger).

(3) Maximum charge and discharge rates and latent cooling capacity of each unit.

(4) Type of glycol recommended for use by both the refrigeration system and the storage system manufacturers. Provide information that lists the latent storage capacity. Highlight the recommended concentration of glycol for optimal performance based on the system capacity profile at the specified design conditions.

f. Protect units on site from physical damage. Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.

g. Level and support tank bottoms over the entire area and insulate from their supporting surface with insulation supplied by the tank manufacturer. Set non-plastic tanks on pressure treated Douglas Fir sleepers. Metal tank manufacturers must provide a factory applied mastic coating for corrosion protection.[

****

NOTE: Include following paragraph for burying of corrosion resistant ice storage units with covers exposed above ground level.

****

h. Only tanks that are certified by manufacturer as being designed for partial below ground installation are allowed. Install tanks in accordance with manufacturer's instructions.

(1) Place tanks in the bottom of a pit on a level placed concrete pad base which has a minimum load bearing capacity required by the manufacturer. Construct the pit so that no water will accumulate above the bottom of the base. Backfill with sand.

(2) After the concrete pad has set, the tanks can be lowered into the pit using a crane, rigging planks and straps. Fill the tanks with water to a height just covering the top of the heat exchanger tube in accordance with manufacturer's installation manual, then backfill with sand. The sand must be put into the pit in a uniform fashion, never creating more than a 300 mm 1 foot difference in the sand level in any portion of the pit. Install headers and then pipe them to the rest of the system.][

****

NOTE: Include following paragraph for burying of corrosion resistant ice storage units totally buried below ground level.

****

i. Only tanks that are certified by manufacturer as being designed for full below ground installation are allowed. Install tanks in accordance with manufacturer's instructions.

(1) Place tanks in the bottom of a pit on a level placed concrete pad base which has a minimum load bearing capacity required by the manufacturer. Construct the pit so that no water will accumulate above the bottom of the base. Backfill with sand.

(2) Place no more than [_____] mm inches of fill on top of the tank covers. Backfill with sand up to the tops of the tanks. Install an inspection port pipe extension on each tank for checking the water level in the tank. [Provide a special inspection port

extension for an ice inventory meter internally housing the meter's insertion probe.]This extension can also be used to check the depth of backfill above the tank.

(3) After the concrete pad is set, the tanks can be lowered into the pit using a crane, rigging planks and straps. Fill the tanks with water to a height just covering the top of the heat exchanger tube in accordance with the manufacturer's installation manual; then backfill the pit with sand. Place the sand into the pit in a uniform fashion, never creating more than a 300 mm 1 foot difference in the sand level in any portion of the pit. Install headers and then pipe them to the rest of the system.

(4) Charge the system with glycol/water mixture. Before burying the headers, run the system for a week at normal operating pressure with no loss of heat transfer fluid. After no loss is detected, insulate and cover the headers with sand flush to the tops of the pipes. Install inspection port extension pipes and then apply sand on top of the tank covers enough to just cover them. Fill final [_____] mm inches with [wood chips] [top soil]. Make the area above the tanks inaccessible to heavy equipment or wheeled vehicles that could damage tanks.]

3.1.3 Access Panels

Provide access panels for all concealed valves, vents, controls, and items requiring inspection or maintenance. Make access panels of sufficient size and locate so that the concealed items may be serviced and maintained or completely removed and replaced. Provide access panels as specified in Section 08 31 00 ACCESS DOORS AND PANELS.

3.1.4 Insulation

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

3.1.5 Special Requirements

Install 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 to provide a complete and operational thermal storage system.

3.2 FIELD PAINTING

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

3.3 CLEANING AND ADJUSTING

Wipe equipment clean, with all traces of oil, dust, dirt, or paint spots removed. Maintain the system in this clean condition until final acceptance. Lubricate bearings with oil or grease as recommended by the manufacturer. Tighten belts proper tension. Adjust control valves and other miscellaneous equipment requiring adjustment to setting indicated or directed. Adjust fans to the speed indicated by the manufacturer to meet specified conditions.

3.4 GLYCOL SYSTEM FILL

Install, clean, test and drain the piping system in accordance with good industry practice. Isolate the thermal storage tanks from the system during all cleaning and flushing prior to the final fill. Have sufficient new, empty drums at the job site to accommodate any overage of the fluid.

3.4.1 Fill for Flush

Measure the volume of the initial fill for flush with a water meter. The next to last drain must be an all low points drain. Meter the last fill for flush. Use high quality water, such as deionized, distilled or municipal water with less than 100 ppm calcium carbonate hardness and less than 50 ppm chloride plus sulfate ions.

Compare the water volume of the initial fill for flush with the water volume of the final fill for flush. Forward these two volume figures to the manufacturer's representative for the heat transfer fluid. Also, inform the manufacturer's representative if the storage tanks have been filled with water. Concentrated heat transfer fluid is required to adjust for the volume of water in the storage tanks.

3.4.2 Flush

Remove residue from cleaning solutions and corrosives. The final drain must be an all low points drain. If a hydrostatic pressure test is specified for the storage tanks prior to filling the system with heat transfer fluid, it should be performed only with high quality water after flushing the system since the water will remain in the storage tanks.

3.4.3 Heat Transfer Fluid

Order the heat transfer fluid by an option of three methods:

a. Premixed with deionized water and furnished in 208 L 55-gallon drums

b. Premixed with deionized water and delivered in volumes above 7570 L 2000 gallons via tanker truck

c. Furnished in 208 L 55-gallon drums of concentrate to be site-mixed with high quality water as specified above before adding to the system.

Fill out and return to the heat transfer fluid manufacturer a questionnaire detailing site conditions before bulk delivery.

3.4.4 Heat Transfer Fluid Filling

With the thermal storage tanks opened to the system, pump the heat transfer fluid into the fill connection. Before starting the fill pump, high points of the system must have vents open. Unlike filling with water, these vent locations must be manned at all times during the filling process in case the heat transfer fluid is inadvertently spilled. When the fluid reaches the vent, manually close the vent and stop the fill pump. Installers must take care to not pressurize the system above 620 kPa 90 psi.

3.4.5 Removing Air

Turn on the system pump for a few minutes at low speed or valve back to half flow. This action will move most air to the system high points. With the system pump off, open the vents and start the fill pump again. Repeat this procedure a few times. When most of the air is eliminated, run the system pump at full flow.

Use the system air eliminator to remove final amounts of air.

3.5 TESTING, ADJUSTING, AND BALANCING

The requirements for testing, adjusting, and balancing are specified in Section 23 05 93 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS. Begin testing, adjusting, and balancing when the entire HVAC system, including controls, has been completed with the exception of performance tests. Submit proposed test schedules for Performance Test and Operational Test, at least 2 weeks prior to the start of related testing. Charge the thermal energy storage system 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.

3.6 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 for the thermal energy storage system must conduct a training course for operating and maintenance personnel as designated by the Contracting Officer. Submit proposed schedule and training material for field training at least 2 weeks prior to the start of related training. Provide training for a period of [_____] hours of normal working time and start after the system is functionally complete but prior to the performance tests. The field instruction must 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 DVD video recording. The recording must 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 must send the answer, in writing, to the Contracting Officer for transmittal to the trainees.

3.7 PERFORMANCE TESTS

After testing, adjusting, and balancing has been completed as specified, test the system as a whole to see that all items perform as integral parts of the system and that operation is as specified. Submit detailed test plan for the cool energy storage system as part of the overall Commissioning Plan. Submit system performance tests report for performance tests in booklet form, upon completion of testing. Test report must have a Statement of Design Intent that includes:

a. Narrative description of the system

b. Performance goals for energy consumption and electric demand

c. Hourly operating profile for design day and minimum-load day

d. Schematic diagram of piping system, including cool storage system

e. Description of control strategies for all possible modes and conditions

f. Maximum usable ice storage discharge temperature

g. Maximum usable cooling supply temperature

h. Criteria for determining fully charged and fully discharged conditions

i. Maximum amount of time available for charging storage

Document all phases of tests performed in the report, including initial test summary, all corrections and adjustments made, and final test results. Make corrections and adjustments as necessary to produce the conditions indicated or specified, and test(s) repeated in entirety until results are satisfactory. Tests must be conducted by the thermal energy storage system and chiller manufacturer's representative. Furnish all instruments required for tests. The accuracy of test instruments must be as specified in Section 23 05 93 TESTING, ADJUSTING, AND BALANCING. Perform tests as described in the paragraphs below:

3.7.1 Operational Test

****

NOTE: Operational Test should be performed when temperatures are approaching or exceeding design day conditions and all lights are on in building so that there is a significant building cooling load to utilize the cool storage energy and demonstrate the various modes of operation.

****

Demonstrate that the entire system is functioning according to the specifications in all modes of operation such as charging (ice making only), partial storage - ice priority (warm day with both ice storage and supplemental chiller), partial storage - chiller priority (hot, humid design day with both chiller and supplemental ice storage), discharge (cooling from ice storage only), and chiller off (cold day) modes of operation. Where the system is designed for high cost on-peak window utility rate structure, demonstrate appropriate modes of operation at specified times of day. All other systems such as hot day/mild day/cold day control scheme must also demonstrate appropriate modes of operation at specified times of day. Test systems designed for proportional control to divide the load between chiller and ice storage to demonstrate components are proportionally loaded per specification. The operational test must cover a period of not less than [72][_____] continuous hours of operation using only system controls in normal mode and specified sequence of operation. Make ice inventory recordings in each storage unit at hourly intervals for the duration of the time period. In addition, record weather controls, including the ambient temperature and humidity in a shaded and weather protected area at hourly intervals along with ice inventory. Also record the building temperature and relative humidity for all zones served at hourly intervals.

3.7.2 Discharge Test

****

NOTE: Discharge testing under field conditions will usually not provide accurate results. Where tank manufacturer already has factory rated and published discharge performance curves, consider whether discharge testing adds value. Discharge testing must also be scheduled during the cooling season so that there is a building cooling load for discharging the cool storage energy and chiller cooling capacity.

****

Conduct discharge test in accordance with ASHRAE 150 with the exception of staying within acceptable deviations from the Specified Load Profile. The actual field tested profile may be done on a best effort basis allowing for reduced building cooling load conditions. This test is intended to measure the amount of cooling energy that can be delivered from the thermal storage device to meet the building cooling load. Begin the test with the thermal storage device in the fully charged condition. Continue the test until the thermal storage device can no longer provide the maximum leaving storage water temperature. Record data and determine total discharge cooling capacity in accordance with ASHRAE 150. In addition, record weather conditions, including ambient temperature and humidity in a shaded and weather protected area and all other pertinent temperatures and weather conditions at hourly intervals along with ice inventory.

3.7.3 Charge Test

****

NOTE: Charge testing under field conditions will usually not provide accurate results. Where tank manufacturer has factory rated and published charge performance curves, consider whether charge testing adds value. Charge testing should only be used on "full storage" systems where the chiller operates only during the 12-hour unoccupied period to charge the ice storage and there is no building cooling load. More often,"partial storage" systems in which a fully loaded chiller operates continuously throughout a design cooling day both charging the ice storage and cooling the building are used, which would be difficult to replicate in a field test unless it occurs on a design day.

****

Conduct charge testing in accordance with ASHRAE 150. The test is intended to measure the amount of cooling that can be stored in the thermal storage device within the time period available for charging. Begin the Charge Test with the thermal storage device in the fully discharged condition. Supply chilled fluid to the thermal storage device at the rate and at the temperatures specified for the design day. Continue the charge test until the thermal storage device reaches the fully charged condition or until the maximum allowable charging period has elapsed. Record data and determine total discharge cooling capacity in accordance with ASHRAE 150.

3.8   OPERATIONS AND MAINTENANCE

3.8.1   Operation Manual

Submit [six] [_____] operation manuals listing step-by-step procedures required for system startup, and shutdown, at least 2 weeks prior to field training. Include in the manuals 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 must be capable of providing [4] [_____] hour on-site response to a service call on an emergency basis.]

3.8.2   Maintenance Manual

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

3.8.3   Operation and Maintenance Training

Provide training in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA. Training must also include preventative maintenance procedures to minimize Legionella contamination in accordance with manufacturer. Submit training schedule and content for review and approval prior to training.

-- End of Section --