SECTION 237100 - THERMAL BATTERY COOLING SYSTEM

1.1 GENERAL

A. The thermal battery - Ice Storage System, shall be supplied from one single source with complete system responsibility. The Ice Storage system, including chiller(s), ice tank(s), plate and frame heat exchanger, and ice storage system control (as specified elsewhere), shall be provided by a single organization. The system supplied must provide twenty-four-hour design day cooling system capacity and performance as indicated in the plans and specifications. This organization shall have factory trained service technicians who will be responsible for the start-up and first year parts and labor warranty of the system including warranties listed elsewhere in the bid documents. The Ice Storage system equipment manufacturer must have supplied at least 10 systems of 5,000 ton-hours or more capacity within a radius of 50 miles of the job site, all of which have operated successfully for at least five years. The Ice Storage Tank, comprised of an insulated vessel and internal heat exchanger tubing, shall be modular in design and be field connected into groups of 2, 3 or 4 ice storage tanks as shown on the plans. The field connected storage vessels shall be of equal capacity to facilitate balancing and shall be filled with water as a freezing fluid, such that the ice tank heat exchanger is totally submerged. The ice tank heat exchanger, in all thermal storage tank modules, shall be piped in parallel and a chilled polypropylene glycol solution of XX% shall be circulated through the tubes. In the charging mode of operation, a cooled glycol solution shall cause ice to form and build on the tube surfaces. In the discharging mode of operation, the melting ice from around the tube surfaces shall cool the glycol solution. The Storage Tanks shall be of the Internal Melt design (the term comes from the fact that during the discharge mode of operation the ice is melted from the tube surface internal to the ice that encases the tube).

B. CALMAC Ice Bank is basis of design. Encapsulated and external melt systems are not acceptable.

1.2 ICE STORAGE SYSTEM PERFORMANCE

A. Daily performance of the ICE ENERGY STORAGE system shall be as scheduled on the twenty-four-hour load profile in the specifications and/or on the drawings. Suppliers shall provide information in accordance with the current *ARI Guideline for Specifying the Thermal Performance of Cool Storage* that proposed equipment will meet minimum performance specified. Each Ice Storage Device shall have factory rated and published charge and discharge performance curves that clearly indicate usable ton-hours of storage at the system design temperatures shown in the plans and specifications. Usable ton-hours shall be shown on these curves and shall be provided with the submittal package. Average supply charging temperature of the glycol (average supply temperature over ice making hours) and final charging temperature must meet minimum scheduled performance as listed. Chiller performance, capacity, and efficiency must also comply with the performance scheduled. Manufacturer’s computer selection program output must demonstrate net usable ton-hours using design day load profiles based on actual operating conditions. If the ice making chillers have centrifugal compressors, chiller manufacturer and ice tank manufacturer must provide a written and signed statement indicating that the equipment provided is a proper match with bid documents.

1.3 ICE STORAGE VESSELS

A. The modular ice storage tank design shall incorporate structure and storage fluid containment in a one-piece (sides and bottom) seamless vessel or seamless containment liner designed for a minimum 30-year service life and shall be constructed solely of corrosion-resistant materials. The vessel shall consist of a seamless one-piece design manufactured with rotationally molded corrosion resistant polypropylene with an average thickness of 3/8 inch (9.5 mm) and a minimum ultimate strength of 2600 psi (18,000kPa) per ASTM D 638-08.

B. The vessel shall include a factory assembled isolated expansion chamber to prevent expansion water from forming capacity reducing ice caps. The vessel shall be totally repairable in the field. Installations shall require no more than three feet of overhead clearance for any ice tank heat exchanger or liner repair.

C. If required by installation manual, manufacturers of thermal storage tank vessels shall provide, install, and warrant tank safety switches and temperature sensors. Manufacturer shall notify control contractor of the quantity of safety BAS points required for the tank farm. Float switches, inventory meters, and sensors shall be included in the ice tank warranty.

D. Steel structured tanks with containment liners may be used if provided with a duplex coating consisting of a powder coating over hot-dipped galvanized steel. The duplex treatment is to include all exterior and interior surfaces, edges, and all internal support structures. Steel vessels must include a minimum of 18 inches between adjacent vessels and walls to perform exterior wall and frame corrosion inspections and maintenance without extending the basis of design tank farm footprint.

E. The duplex treatment shall be applied to all exposed steel and metal edges and welds. Ice tank and fluid containment shall be warranted as designated under warranty section.

F. All thermal storage tanks, and if needed tank liners, must be designed and able to withstand, without damage or distortion, repeated cycles of total freezing of ALL water within it which may be due to control malfunctions or ambient temperatures. Damages caused by a total freeze shall be repaired by manufacturer during warranty period defined in the ice tank vessel warranty in this specification. A total freeze shall not void warranty other warranty coverages.

G. All thermal storage vessels must be capable of being re-deployed after original commissioning for use at other sites with remaining specified warranty in force. If redeployment is not possible without a redeployment kit, provide price add for entire system add for redeployment capabilities.

H. Manufacturers of thermal storage tank vessels shall provide, install, and warrant all heat tracing tape if required for inventory meters, site glasses, and connections.

1.4 ICE TANK HEAT EXCHANGER

A. The ice tank shall contain a spiral-wound, mat type heat exchanger, constructed entirely of polypropylene headers and 5/8-inch O.D. polypropylene tubing arranged in multiple parallel circuits with OPPOSITE direction of flow in adjoining tubes for even ice making and melting. To avoid blockages from sediment accumulation, a majority of the heat exchanger surface shall be oriented in a horizontal manner. To avoid blockages from particulate the minimum aperture that coolant will need to pass through shall not be less than 3/8”.

B. Manufacturers supplying heat exchanger tubing with a majority of vertical flow paths must install and warrant a self-cleaning 5-micron glycol fluid filter and strainer system to filter glycol entering tank farm to eliminate tube blockages in heat exchanger tubes.

C. All heat exchanger connections and internal header connections shall be welded. Mechanical fittings of any kind are not acceptable. *If the tank heat exchanger tubing and the internal tank distribution piping do not include welded construction, the ice tank manufacturer must provide factory personnel to annually inspect all mechanical connections for twenty-five years.*

D. Steel heat exchanger tubes (1.05" O.D.) may be used provided steel framework is hot dip galvanized and powder coated after fabrication and coated as directed above in tank specification. All ice tank heat exchangers shall be warranted as specified elsewhere.

E. The heat exchanger shall be capable of operating up to a 90 psi (620 kPa) maximum pressure and shall have a burst pressure rated for 4 times the maximum operating pressure.

F. Each ice tank heat exchanger and its associated piping shall be factory hydrostatically-pressure tested to a minimum of 250 psi (1724 kPa) after tank insertion, not prior, and be documented. The pressure test documents shall be supplied with tanks upon request.

G. Multiple modular thermal storage tank systems shall be piped parallel in reverse return for self-balancing. At design conditions the ice tank flow shall not change greater than 3% by varying the pressure across the tank farm by one foot (0.43 psi). Manufacturers unable to meet this criterion must provide install and warrant balancing valves for the tank farm. Manufacturer must provide pressure drop curves of ice tank with submittal package.

H. The heat exchanger should be repairable without removal from tank Ice tanks that require removal of heat exchanger for tube repair shall include enough room in their ice tank farm footprint for rigging apparatus and have preapproval for space acquisition and layout changes by engineer. If removal of tank heat exchanger is required during warranty period, tank manufacturer shall provide to owner, at their option, money or labor for heat exchanger removal and replacement during containment warranty period.

I. Pressure relief valves between each tank, and valves that connect the tank to the system, must be provided and warranted by non-basis of design ice tank manufacturer's if required by that ice tank manufacturer.

1.5 ICE TANK COVERS

A. Covers shall be provided for all ice modules and/or tanks. Covers for buried vessels shall be designed to support architectural landscaping wood chips, or other similar material, having a maximum depth of twelve inches. Covers shall also support the weight of 2 average adults (200 pounds) at any point on the tank farm.

B. Covers shall be in modular sections that can be readily lifted, removed, and replaced by two men. Each section shall weigh no more than 250 pounds and shall have smoothed edges or handles for easy and safe gripping.

C. Each vessel shall have at least one inspection port in the cover, which can be used for visual inspection, determining liquid level, and for filling the vessel with water, without removing the cover(s).

D. Covers for steel vessels shall be a minimum of 16 gauge stainless or 14 gauge for hot dipped galvanized and powder coated steel of the same process used on sides, bottom and support structures.

E. Ice tank covers shall have seamless tops to prevent rainwater or snow melt from entering ice tank. Warranty coverage for ice tank covers shall include replacement covers if lids allow rainwater to enter tank during warranty period.

1.6 ICE TANK INSULATION

A. The bottom, sides and cover(s) of each vessel shall be factory insulated. Insulation on the interior of the structural containment vessel is unacceptable.

B. Manufacturer must provide adequate insulation to limit standby losses not to exceed ONE PERCENT of the total stored capacity when in an 85-degree F. environment for a period of twenty-four hours.

C. For polypropylene vessels that freeze solid the bottom and the sides of the tank shall be insulated externally with a minimum of two inches of expanded polystyrene or polyurethane applied in overlapping layers having a total minimum R- factor of nine (9). Insulation of sides shall be covered with a .032-inch-thick aluminum jacket for protection and reflectance.

D. The covers of all vessel types shall have insulation injected into the interior cavity of the cover and have an average R- factor of 24. Insulation with direct access or contact with the storage fluid or ambient air is not acceptable.

E. For stainless steel or duplex coated steel vessels insulation meeting the standby loss criteria shall be applied between the exterior of the containment wall or pool type liner and the interior of the structural support system. Insulation of sides and bottom of vessel shall be covered with a minimum 30 mil thick PVC or EPDM impermeable liner, with all seams and joints double lapped and solvent welded. All fastening materials used to hold the liner in place shall be non-corrosive plastic, or stainless steel. Galvanized fasteners are not acceptable.

1.7 ICE STORAGE COOLING SYSTEM

A. Hydrostatically flush clean and field pressure test all piping EXTERNAL to thermal storage tanks as specified elsewhere to remove welding slag, flux, and dirt. If hydrostatic test is with water the ice storage tanks shall be valved off (isolated) to eliminate filling the ice tanks with water, which cannot be easily replaced with the pre-mixed glycol.

B. After successful completion of the test, drain the system and add premixed glycol to the system as described in another part of the specification. Upon completion of the filling and removal of air, pressures test the ice tanks in accordance with manufacturer's recommendations.

C. The system shall be filled with a pre-mixed glycol solution resulting in a minimum three parts de-ionized water to one part inhibited glycol when operation. (25% mixture or greater as specified elsewhere can be initially installed and local approved tap water can be used to bring system to final 25%). Glycol shall be a formulated premixed product like Dowtherm or Wintrex. Automotive glycol, and field inhibited glycol is not acceptable. See heat transfer fluid specification. The piping system shall contain a 2-inch fill port on the suction side of the system glycol pumps.

D. A lug type, full flow shut off valve shall be included (supplied by contractor) for field installation and insulation in the supply and return lines of each grouping of 3 tanks. Liquid level, and/or pressure switches in the expansion tank shall provide glycol system leak protection.

E. Tank bottoms shall be level and supported over the entire area and insulated from their supporting surface with insulation supplied by the tank manufacturer. Follow manufacturer's installation recommendations for partially buried or totally buried tanks.

F. The thermal storage farm system shall be provided with ice inventory-measuring device, which will indicate the amount of ice available at any time within an accuracy of +/- 5 percent. Each ice tank manufacturer shall provide the number of meters indicated in their installation literature. This ice inventory measuring device(s) shall also be equipped with an electric transducer capable of producing a 4 - 20 ma. signal which can interface with the building automation system.

G. This device is for indication only and is NOT TO BE USED FOR TERMINATION OF CHARGE CYCLE CONTROL OF ICE SYSTEM.

1.8 TREATMENT OF PHASE CHANGE WATER

A. The ice tank manufacturer shall supply the first water treatment chemicals required for treatment of the phase change water against biological growth AND tank corrosion.

B. The treatment must eliminate algae, bacteria, and metal corrosion (if metal tanks supplied). The submittal documents must contain the name(s), and quantities required for the ten-year chemical treatment. Rules for handling, storing, and the amount of room required for storing, , and rules for application must also be provided. Manufacturer of ice tanks using galvanized steel heat exchangers or mechanical fittings and fasteners must provide an annual inspection by factory-trained personnel for heat exchanger and tank corrosion during warranty period shown below.

1.9 ICE TANK VESSEL WARRANTY (tank containment)

A. The ice tanks (containment vessels) shall be warranted to cover all parts of the tank vessel against manufacturing defects for 10 years from the date of shipment to the jobsite. Manufacturers of ice tanks that require the installation of float switches, heat tracing tape, tank pressure relief valves, sight glass, and corrosion protection for phase change fluid containment and/or rain multi-piece covers shall provide a parts warranty to include all components of the containment system for TEN YEARS from date of shipment to jobsite. A *warranty certificate of authenticity* must be provided from the manufacturer at the time of submittal specifically mentioning the tank and required ancillary equipment parts warranty of 10 years, including all parts required for complete repair and/or redeployment. The warranty will remain in force through freeze solid events that could occur by any means. If the company liable for the ice storage tank offering, either manufacturer or broker, has been in business for a time period shorter than the length of the warranty period (10 years), a “Warranty Certificate” from a third-party warranty program is required. The certificate must come from a company that has been in the product warranty business for over 20 years and include the scope and length of the specified warranty. The warranty must include complete repairs of freeze solid events (total freezing of all of the water in the tanks) and remain in force after redeployment (moving the tanks to a new location) during the described warranty period.

1.10 ICE TANK HEAT EXCHANGER WARRANTY (internal tank components)

A. Manufacturer of ice tanks must provide complete parts warranty for ice tank heat exchanger (internal tank components) and ice inventory meter and/or ice thickness meter for 5 YEARS from date of shipment to job site.

B. A *warranty certificate of authenticity* must be provided from the manufacturer at time of submittal specifically mentioning the ice tank heat exchanger parts and labor warranty of 10 years including all parts and labor required for complete repair. The warranty will remain in force through freeze solid events that could occur by any means. If the company liable for the ice storage tank offering, either the manufacturer or broker, has been in business for a time period shorter than the length of the warranty period (10 years), a “Warranty Certificate” from a third party warranty program that has been in the product warranty business for over 20 years shall be provided.

C. It shall include the scope and length of the specified warranty and specify coverage of freeze solid events, 90 psi rating, sediment blockage, and coverage if the tanks are redeployed to a new location.

D. This limited parts warranty against manufacturing defects does not cover acts of God or misuse of the equipment. Access to the tanks must be provided to allow for service. Heat transfer fluid (glycol) disposal and make-up, if required, are not covered in this warranty.

Ice Energy Storage System Performance

CHILLER AND ICE TANK MINIMUM PERFORMANCE
ARI GUIDELINE T 2002

CHILLER COOLING MODE

Chiller capacity @ (system design temp.), 25% glycol, 95 deg. F. Ambient	____ tons
Chiller efficiency at above conditions	____ kw
Chiller glycol flow, cooling mode	____ gpm

CHILLER ICE MAKING MODE

Chiller capacity @ (average ice making temp.) 25% glycol, 80 deg. F. Ambient	____ tons
Chiller efficiency at above conditions	____ kw
Chiller flow, ice making	____ gpm

ICE TANK STORAGE FARM

Total Usable latent storage @ 50 deg. F. ent. / 42 deg. F. lvg., 25% glycol, 8 hours	____ tn-hrs
Ice making hours	____ hours
Average ice making glycol temperature minimum	____ deg F
Minimum ice making glycol temperature (last hour of charging)	____ deg F
Number of CALMAC Modules	____ modules
Model and Number of CALMAC tanks required	____ tanks

OPC System, chillers and tanks, must perform with the above minimum efficiencies and in accordance with the attached twenty-four-hour system profile.

To avoid chiller surging and to keep energy consumption as low as possible Ice Energy Storage Systems with lower ice making temperatures will not be accepted! Ice storage manufacturer must add surface area to increase system ice making temperature to comply with the above minimum system performance standards

Ice Energy Storage System Performance Specification

(Page 3 of CALMAC IcePick Selection Program See example next page)

SYSTEM TWENTY-FOUR HOUR DAILY PROFILE

HOUR & PD TYPE	LOAD TONS	CHLR TONS	STRG TONS	TANK TONS	TN-HRS TOTAL	TN-HRS/ TANK	REQD % CHRG	AVLB CHLR TEMP	GPM STRG TEMP	MIN TEMP	RET TEMP	PER TANK PSI
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												
16												
17												
18												
19												
20												
21												
22												
23												
24												

Tank model number: _____
Number of tanks required: _____
Hour type:

I - Ice making hour
P- Partial storage hour
F- Full storage hour

Example Design Day Ice Energy Storage System Analysis

Kohl's-Fallbrook Center, LA CA 1 5/3/02

DESIGN DAY SYSTEM ANALYSIS

CHILLER UPSTREAM - SERIES FLOW	NOMINAL CHILLER SIZE = 193.1
SYSTEM SUPPLY TEMPERATURE (F) = 40.0	NUMBER OF TANKS = 3 MODEL 1500
SYSTEM RETURN TEMPERATURE (F) = 51.3	PERCENT ETHYLENE GLYCOL = 25.0
FLOW (GPM) : DISCHARGE = 450	DELTA P (PSI) : DISCHARGE = 6.9
CHARGE = 450	CHARGE = 7.7
	AVAILABLE UNUSED ICE (TONHRS) = 439

HOUR & TYPE	LOAD TONS	CHLR TONS	STRG TONS	TANK TONS	TONHRS TOTAL	TONHRS PER TANK	% CHRG	CHLR TEMP	REQD STRG TEMP	AVLB MIN TEMP	RTRN TEMP	GPM PER TANK	PD PSI	F L G
1 I	0	142.4	142.4	47.5	406	135.5	23.8	23.6	31.7	31.7	31.7	150.0	7.7	
2 I	0	142.4	142.4	47.5	549	182.9	32.1	23.5	31.6	31.6	31.6	150.0	7.7	
3 I	0	142.4	142.4	47.5	691	230.4	40.4	23.4	31.5	31.5	31.5	150.0	7.7	
4 I	0	142.4	142.4	47.5	834	277.8	48.7	23.1	31.2	31.2	31.2	150.0	7.7	
5 I	0	142.4	142.4	47.5	976	325.3	57.1	22.8	30.9	30.9	30.9	150.0	7.7	
6 I	0	142.4	142.4	47.5	1118	372.8	65.4	22.3	30.4	30.4	30.4	150.0	7.7	
7 P	0	0.0	0.0	.0	1118	372.8	65.4	40.0	40.0	32.0	40.0	.0	****	
8 P	0	0.0	0.0	.0	1118	372.8	65.4	40.0	40.0	32.0	40.0	.0	****	
9 P	130	130.0	0.0	.0	1118	372.8	65.4	40.0	40.0	32.0	47.4	.0	****	
10 P	146	146.0	0.0	.0	1118	372.8	65.4	40.0	40.0	32.0	48.3	.0	****	
11 P	160	160.0	0.0	.0	1118	372.8	65.4	40.0	40.0	32.0	49.1	.0	****	
12 P	180	180.0	0.0	.0	1118	372.8	65.4	40.0	40.0	32.0	50.2	.0	****	
13 F	183	0.0	-183.0	-61.0	935	311.8	54.7	50.4	40.0	33.4	50.4	91.5	3.7	
14 F	192	0.0	-192.0	-64.0	743	247.8	43.5	50.9	40.0	34.8	50.9	101.7	4.2	
15 F	200	0.0	-200.0	-66.7	543	181.1	31.8	51.3	40.0	36.1	51.3	111.9	4.7	
16 F	192	0.0	-192.0	-64.0	351	117.1	20.5	50.9	40.0	37.1	50.9	118.5	5.1	
17 F	180	0.0	-180.0	-60.0	171	57.1	10.0	50.2	40.0	37.7	50.2	122.1	5.3	
18 F	171	0.0	-171.0	-57.0	0	.1	0.0	49.7	40.0	38.5	49.7	130.5	5.8	
19 P	154	154.0	0.0	.0	0	.1	0.0	40.0	40.0	32.0	48.7	.0	****	
20 P	142	142.0	0.0	.0	0	.1	0.0	40.0	40.0	32.0	48.0	.0	****	
21 P	0	0.0	0.0	.0	0	.1	0.0	40.0	40.0	32.0	40.0	.0	****	
22 P	0	0.0	0.0	.0	0	.1	0.0	40.0	40.0	32.0	40.0	.0	****	
23 I	0	121.7	121.7	40.6	122	40.6	7.1	25.0	31.8	31.8	31.8	150.0	7.6	
24 I	0	142.4	142.4	47.5	264	88.0	15.4	23.7	31.8	31.8	31.8	150.0	7.7	

TANK DISCHARGE DATA

HOUR	TYPE	TONS /TANK	INLET TEMP(F)	OUTLET TEMP(F)	% TANK DISCH	TONHRS DISCH	OUT OF RANGE
8	P	42.8	48.8	40.0	7.5	42.80	
9	P	30.3	47.4	40.0	12.8	73.10	
10	P	17.8	46.0	40.0	15.9	90.90	
11	P	30.3	47.4	40.0	21.3	121.20	
12	P	42.8	48.8	40.0	28.8	164.00	
13	F	61.0	50.4	40.0	10.7	61.00	
14	F	64.0	50.9	40.0	21.9	125.00	
15	F	66.7	51.3	40.0	33.6	191.67	
16	F	64.0	50.9	40.0	44.9	255.67	
17	F	60.0	50.2	40.0	55.4	315.67	
18	F	57.0	49.7	40.0	65.4	372.67	

END OF SECTION 237100