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Benefits

Lowest First Cost

Systems with ice thermal storage can be installed at the same or lower first cost than traditional systems when designed with the colder supply water available from ice. The savings that result from the use of smaller chillers and cooling towers, reduced pump and pipe sizes, and less connected horsepower offset the cost of the ice thermal storage equipment. Additional savings can be found when using lower temperature air distribution, which allows for reduced ductwork and fan sizes.

• **Smaller Chillers and Heat Rejection Equipment:** By designing the system around 24-hour per day chiller operation, the size of the chillers and cooling towers or air-cooled condensers required for an ice storage system is significantly reduced, when compared to conventional chillers and heat rejection equipment sized for the instantaneous peak load. A typical thermal storage design includes chillers that provide 50 to 60% of the peak cooling load. The balance of the cooling requirement is provided from the ice storage system.

• **Reduced Pump and Pipe Sizes:** Pump and pipe sizes are also reduced in a properly designed ice storage system. Substantial savings in the chilled water distribution loop are realized when the system design incorporates reduced flow rates that result from using a larger temperature range in the water loop. Use of a larger temperature range, for example 18°F (10°C) instead of the more traditional 10°F (5.5°C) results in a reduction of pipe size. Condenser water pipe sizes are reduced due to lower flow requirements for the smaller chiller. Pump savings due to reduced chilled water and condenser water flow rates are also realized.

• **Reduced Cooling Coil and Supply Air Fan Sizes:** Cooling coils sized using lower supply water temperatures and traditional supply air temperatures are generally smaller due to fewer rows. The reduction in rows leads to lower supply fan HP (kW).

• **Reduced Air Handling Equipment:** When the air distribution is designed with lower supply air temperatures, the size of the ductwork, fans and fan motors are reduced.
• **Reduced Electrical Distribution:** Smaller chillers, heat rejection equipment and pumps require less horsepower than a traditional system, which results in smaller transformers, switchgear, wire sizes and starter panels.

• **Reduced Generator Size:** If a facility has a generator for daily or back-up power, the size of the generator will be significantly reduced when the peak electrical load of the facility is reduced using ice storage.

**Reduced Energy Cost**

An ice thermal storage system reduces peak demand, shifts energy usage to non-peak hours, saves energy, and reduces energy costs.

• **Reduces Peak Demand and Shifts Energy Usage:** With less connected horsepower, ice storage can lower peak electrical demand for the HVAC or process cooling system by 50% or more. Since most electrical rates include demand charges during peak demand times and/or higher day versus night kWh charges, savings on electrical bills can be substantial. Peak electrical demand rates of $15 to $18 per kW are not uncommon. In areas with “real time pricing”, where the electric rate varies hour-by-hour based on the market price of electricity, day to night kWh costs can vary by 500 to 1000%. The use of electricity at night versus peak daytime hours can lead to large savings on energy bills.

• **Saves Energy:** Total annual kilowatt-hours used are less when the system is designed to take advantage of the low supply water temperature available from ice storage system. Lower kWh consumption is possible for several reasons:

1. Although making ice requires more energy than producing chilled water, the efficiency penalty is not as large since the ice is made at night when condensing temperatures are lower, increasing the efficiency of the chiller.
2. Ice systems typically operate the chiller at full load. Chillers are inefficient when run with low loads during the spring and fall. A conventional chiller will operate at less than 30% capacity for half the year.
3. Reduced pumping horsepower.
4. Reduced fan horsepower due to lower air pressure drop across the cooling coil. A higher chilled water temperature differential across the cooling coil usually results in fewer rows and therefore a lower pressure drop.
5. The ability to recover waste heat from the chiller for heating water both night and day.
Benefits

Additional kWh savings are possible if the air distribution is designed to take advantage of the low temperatures available from the ice storage system. As the electric industry continues to deregulate, and time-of-use rates, real time pricing schedules and negotiated power prices become standard, ice storage can provide even greater future savings in operating costs.

Variable Capacity

The ice storage system will maintain a constant supply temperature regardless of the variations in instantaneous cooling demand. The flow and entering water temperature set the instantaneous capacity.

Improved System Reliability

Ice storage systems provide the reliability necessary to ensure air-conditioning is available. With traditional systems, installing multiple chillers provides redundancy. In the event of a mechanical failure of one chiller, the second chiller provides limited cooling capacity. The maximum available cooling for the traditional system would only be 50% on a design day.

Most ice storage systems utilize two chillers in addition to the ice storage equipment. Two chillers are designed to provide approximately 60% of the required cooling on a design day while the ice storage provides the remaining 40% of the cooling capacity. In the event only one chiller is available to provide cooling during the day, up to 70% of the cooling capacity is available. The one operable chiller provides 30% of the cooling requirement while the ice provides up to 40%. Based on typical HVAC load profiles and ASHRAE weather data, 70% of the cooling capacity would meet the total daily cooling requirements 85% of the time.
**Reduced Maintenance**

The ice storage coils have no moving parts, so very little maintenance is required. Because the chillers, pumps and heat rejection equipment are smaller, ice storage systems will have less maintenance than a traditional system. The ice storage system also allows a chiller to undergo routine maintenance during the day when the ice storage can handle the system load.

**Environmentally Friendly**

Reducing energy consumption and using electricity at night will reduce global warming. Electricity generated at night generally has a lower heat rate (lower fuel use per power output), and therefore lower carbon dioxide and greenhouse gas emissions resulting in less global warming. The California Energy Commission concluded that the use of electricity at night created a 31% reduction in air emissions over the use of electricity during the day.

With smaller chillers, an ice storage system reduces the amount of refrigerant in a system. Most refrigerants in use today are slated to be banned in the future under the Montreal Protocol because they contribute to global warming. Using smaller amounts of refrigerant helps to save the ozone layer and reduce global warming.
Proven Technology

BAC has successfully applied ice storage technology to thousands of installations worldwide. BAC has the application and system experience to assist in the design, installation and operation of any ice storage system. BAC has supplied ICE CHILLER® Thermal Storage Products for projects that range in size from 90 to 125,000 ton-hours (0.3 to 441.3 MWh). Installations include office buildings, hospitals, manufacturing processes, schools, universities, sports arenas, produce storage facilities, hotels and district cooling applications.

The ICE CHILLER® Product includes a variety of factory-assembled units. For large applications, where space is limited or factory-assembled units are not cost effective, ICE CHILLER® Thermal Storage Coils are available for installation in field-erected tanks.

The BAC product offering provides system design flexibility. Ice can be built using various refrigerants or glycols on steel coils and is used to provide either chilled water or chilled glycol to the cooling system. This flexibility, combined with a broad range of application experiences, allows BAC to provide a cost-effective product to meet your specific requirements.

Merchandise Mart

Merchandise Mart in Chicago, Illinois installed 26,400 ton-hours (93.2 MWh) of ICE CHILLER® Thermal Storage Coils in a retrofit of the building’s air-conditioning system. The Merchandise Mart was built in 1930. The increased air-conditioning load on the building from computers, other electrical equipment and increased people density made the old system too small. Ice thermal storage, with low temperature water, allowed the retrofit of the air-conditioning system to go ahead without replacing piping and ductwork. Increasing the temperature ranges on the piping and air distribution system allowed the Merchandise Mart to install an ice storage system at a lower first cost than a conventional system.

Johns Hopkins Applied Physics Lab

The Johns Hopkins University Applied Physics Lab in Laurel, MD installed 5,600 ton-hours (19.8 MWh) of ICE CHILLER® Thermal Storage Coils to cool the new Steven Mueller Building which houses offices, labs and clean rooms. Another 2,800 ton-hours (9.9 MWh) of ICE CHILLER® Thermal Storage Coils were added to cool adjacent office and lab buildings. The ice thermal storage allows the Applied Physics Lab to save over $150,000 per year on its electric bill.
Friendship Annex 3 Office Building
The HVAC renovation of Friendship Annex (FANX) 2 and 3 in Baltimore, MD received the “Outstanding Engineering Achievement of the Year Award” from the Engineering Society of Baltimore. Ice with low temperature air distribution cools these renovated buildings. To meet federal guidelines, a comprehensive study of five alternate systems was made using life cycle costing. The analysis showed ice storage with low temperature chilled water and low temperature air to be the most economical system. A total of 15,230 ton-hours (53.8 MWh) of ICE CHILLER® Thermal Storage Units were installed for the two buildings.

Taipei 101
Taipei 101 is located in the central government and business district of Taipei, Taiwan. The building consists of a podium shopping and entertainment complex and office tower. Completed in August 2002, the 101-floor office tower is the world’s tallest building at 508 meters.

BAC ice storage equipment (36,450 ton-hours or 128.3 MWh) was selected because of its ability to provide low fluid temperatures, in this case 36°F (2°C). Low supply temperatures allowed economical selection of pressure isolation heat exchangers on the 42nd and 74th floors. Additionally, the low supply temperature allowed cold air distribution to be used throughout, thus reducing first costs and operating costs while providing improved occupant comfort.

IMUX Beijing District Cooling
IMUX Beijing District Cooling’s first central cooling plant is located in Beijing’s West Zone Zhongguancun Science and Technology Park, China’s largest science park focused on developing high-tech enterprises. The plant, largely located underground, incorporates 29,800 (104.9 MWh) ton-hours of BAC ice storage coils in a system which effectively uses less expensive nighttime power (75% less expensive than daytime power). Chilled water is supplied at 34°F (1°C) to a campus-style chilled water distribution loop. Many of the buildings served employ cold air distribution systems to achieve even lower construction and operating costs.
Proven Technology

Low Temperature Air

Omni Interlocken Resort Hotel

The Omni Interlocken Resort Hotel just outside of Denver, CO was designed with a low temperature air and water system using ICE CHILLER® Thermal Storage Units. The challenge was to design a high-quality HVAC system sensitive to building aesthetics, which would provide good guest comfort, low operating/maintenance costs and could be constructed within a tight construction budget. The first conceptual design was a four-pipe fan-coil system for the hotel rooms with air-cooled chillers and rooftop air-handler units for the public spaces. The final design was a low temperature air system with Modular ICE CHILLER® Thermal Storage Units. This low temperature air system was $500,000 less than the original conceptual design. In addition, the hotel’s energy bills are $100,000 less than with a conventional system.

Villa Julie College

Modular ICE CHILLER® Thermal Storage Units were part of an expansion that doubled the size of this private college in Baltimore, MD. The new facilities added 135,700 ft² (12,620 m²) of space to the campus and include a 400-seat auditorium and theater, gymnasium with showers and locker rooms, student center, video center, academic and computer classrooms, kitchen and administrative offices. The architect designed the new buildings with the intention that the structure be part of the visual space. This reduced the space allotted for the mechanical equipment. The engineer designed a low temperature air system that delivers 45°F (7°C) air temperature to VAV series fan powered boxes. The use of smaller piping and ductwork made it possible to avoid architectural changes that would affect the aesthetics of the design.
Food Processing

Zippy's Restaurant Central Facility
At Zippy’s in Honolulu, HI, food is cooked in a central kitchen where it is cooled and packaged for use in local Zippy’s restaurants. The FDA requires that the food in the cooking vessels be cooled to 45°F (7°C) in less than one hour to prevent contamination. The cooking vessels in the kitchen need varying amounts of cooling depending on the dish that is being prepared, and when it finishes its cooking cycle. Because of the varying cooling load from day to day and hour to hour and the need for a quick cool down period, standard chillers are not a good match for this application. Ice storage with its variable capacity and low supply temperature is an excellent match for this process cooling application.

Power Generation

Wolverine Power
Wolverine Power, located in central Michigan, is a generation and transmission electric cooperative. For a new generating plant with (2) 22-megawatt Rolls Royce turbines, Wolverine Power elected to use ice storage for their turbine inlet air cooling. They installed 7,610 ton-hours (26.9 MWH) of ICE CHILLER® Thermal Storage Units to generate 40°F (4.4°C) chilled water, which provides 55°F (13°C) inlet air.

The generating plant’s ice storage capacity can be used over a 16-hour period as partial storage or over a 4-hour period as full storage, depending on the value of power on the open market. During peak summer time, the increased power capacity is worth up to $3,500 per hour in electricity sales.

Emergency Cooling

Verizon
Verizon, the provider of telephone service to a large portion of the east coast, uses an ICE CHILLER® Thermal Storage Unit to provide back-up cooling to one of its computer centers in Silver Spring, MD. If the chiller that provides cooling goes down for any reason, power outage or alarm, the system immediately switches over to the ice storage system for cooling. The pump on the ice storage system is on the continuous power back up with the computers. There is enough ice to provide cooling for 30 minutes. This gives Verizon enough time to clear the alarm or get the back-up generator running and the chiller back on line.
Construction Details
Covers
• Watertight
• G-235 (Z700 Metric) hot-dip galvanized steel panels
• Insulated with 2” expanded polystyrene insulation

Coil Support Beams
• Prevent contact between coil and primary liner

Glycol Connections
• Grooved for mechanical coupling

Galvanized Steel Coil
• Continuous serpentine, steel tubing
• Hot-dip galvanized after fabrication (HDGAF)
• Pneumatically tested at 190 psig
• Rated for 150 psig operating pressure

Primary Liner
• Single piece
• 48-hour integrity test before shipment

Extruded Polystyrene Insulation
• 1.5” thick, installed between primary and secondary liners

Secondary Liner/Vapor Barrier
• Prevents moisture from penetrating through the insulation

Wall Panel
• Heavy-gauge galvanized steel with double brake flanges
• 3” of expanded polystyrene insulation

Sight Tube
• Visual indicator of water level corresponding to the amount of ice in the unit

Operating Control (Not Shown)
• High-level float switch and low water cutout mounted on the outside of the tank
• Provided on all tanks

Ice Inventory Sensor (Optional)
• Differential pressure transmitter provides an electrical 4-20 mA output signal which is proportional to the amount of ice in inventory
Engineering Data

Do not use for construction. Refer to factory certified dimensions. This handbook includes data current at the time of publication, which should be reconfirmed at the time of purchase. Up-to-date engineering data and more can be found at www.BaltimoreAircoil.com.

Notes:
1. Unit should be continuously supported on a flat level surface.
2. All connections are grooved for mechanical coupling.
Custom Coils

BAC will manufacture custom ICE CHILLER® Thermal Storage Coils to meet project specific requirements. BAC has done extensive research and testing on the build and melt characteristics of ice storage. This research and testing has resulted in selection capabilities unmatched by any other company in the industry.

BAC can predict the temperatures required on an hour-by-hour basis for building ice on custom coils, over a variety of conditions and build times. The physical space available, load profile, discharge temperatures, chiller capacity and operating sequences can be evaluated to find the design that best meets the application.

The ICE CHILLER® Thermal Storage Coils are constructed of continuous 1.05" O.D. all prime surface serpentine steel tubing, with no intermediate butt welds. The coils are assembled in a structural steel frame designed to support the weight of the coil stack with a full ice build. After fabrication the coils are tested for leaks using 375 psig air pressure under water, then hot-dip galvanized for corrosion protection.

For glycol applications the coils are configured to provide countercurrent glycol flow in adjacent circuits for maximum storage capacity.

Individual coils are factory-assembled into modules of two (2) coils. Glycol manifolds are coated with zinc-rich, cold galvanizing finish at the factory. Necessary support steel and lifting lugs are provided on the modules to allow for lifting into and final positioning within the storage tank.
Engineering Data: Modes of Operation

The modular ICE CHILLER® Thermal Storage Unit can operate in any of five distinct operating modes. These modes of operation provide the flexibility required by building operators to meet their daily HVAC cooling requirements.

Ice Build

In this operating mode, ice is built by circulating a 25% solution (by weight) of inhibited ethylene/propylene glycol through the coils contained in the ICE CHILLER® Thermal Storage Unit. Figure 1 illustrates typical chiller supply temperatures for 8, 10 and 12 hour build cycles. For a typical 10-hour build time, the supply glycol temperature is never lower than 22°F (-5.6°C). As the graph illustrates, for build times exceeding 10 hours, the minimum glycol temperature is greater than 22°F (-5.6°C). For build times less than 10 hours, the minimum glycol temperature will be lower than 22°F (-5.6°C) at the end of the build cycle. This performance is based on a chiller flow rate associated with a 5°F (2.8°C) range. When a larger temperature range is the basis of the chiller selection, the chiller supply temperatures will be lower than shown in Figure 1.

![Figure 1](image-url.com)
**Ice Build with Cooling**

When cooling loads exist during the ice build period, some of the cold glycol used to build ice is diverted to the cooling load to provide the required cooling. The amount of glycol diverted is determined by the building loop set point temperature. BAC recommends that this mode of operation be applied on systems using primary/secondary pumping. This reduces the possibility of damaging the cooling coil or heat exchanger by pumping cold glycol, lower than 32°F (0°C), to this equipment.

**Cooling – Ice Only**

In this operating mode the chiller is off. The warm return glycol solution is cooled to the desired set point temperature by melting ice stored in the modular ICE CHILLER® Thermal Storage Unit.

**Cooling – Chiller Only**

In this operating mode the chiller supplies all the building cooling requirements. Glycol flow is diverted around the thermal storage equipment to allow the cold supply glycol to flow directly to the cooling load. Temperature set points are maintained by the chiller.

**Cooling – Ice with Chiller**

In this operating mode, cooling is provided by the combined operation of the chiller and ice storage equipment. The glycol chiller precools the warm return glycol. The partially cooled glycol solution then passes through the ICE CHILLER® Thermal Storage Unit where it is cooled by the ice to the design temperature.

*Modular Ice Thermal Storage Unit*
Two basic flow schematics are applied to select ICE CHILLER® Thermal Storage Units. Figure 2 illustrates a single piping loop with the chiller installed upstream of the thermal storage equipment. This design allows the thermal storage system to operate in four of the five possible operating modes. They are Ice Build, Cooling-Ice Only, Cooling-Chiller Only and Cooling-Ice with Chiller.

For Figure 2 the following control logic is applied:

<table>
<thead>
<tr>
<th>Mode</th>
<th>Chiller</th>
<th>P-1</th>
<th>V-1</th>
<th>V-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ice Build</td>
<td>On</td>
<td>On</td>
<td>A-C</td>
<td>A-B</td>
</tr>
<tr>
<td>Cooling - Ice Only</td>
<td>Off</td>
<td>On</td>
<td>Modulate</td>
<td>A-C</td>
</tr>
<tr>
<td>Cooling - Chiller Only</td>
<td>On</td>
<td>On</td>
<td>A-C</td>
<td>A-C</td>
</tr>
<tr>
<td>Cooling - Ice with Chiller</td>
<td>On</td>
<td>On</td>
<td>Modulate</td>
<td>A-C</td>
</tr>
</tbody>
</table>

Valve V-1 modulates in response to temperature sensor, TS-1. Valve V-2 could be positioned to either maintain a constant flow, less than P-1, or modulate in response to the return glycol temperature from the cooling load.

When the building loop contains chilled water, a heat exchanger must be installed to separate the glycol loop from the building’s chilled water loop. On applications where an existing water chiller is available, it can be installed in the chilled water loop to reduce the load on the thermal storage system.

This design should not be used when there is a requirement to build ice and provide cooling. This would require the cold return glycol from the thermal storage equipment be pumped to the cooling load or heat exchanger. Since the glycol temperature is below 32°F (0°C), the cooling coil or heat exchanger is subject to freezing. The flow schematic illustrated in Figure 3 details a primary/secondary pumping loop with the chiller located upstream of the thermal storage equipment. This design allows the system to operate in all five operating modes.
For Figure 3 the following control logic is applied:

<table>
<thead>
<tr>
<th>Mode</th>
<th>Chiller</th>
<th>P-1</th>
<th>P-2</th>
<th>V-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ice Build</td>
<td>On</td>
<td>On</td>
<td>Off</td>
<td>A-B</td>
</tr>
<tr>
<td>Ice Build with Cooling</td>
<td>On</td>
<td>On</td>
<td>On</td>
<td>A-B</td>
</tr>
<tr>
<td>Cooling - Ice Only</td>
<td>Off</td>
<td>On</td>
<td>On</td>
<td>Modulate</td>
</tr>
<tr>
<td>Cooling - Chiller Only</td>
<td>On</td>
<td>On</td>
<td>On</td>
<td>A-C</td>
</tr>
<tr>
<td>Cooling - Ice with Chiller</td>
<td>On</td>
<td>On</td>
<td>On</td>
<td>Modulate</td>
</tr>
</tbody>
</table>

Valve V-1 and Valve V-2 modulate, depending on the operating mode, in response to temperature sensor, TS-1. The benefit provided by the primary/secondary pumping loop is that the system can build ice and provide cooling without fear of freezing a cooling coil or heat exchanger. This system design also allows for different flow rates in each of the pumping loops. When the flow rates in the pumping loops are different, the glycol flow rate in the primary loop should be greater than or equal to the glycol flow rate in the secondary loop. As in the single loop schematic, a heat exchanger and a base water chiller can be added to the system schematic.

Variations to these schematics are possible but these are the most common for ice storage systems. One variation positions the chiller downstream of the ice storage equipment. By positioning the chiller downstream of the ice, the chiller is used to maintain the required supply temperature. In Figures 2 and 3, the chiller is installed upstream of the ice. This offers two significant advantages compared to system designs that locate the chiller downstream of the ice. First, the chiller operates at higher glycol temperatures to precool the return glycol. This enables the chiller to operate at a higher capacity which reduces the amount of ice required. Second, since the chiller is operating at higher evaporator temperatures, the efficiency (kW/TR) of the chiller is improved.
The ICE CHILLER® Thermal Storage Unit(s) shall be Baltimore Aircoil Company Model TSU-_____. Each unit shall have a latent ton-hour storage capacity of ______ ton-hours to be generated in ____ hours when supplied with ______ USGPM (lps) of a 25% (by weight) solution of industrially inhibited ethylene/propylene glycol. The minimum glycol temperature required during the ice build operating mode shall be ______ °F(°C). Rated system performance shall be provided in the format recommended by the Air-Conditioning & Refrigeration Institute (ARI) Guideline T. The thermal storage units shall be modular in design. Unit design shall allow units of different sizes to be installed in order to optimize unit selection and minimize space requirements. Tanks sizes can be mixed due to internal piping arrangements that create a balanced flow due to uniform pressure drop through the coil circuits.

The tank shall be constructed of heavy-gauge galvanized steel panels and include double brake flanges for structural strength. The tank walls shall be supplied with a minimum of 4-1/2" of insulation that provides a total insulating value of R-18. The tank design shall utilize multiple liners. The primary liner, which forms the interior of the unit, shall be of single piece construction and be suitable for low temperature applications. The secondary liner/vapor barrier shall be separated from the primary liner by 1-1/2" of extruded polystyrene insulation. The tank bottom shall be insulated with 2" of expanded polystyrene insulation and 1" of extruded polystyrene insulation.

The ICE CHILLER® Thermal Storage Unit shall be provided with watertight, sectional covers constructed of hot-dip galvanized steel. The covers shall be insulated with a minimum of 2" of expanded polystyrene insulation.

Contained within the tank shall be a steel heat exchanger that is constructed of 1.05" O.D., all prime surface serpentine steel tubing encased in a steel framework. The coil, which is hot-dip galvanized after fabrication, shall be pneumatically tested at 190 psig and rated for 150 psig operating pressure. The coil circuits are configured to provide maximum storage capacity. The coil connections on the unit are galvanized steel and are grooved for mechanical coupling.

Each ICE CHILLER® Thermal Storage Unit shall be provided with a sight tube. The sight tube, which shall be fabricated from clear plastic pipe, shall display the tank water level and corresponding ice inventory.

Operating controls, consisting of two float switches, shall be mounted on the outside of the tank. The high level float switch terminates the build cycle when the water level reaches the 100% ice build level. The high level switch shall also prevent re-initiation of the build cycle until approximately 15% of the ice has been discharged. The second float switch is a low water cutout. The cutout requires that the water level in the ICE CHILLER® Thermal Storage Unit be at or above the 0% ice build level before the ice build cycle can begin. An optional differential pressure transmitter shall be available to supply an electrical output signal proportional to the amount of ice in inventory.

The heat transfer fluid shall be an industrially inhibited, 25% by weight, ethylene/propylene glycol solution specifically designed for HVAC applications. The 25% (by weight) solution is designed to provide freeze/burst and corrosion protection as well as efficient heat transfer in water based, closed loop systems. Corrosion inhibitors shall be provided to keep pipes free of corrosion without fouling. DOWTHERM® SR-1 and UCARTHERM® are acceptable fluids.

Overall unit dimensions shall not exceed approximately _____ ft (m) by ____ ft (m) with an overall height not exceeding ____ ft (m). The operating weight shall not exceed ______ lbs (kg).

Engineering Considerations -
ICE CHILLER® Thermal Storage Products

Installation
ICE CHILLER® Thermal Storage Units are designed to be installed outdoors. The units must be installed on a continuous flat level surface. The pitch of the slab must not exceed 1/8” over a 10’ span. Figure 1 details ICE CHILLER® Thermal Storage Unit layout guidelines. The units should be positioned so there is sufficient clearance between units and adjacent walls to allow easy access. When multiple units are installed, a minimum of 18" is recommended side-to-side and 3'-0” end-to-end for access to the operating controls.

When installed indoors, the access and slab requirements described above also apply. The units should be placed close to a floor drain in the event they need to be drained. The minimum height requirement above the tank for proper pipe installation is 3 feet. Figure 2 illustrates the recommended overhead clearance for ICE CHILLER® Thermal Storage Units.

For large ton-hour applications, BAC will provide ICE CHILLER® Thermal Storage Coils for installation in field fabricated concrete tanks. When coils are required, BAC’s manufacturing capabilities allow coils to be manufactured in the size and configuration necessary to meet specific site and performance requirements. The concrete tank design is to be completed by a qualified structural engineer. Figure 3 illustrates the ICE CHILLER® Thermal Storage Coil layout guidelines. For large projects that require ICE CHILLER® Coils, contact your local BAC Representative for selection and dimensional information.
Unit Piping

Piping to the ICE CHILLER® Thermal Storage Unit should follow established piping guidelines. The coil connections on the unit are galvanized steel and are grooved for mechanical coupling.

For single tank applications, each pair of manifolded coil connections should include a shut-off valve, so the unit can be isolated from the system. Figure 4 illustrates the valve arrangement for a single unit. It is recommended that the piping include a bypass circuit to allow operation of the system without the ICE CHILLER® Thermal Storage Unit in the piping loop. This bypass can be incorporated into the piping design by installing a three way/modulating valve. This valve can also be used to control the leaving glycol temperature from the thermal storage unit. Temperature and pressure taps should be installed to allow for easier flow balancing and system troubleshooting. A relief valve, set at a maximum of 150 psi, must be installed between the shut-off valves and the coil connections to protect the coils from excessive pressures due to hydraulic expansion. The relief valve should be vented to a portion of the system which can accommodate expansion.

CAUTION:
The system must include an expansion tank to accommodate changes in fluid volume. Adequately sized air vents must be installed at the high points in the piping loop to remove trapped air from the system.

Figure 5 illustrates reverse return piping for multiple units installed in parallel. The use of reverse return piping is recommended to ensure balanced flow to each unit. Shut-off valves at each unit can be used as balancing valves.

When large quantities of ICE CHILLER® Thermal Storage Units are installed, the system should be divided into groups of units. Then, balancing of each unit can be eliminated and a common balancing valve for each group of units installed. Shut-off valves for isolating individual units should be installed but not used for balancing glycol flow to the unit.
Controls
To ensure efficient operation of the ICE CHILLER® Thermal Storage Units, each system is provided with factory installed operating controls. A brief description of the controls follow.

Once the ice build cycle has been initiated, the glycol chiller should run at full capacity without cycling or unloading until the ICE CHILLER® Thermal Storage Units are fully charged. When the units are fully charged, the chiller should be turned off and not allowed to re-start until cooling is required. The ice build cycle is terminated by the operating control assembly. This assembly includes a low water cutout and a shut-off switch. The low water cutout prevents the ice build mode from starting if there is insufficient water in the tank. The shut-off switch will terminate the build cycle when the units are fully charged and will prevent the next ice build mode from starting until 15% of the ice has melted.

**Note: Multiple operating control assemblies must be wired in series so that a full build signal from any one tank will terminate the ice build cycle.**

An inventory sensor that provides a 4 - 20 mA signal is available. This sensor should be used for determining the amount of ice in inventory, but not to terminate the ice build cycle. Complete operating control details are provided in the Installation, Operation and Maintenance Manual.

Glycol
ICE CHILLER® Thermal Storage Units typically use a 25% (by weight) solution of industrially inhibited ethylene/proplylene glycol for both corrosion protection and freeze protection. Industrial grade inhibited glycol is specifically designed to prevent corrosion in HVAC and heat transfer equipment. Inhibitors are used to prevent the ethylene glycol from becoming acidic and to protect the metal components in the thermal storage system. The system’s lowest operating temperature should be 5°F to 7°F (2.8°C to 3.9°C) above the glycol freeze point. The freeze point for a system with 25% by weight ethylene glycol is 13°F (10.6°C); the freeze point for a system with 25% by weight propylene glycol is 15°F (9.4°C).

Acceptable industrial grade inhibited glycol solutions are DOWTHERM® SR–1, DOWFROST® HD and UCARTHERM®. Use of other brands of glycol in ICE CHILLER® Thermal Storage Products should be approved by BAC.

**CAUTION:**
Uninhibited glycol and automotive antifreeze are NOT to be used on thermal storage applications.

Water Treatment
In the near freezing temperatures of the ICE CHILLER® Thermal Storage Unit, scale and corrosion are naturally minimized. Therefore, water treatment for these two conditions may not be required or may require minimal attention unless the water is corrosive in nature. To control biological growth, a biocide may be needed to prevent the spread of iron bacteria or other organisms. For specific recommendations, consult a reputable local water treatment company and follow these guidelines:


<table>
<thead>
<tr>
<th>Property of Water</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7.0 to 9.0</td>
</tr>
<tr>
<td>Hardness as CaCO₃</td>
<td>30 to 500 ppm</td>
</tr>
<tr>
<td>Alkalinity as CaCO₃</td>
<td>500 ppm maximum</td>
</tr>
<tr>
<td>Total Dissolved Solids</td>
<td>625 ppm maximum</td>
</tr>
<tr>
<td>Maximum Conductivity</td>
<td>1000 micromhos/cm @ 32°F</td>
</tr>
<tr>
<td>Chlorides</td>
<td>125 ppm maximum as Cl</td>
</tr>
<tr>
<td>Sulfates</td>
<td>125 ppm maximum</td>
</tr>
</tbody>
</table>

‘Note: A pH of 8.3 or higher requires periodic passivation of the galvanized steel to prevent “white rust,” the accumulation of white, waxy, nonprotective zinc corrosion on galvanized steel surfaces.

To assure full capacity of the ICE CHILLER® Thermal Storage Unit, the water treatment should not alter the freeze point of water.

**Winterization**

**CAUTION:** Precautions must be taken to protect the unit and associated piping from freezing conditions. Heat tracing and insulation should be installed on all piping connected to the unit. The sight tube, operating controls and optional inventory sensor must be protected if the units are installed outdoors and exposed to sub-freezing ambient conditions. For this purpose, BAC can provide an optional heated enclosure, complete with a 100 W heater. Otherwise, the sight tube, operating controls and optional inventory sensor must be heat traced and insulated. It is not necessary to drain the unit during cold weather.

**Pressure Drop**

The ICE CHILLER® Thermal Storage Unit is designed for low pressure drop. Figure 6 shows the pressure drop associated with each unit for a 25% solution of industrially inhibited ethylene glycol. Data for flow rates not shown should not be extrapolated from the performance curve. Pressure drops for flow rates not presented in this table, and for alternative fluids, are available by contacting the local BAC Representative.

**Warranties**

Please refer to the Limitation of Warranties applicable to and in effect at the time of the sale/purchase.