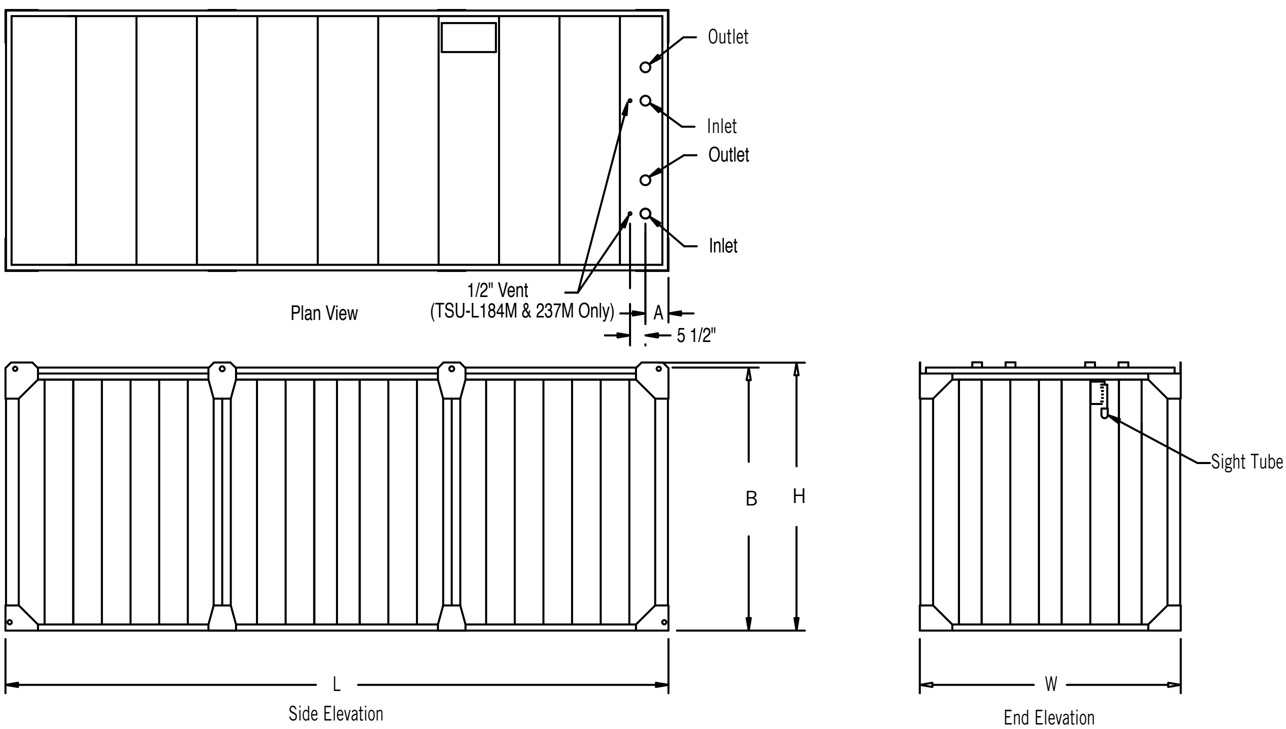
TSUM Engineering Data



Model Number	Weights (lbs)		Volumes (gal)		Dimensions					Connection Size
	Operating	Shipping	Tank (Water)	Coil (Glycol)	L	W	H	A	B	
TSU-237M	39,100	9,750	2,990	260	10'-7 5/8"	7'-10 3/8"	8'-0"	8 5/8"	7'-10"	2"
TSU-476M	73,900	16,750	5,840	495	19'-10 1/4"	7'-10 3/8"	8'-0"	9 3/4"	7'-10"	3"
TSU-594M	93,100	20,200	7,460	610	19'-10 1/4"	9'-9 1/4"	8'-0"	9 3/4"	7'-10"	3"
TSU-761M	113,800	24,000	9,150	790	19'-10 1/4"	11'-9 3/4"	8'-0"	9 3/4"	7'-10"	3"
TSU-L184M	31,700	8,300	2,330	205	10'-7 5/8"	7'-10 3/8"	6'-6 3/4"	8 5/8"	6'-4 3/4"	2"
TSU-L370M	59,700	14,100	4,560	385	19'-10 1/4"	7'-10 3/8"	6'-6 3/4"	9 3/4"	6'-4 3/4"	3"
TSU-L462M	75,000	17,000	5,820	477	19'-10 1/4"	9'-9 1/4"	6'-6 3/4"	9 3/4"	6'-4 3/4"	3"
TSU-L592M	91,650	20,300	7,140	602	19'-10 1/4"	11'-9 3/4"	6'-6 3/4"	9 3/4"	6'-4 3/4"	3"

NOTES:

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

Do not use for construction. Refer to factory certified dimensions. This catalog includes data current at the time of publication, which should be reconfirmed at the time of purchase.

Engineering Considerations – HVAC

Modes of Operation

ICE BUILD

In this operating mode, ice is built by circulating a solution 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 with a chiller flow rate associated with 5˚F (2.8˚C) range. As build time increases, so does minimum glycol temperature. When a larger temperature range is the basis for chiller selection, the chiller supply temperatures will be lower than shown.

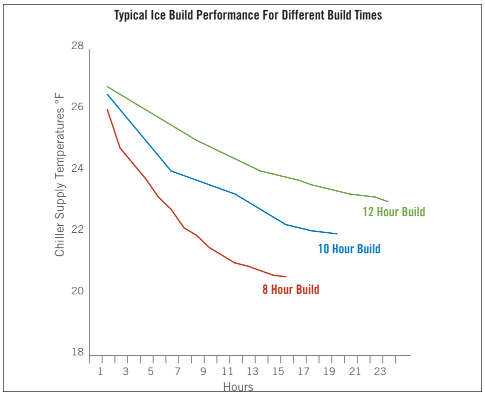


Figure 1

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 the equipment.

Modular Ice Thermal Storage Unit

COOLING - ICE ONLY

In this operating mode the chiller is off. The heat is rejected from the system by melting ice stored in the modular ICE CHILLER Thermal Storage Unit.

NOTE: See **page G14** and **G15** for system schematics and control logic.

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 is 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.

Engineering Considerations – HVAC

System Schematics

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.

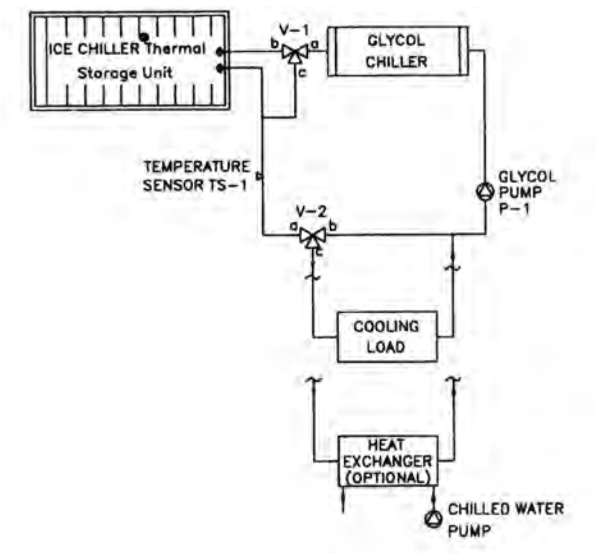


Figure 2

FOR FIGURE 2 THE FOLLOWING CONTROL LOGIC IS APPLIED

Mode	Chiller	P-1	V-1	V-2
Ice Build	On	On	A-B	A-B
Cooling - Ice Only	Off	On	Modulate	A-C
Cooling - Chiller Only	On	On	A-C	A-C
Cooling - Ice with Chiller	On	On	Modulate	A-C

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.

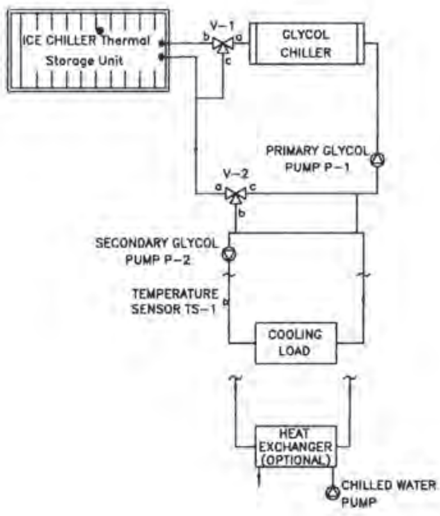


Figure 3

FOR FIGURE 3 THE FOLLOWING CONTROL LOGIC IS APPLIED:

Mode	Chiller	P-1	P-2	V-1	V-2
Ice Build	On	On	Off	A-B	A-C
Ice Build with Cooling	On	On	On	A-B	Modulate
Cooling - Ice Only	Off	On	On	Modulate	A-B
Cooling - Chiller Only	On	On	On	A-C	A-B
Cooling - Ice with Chiller	On	On	On	Modulate	A-B

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.

Engineering Considerations – HVAC

Installation

ICE CHILLER® Thermal Storage Units are designed to be installed indoors or 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 4** 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’. **Figure 5** 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 6** 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.

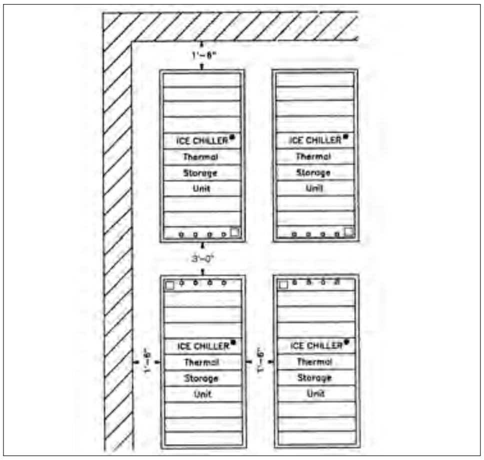


Figure 4

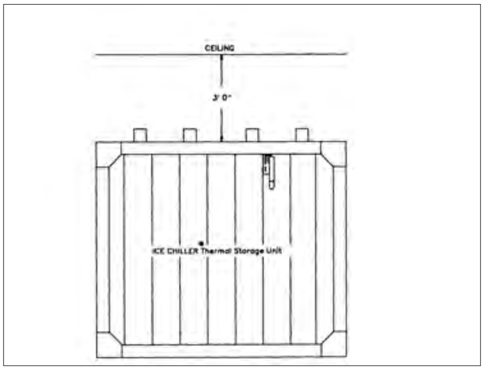


Figure 5

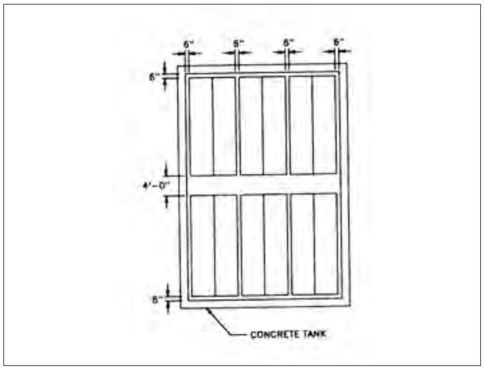


Figure 6

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 7** 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 300 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.

NOTE: 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 8 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.

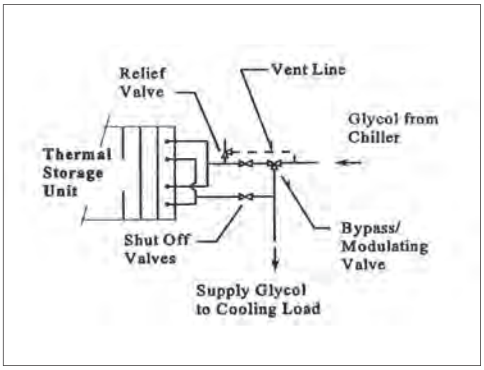


Figure 7

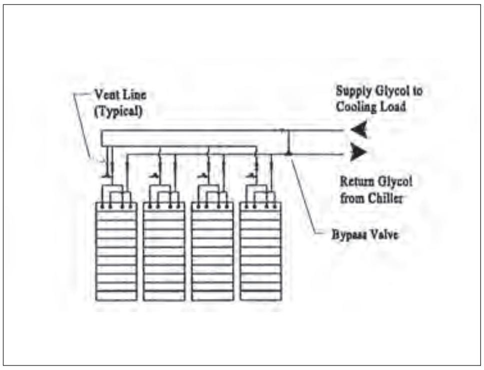


Figure 8

Engineering Considerations – HVAC

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*, that can be found at www.BaltimoreAircoil.com.

Glycol

ICE CHILLER Thermal Storage Units typically use a 25% (by weight) solution of industrially inhibited ethylene/propylene 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.

DOWTHERM® SR-1, DOWFROST® and UCARTHERM® are registered trademarks of The Dow Chemical Company or its subsidaries.

NOTE: 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 the guidelines in Table 1. To assure full capacity of the ICE CHILLER Thermal Storage Unit, water treatment should not alter the freeze point of the water in the tank.

TABLE 1: WATER QUALITY GUIDELINES

Property of Water	Recommended Levels
pH	6.5 to 9.0[1]
Total Suspended Solids	25 ppm
Total Dissolved Solids (TDS)	1,500 ppm
Conductivity	2,400 (microohms/cm)
Alkalinity as $CaCO_3$	500 ppm[2]
Calcium Hardness as $CaCO_3$	50 to 600 ppm[2]
Chlorides (CL)	250 ppm
Sulfates	250 ppm
Silica	150 ppm

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.

Winterization

NOTE: 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.

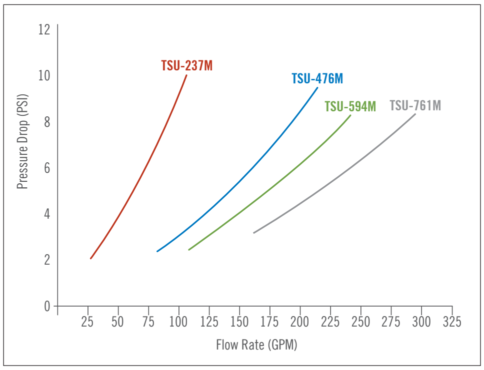


Figure 9

Pressure Drop

The ICE CHILLER® Thermal Storage Unit is designed for low pressure drop. **Figure 9** 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 chart, and for alternative fluids, are available by contacting the local BAC Representative.