TRANE

Ice-enhanced Air-cooled Chiller Plant

An EarthWise™ System from Trane

Ingersoll Rand

EarthWise Systems are good for business

Trane EarthWise™ Systems are a comprehensive approach to HVAC system design that supports what is best for your building, right for the environment and good for your bottom line.

Cooling without compromises. EarthWise Systems deliver prepackaged operational efficiencies that support sustainable building performance making it easy to do the right thing. Trane EarthWise systems leverage high-efficiency HVAC equipment and advanced controls to optimize whole system design and operation.

Energy prices are uncertain, but trends are not. With even higher energy costs on the horizon, owners should be making plans to mitigate the impact on operating expenses. An obvious place to start is with one of the biggest energy consumers in the building: the cooling system. Adding thermal energy storage to an HVAC system can reduce energy costs associated with comfort cooling by shifting equipment operation from high- to low-cost times of day.

The Trane EarthWise Ice-enhanced Air-cooled Chiller Plant simplifies the design and implementation of thermal storage systems. This means you can take advantage of the one component of energy pricing that has not gone up in 30 years—off-peak electricity.

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Smart meters and demand response programs are coming to a utility near you. With thermal storage in place, you are ready to respond to these signals or events, without compromising your building operations. Having the capability to respond to energy signals or scarcity allows you to play an active role in controlling the energy costs for your facility. You also contribute to national energy security by helping all of us work together to use our energy resources wisely.

Supporting renewable energy. By shifting energy use to times when renewable energy is available, thermal storage systems contribute significantly to the emerging vision of energy in the future. Energy storage doesn’t have to be an industrial power battery made out of expensive, cutting-edge materials. It can be as simple as a few ice tanks on every mid- to large-scale cooling system. Today’s ice storage systems are more cost optimized and flexible than ever.

Thermal energy storage can work in tandem with other renewable energy systems. In many locations suitable for capturing wind energy, the wind blows hardest at night. That electricity generation is not good timing for a building, unless it uses thermal energy storage. Conversely, solar energy must be converted during the day, when electricity generation may be strained both by cooling equipment demand and by reductions in turbine generation performance. By shifting energy for cooling to nighttime hours, we can not only capture green energy from the wind, but we also offload its burden on solar energy during the day.

EarthWise Ice-enhanced Air-cooled Chiller Plant

The Trane EarthWise™ Ice-enhanced Air-cooled Chiller Plant includes eight standard configurations for air-cooled chillers, ice tanks and customizable system controls that provide an advanced starting point for designing an ice storage system.

Trane has engineered and developed this prepackaged system based on previous successes. Approximately 80 percent of the installed ice storage projects use air-cooled chillers and internal melt modular ice tanks. By limiting the scope to a specific style of chiller, the appropriate type of ice storage system can be readily identified.

Identifying the repeatable aspects of these designs allows us to compress the time it takes for the system to go from the idea phase to the commissioning phase. System completion packaged skids, preprogrammed control sequences, operator graphics and drawings are some of the new features developed to support this system.

As with every EarthWise System, Trane provides, supports, and deploys energy modeling during the system design phase. Trane Air-conditioning Economics (TRACE™) software can be used to determine whether this system can be expected to help your building earn high performance designation.

System package benefits

Reduced risk and engineering costs

- Preprogrammed system controls
- Pre-engineered system packages

Repeatability

- Avoid installation and commissioning pitfalls
- Avoid or reduce custom programming
- Simplify maintenance with repeated elements across many installed systems

Optimized components

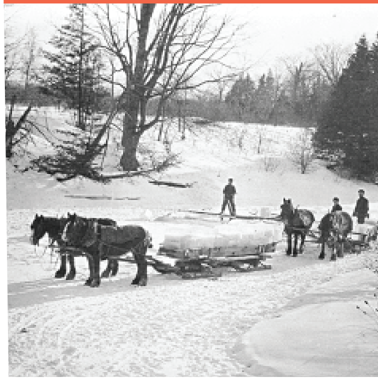
- Least expensive first-cost system
- Lowest total cost of ownership system
- System expansion in the most appropriate way (more chiller, or more tank?)

Reliability

- CALMAC IceBank® tanks have no moving parts
- Ice provides partial system redundancy, minimizing assets to maintain

A little history …

Trane has been educating the industry for decades on chiller-based thermal storage systems. Refrigeration itself began as an ice storing and melting application, which is why cooling is rated in tons. So it’s appropriate that a natural element such as frozen water and its capacity for storing thermal energy can and should be tapped again for Earth-friendlier cooling.



Better together for simplified off-peak cooling

Air-cooled chillers fit well with ice storage. This EarthWise system delivers water-cooled, chilled-water system performance without water-cooled complexity while costing the same or only slightly more than a traditional chilled-water system.

Efficiency

- Air-cooled chillers use compressors well suited for making ice, with low performance penalty when not making ice.
- Using cold fluid and cold air reduces transfer energy in fans and pumps, and sheet metal and piping costs can be reduced.
- Electric grid efficiency is improved by allowing a utility to have less "spinning reserves" idling and wasting energy.
- Natural gas turbines are more efficient at night than during the day, saving energy.

Cost

- By using ice as part of the system redundancy, chiller size can be reduced, which offsets much of the cost of adding ice storage tanks to a partial storage project.
- By using cold fluid and cold air, fans, pumps, and ductwork can be right sized in a trade-off with energy costs.
- In many climates, air-cooled chillers may use glycol in the evaporator already to prevent freezing during cold weather, so the cost of glycol is already included.
- Ice storage is a lot less expensive per ton-hour than chilled-water storage for small to medium sized systems.

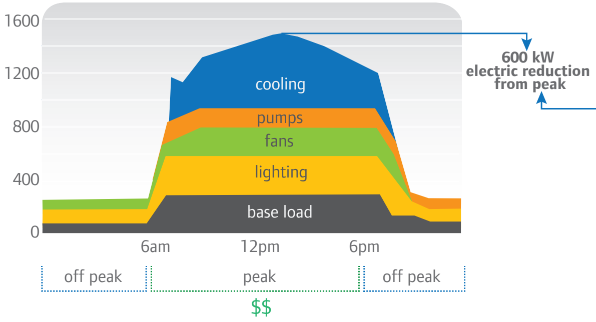
Flexibility

- Easy conversion to add ice making capability to existing air-cooled chillers.
- Chiller plants with ice storage allow for operational flexibility; the cooling is created when it makes sense, not necessarily when it is used.
- Ice storage allows chiller maintenance to occur even during a summer day when technicians can see the chiller better.

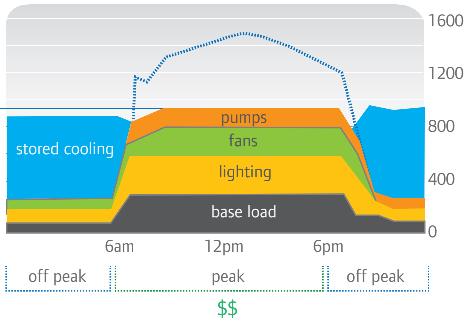
Predetermined system design

- By making decisions about the system design, the common options are easier to accommodate in system controls. These controls are then standardized to help reduce opportunities for errors and reduce custom controls programming.
- System completion skids reduce design and installation time, lower the system complexity, and standardize maintenance with Trane parts identification.

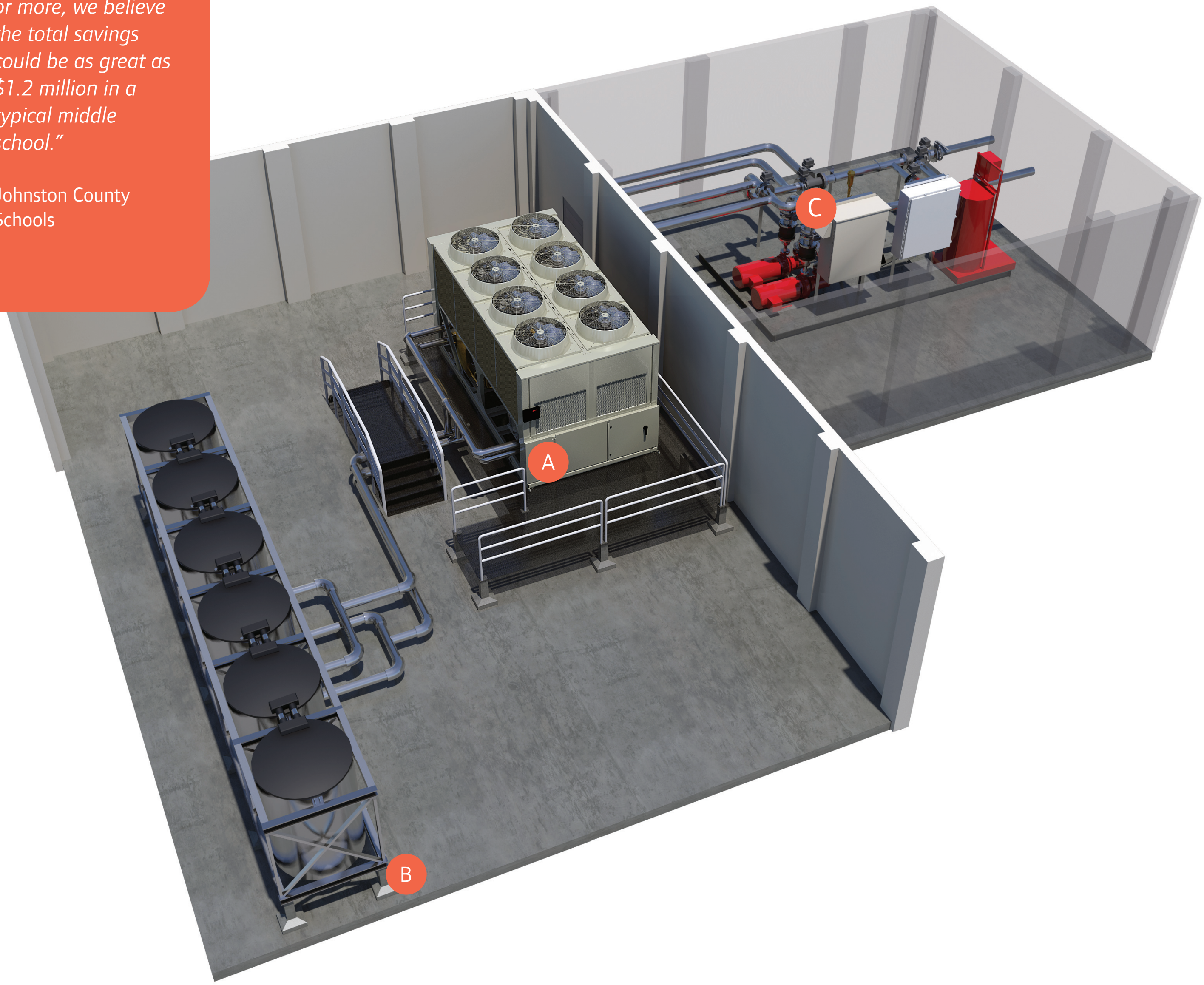
Typical electric load make-up



Electric load profile with thermal storage



> *"We have found project simple paybacks of as little as two years, always less than four years. Over the anticipated life of the school of 40 years or more, we believe the total savings could be as great as $1.2 million in a typical middle school."*
>
> Johnston County Schools



A **Trane air-cooled chillers** with built-in ice storage support provide water-cooled efficiency without the added cost, maintenance and complexity of a water-cooled system.

B **CALMAC IceBank® thermal energy storage tanks** offer pre-engineered, factory-built reliability with tested, efficient and repeatable performance.

C **System completion module** provides single-source responsibility. Each module includes a pre-engineered pumping system, single point power and control connection, factory mounted Trane controls, installation logistics, start-up and commissioning coordination, and warranty/technical support.

Why modular ice tanks?

Pre-engineered, factory-built reliability and documented performance. Factory-built modular ice tank performance is documented, tested and repeatable over the life of the system. The net usable ton hours of a modular, standardized tank are known. In contrast, field-built ice tank performance is unknown. The cylindrical shape of the CALMAC tank is stronger and the high density polyethylene construction with thermal welds is very durable. There are no moving parts and the tank is 99 percent recyclable.

Why internal melt ice tanks?

Internal melt tanks like the CALMAC IceBank do not send frozen water out to the load coils. An intermediate medium such as glycol is used in a closed loop between the tanks and the chiller. An optional heat exchanger can be easily added to separate the glycol loop from the water loop if needed. Alternatively, glycol can be sent all the way to the load coils, especially in smaller systems. Here are just a few key benefits of internal melt ice tanks.

Efficiency (warmer charge temperatures). Counter-flow heat exchanger provides consistent temperatures throughout the tank for repeatable optimum charge and discharge performance. Average ice build is ½ inch for efficient charging performance.

In contrast, an external melt coil will make ice through ice, and require a lower charge temperature and more chiller energy.

No agitation required. External melt tanks are more prone to ice bridging and capping. A bridge joins adjacent tubes with ice, preventing the efficient flow of water for melting. A cap is a block of ice that pushes up and out of contact with the coil surface. Both bridging and capping reduce the net usable capacity of the ice, unless agitation is used to stir the tank and create more uniform ice production and melting.

Charge while cooling. This mode is not possible with external melt tanks, because the fluid melting the ice is the fluid going through the chiller. It's not possible to melt ice while you're simultaneously building ice. However, peak (instantaneous) tons discharged will be lower with internal melt tanks.

Why air-cooled chillers?

Designed for ice-making efficiency. With few exceptions, air-cooled chillers use positive displacement compressors: screw and scroll technology. They are readily capable of creating the extra head pressure required on ice storage systems, and are especially efficient at night when the outdoor dry-bulb temperatures are suppressed. The change in outdoor dry bulb from day to night is typically more drastic than the change in outdoor wet bulb, which gives air-cooled equipment more efficiency improvement at night than water-cooled equipment.

Lower system cost. This system is simpler and therefore costs less to engineer and install, with lower cost components. Because an air-cooled system is typically smaller, it's also easier to package and pre-engineer, with few options that take extra time to properly consider. Air-cooled chillers are often regularly selected to cool anti-freeze solutions, to protect them while operating in cold climates, so the cost of glycol may already be included.

Simplicity. Smaller systems are not as complex and do not require dedicated maintenance resources. As the systems get larger, water-cooled systems make more sense because water-cooled chillers are available in higher capacities.

When does ice storage make sense?

There are number of reasons to bring ice storage into the system design discussion as we previously addressed. The real question is: When does it make sense? The answer should be: When it has the lowest life-cycle cost compared to alternative systems, and fits within the budget. There are a number of economic analysis tools readily available.

The easiest way to include ice storage and stay within budget is to use air-cooled chillers, not too many tanks, and a downsized chiller. However, the lowest life cycle cost system may include more tanks and larger chillers and cost more to install. Whether the preferred larger system is affordable today can be determined by the availability of incentives or rebates from one or a number of sources.

Off peak cooling using ice storage is not for everyone. The following are key considerations.

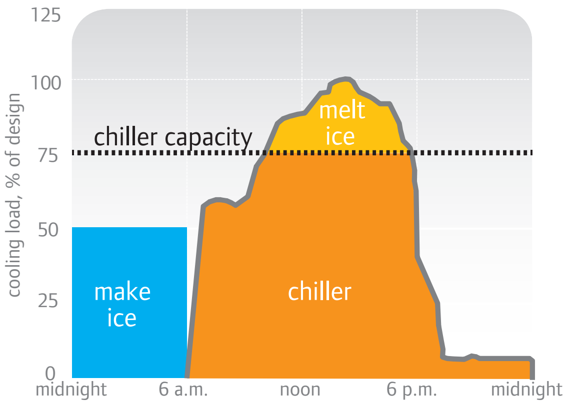
Are you seeking green building designation? High-performance building designation steers the discussion toward systems that have lower energy costs. How much can an ice storage system reduce annual energy? Ice storage systems can earn up to six LEED points (depending on the baseline system and local utility rates), as well as LEED Pilot Program points (one or two). For projects following ASHRAE 189.1 (the high performance green building standard), ice storage can help satisfy the prescriptive requirement in 7.4.5.1 Peak Load Reduction:

"Building projects shall contain automatic systems, such as demand limiting or load shifting, that are capable of reducing electric peak demand of the building by not less than 10% of the projected peak demand. Standby power generation shall not be used to achieve the reduction in peak demand."

How much does it cost up front? It may cost more to install than you think you can afford, though you may be able to get the system cost in budget by using the right design. It's easier to justify an ice storage system when improvements to your system are planned, and if you already have a chilled-water system in place or planned. The incremental cost is the key.

Depending on the shape of your design day load profile, a downsized chiller can be the right fit if you're able to use the ice for a portion of the customary system redundancy allowance. This has the added benefit of not leading to oversized chillers that operate at an inefficient point for many hours. The figure below shows a chiller sized to handle the design day peak load only when supplemented with ice. The load profile allows for tanks to be charged after the coincident cooling loads have diminished.

For more information on ice storage for LEED projects, refer to Trane *Engineers Newsletter* volume 36-3 (2007). Visit trane.com/EN.



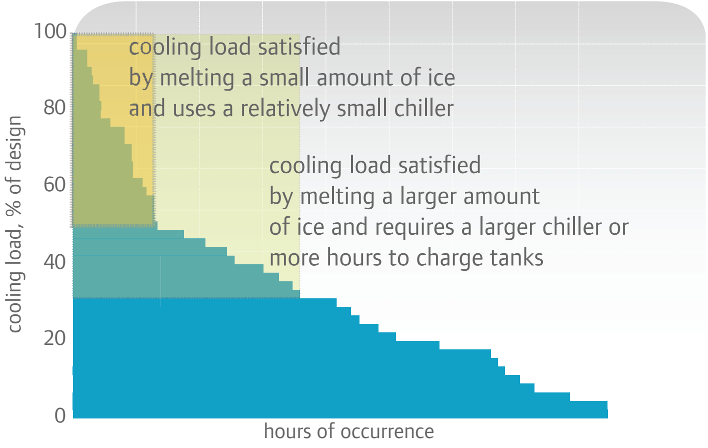
What are the electric rates and are there incentive programs? Electric rate structures in many areas are suitable for ice storage. In some cases, the electric rate structure necessary for ice storage to reduce energy cost is one that you're not subscribed to right now. This can be as simple as a call to the local utility company to find out what electricity rates are available, and if there are rebates or other incentives in your area for off-peak cooling.

Generally speaking, ice storage should be considered when one or more of the following exist in your electricity rate structure.

- Demand charges greater than $6 per kW
- Daytime energy is $0.06 per kWh more expensive than night time energy
- Flat rate ("negotiated pricing") accounts for the load profile during negotiations
- Load profile penalties (i.e. stepped rates, kWh/kW floating cutoffs, "Hours of Use Demand")
- Demand ratchet clauses ("larger of monthly demand or 80 percent of previous 12-months' demand")
- Real time pricing (look ahead signal of electricity costs, changes as often as every 15 minutes)
- Curtailment rates (agreeing to reduce power use when a load reduction is requested)

What is the cooling load profile? The hours in the day when the chiller isn't at full capacity are used to recharge the ice tanks. You may not have a cooling load that varies enough throughout the day to accommodate storing cooling energy. If the load-profile is flat, larger chilled-water storage systems may become attractive, especially if the system requires a high degree of redundancy, such as a data center or a manufacturing process. Life cycle analysis should account for year-round cooling loads. The graph below shows a cooling load duration curve. The shape of the curve tells you how many ton-hours are setting your on-peak electricity costs. A larger system would satisfy more of system peak cooling requirements.

Do I have other reasons for storage such as limited or unreliable electricity? Some buildings are constrained by the consistent availability of electricity. Examples include buildings in areas that suffer from regular brownouts and blackouts, facilities switching from steam-driven to electric chillers, buildings in formerly rural areas without adequate infrastructure, or those with onsite power generation. Ice storage can be part of the solution because it requires less peak energy generation.



Sample life-cycle analysis

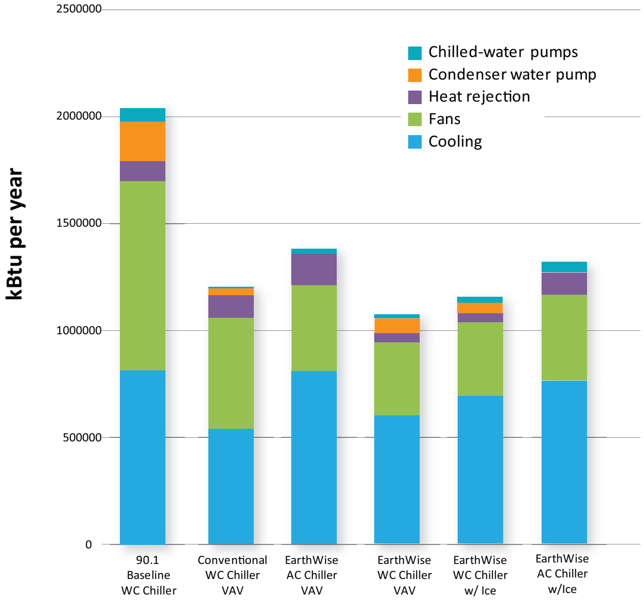
The following energy and annual operating costs were calculated using TRACE™ for a mid-sized, 150-ton office building in San Jose, California. The ASHRAE 90.1 baseline is at the far left, with various system options charted to the right.

Site energy consumption. The EarthWise chilled-water system options all save energy over the energy code baseline chiller system. (See *Site energy* graph below.) The EarthWise ice-enhanced air-cooled chiller system at the far right uses more site energy than the water-cooled chiller systems. However, for a comprehensive evaluation of ice storage, we must continue the analysis and consider source energy, first cost and overall operating costs.

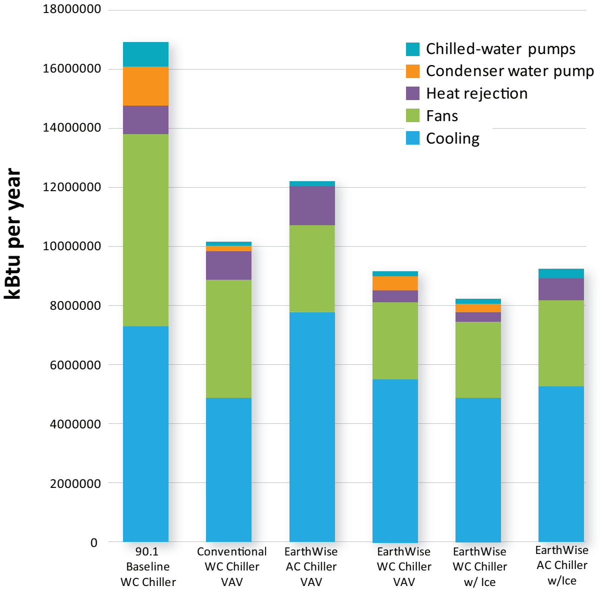
Source energy consumption is fuel energy used to create the electricity. Because power generation equipment is less efficient on hot summer days, converting site energy to source energy better reflects the overall energy consumed. (See *Source energy* graph below.)

The EarthWise air-cooled ice storage system has source energy use comparable to an EarthWise water-cooled, chilled-water system without ice storage.

TRACE energy analysis:
Cooling equipment site energy (kBtu)



TRACE energy analysis:
Cooling equipment source energy TDV (kBtu)



System costs. Annual operating costs include energy, maintenance and water costs. (See *life-cycle* graph below.) First costs include the equipment and installation costs of the system. Life-cycle costs include all revenue and cost streams for 20 years, including economic factors such as inflation and tax implications.

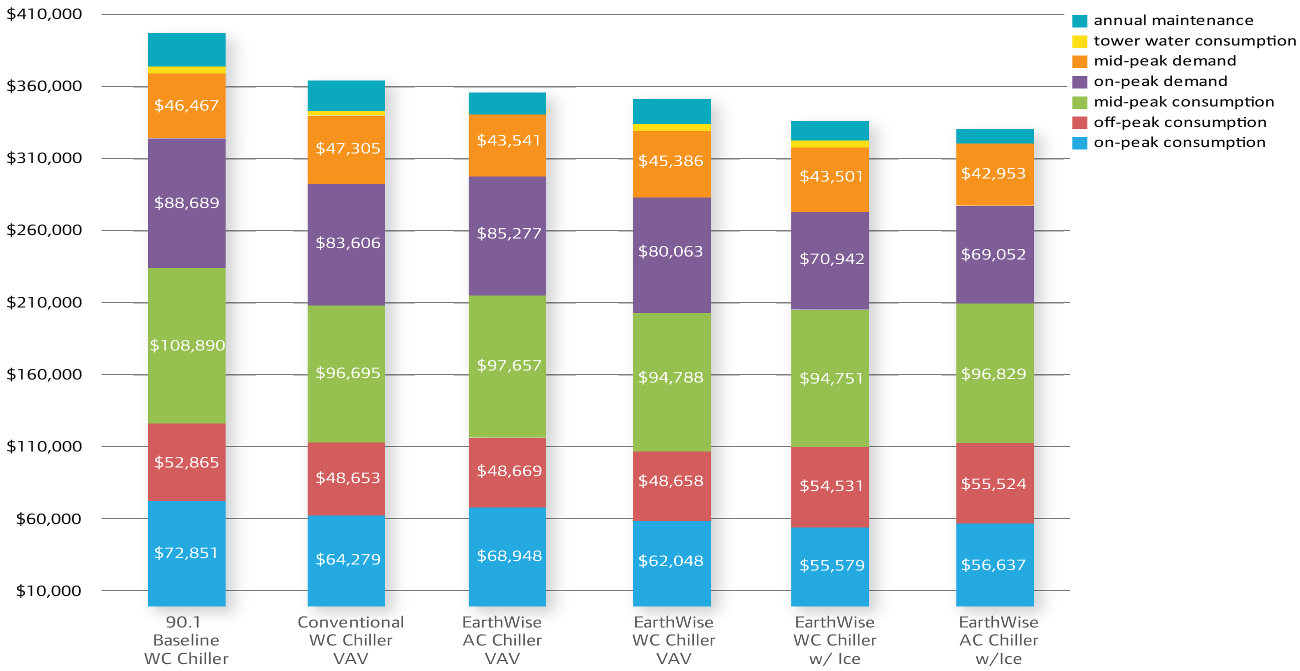
For this particular combination of building, climate, and utility tariff, the EarthWise ice-enhanced air-cooled chiller system had the lowest first cost and the lowest total cost of ownership of all the alternatives.

For LEED® designation, this system would have earned approximately two points for energy cost savings and would help with water conservation credits. In addition, a LEED 2009 pilot program allows for an additional one to two points for ice-storage systems, depending on how the building automation system reponds to utility signals.

The life-cycle analysis demonstrates 14 percent energy cost savings.

- Approximately two LEED points
- One to two LEED pilot points
- Plus help on water credits (for more points don't downsize pipes or ducts)

TRACE life-cycle analysis: Annual operating expense, full building



$\$13.92/\text{ft}^2$	$\$12.68/\text{ft}^2$	$\$10.52/\text{ft}^2$	$\$11.42/\text{ft}^2$	$\$11.35/\text{ft}^2$	$\$10.98/\text{ft}^2$	cooling installed cost per ft^2
$10,325,891	$9,402,723	$8,879,988	$8,594,794	$8,709,196	$8,405,565	20-year life cycle cost

How much ice?

The following considerations will drive the number of tanks to install.

Chiller capability and charge time.
An existing chiller retrofit for ice storage has a defined maximum flow rate that determines the number of tanks it can charge. The number of hours available for charging tanks may also limit the number of tanks that could be purchased.

Budget. The budget alone can determine how many tanks to purchase. If too few tanks are purchased, the final charge temperature may require more glycol solution. You also might consider downsizing your chiller. In any case, system redundancy should be considered, which leads to the next topic, operational flexibility.

Operational flexibility requirements. If your only ice making chiller shuts down unexpectedly, and it's your only chiller, and there is a critical cooling load, let's hope it happened when stored ice is available for cooling. If it did, you may have eight hours or possibly several mild days to resolve the problem before you run out of ice. The desire for complete redundancy may lead to the purchase of another chiller (n+1), a back-up cooling system for critical loads, or preinstalled rental chiller piping connections.

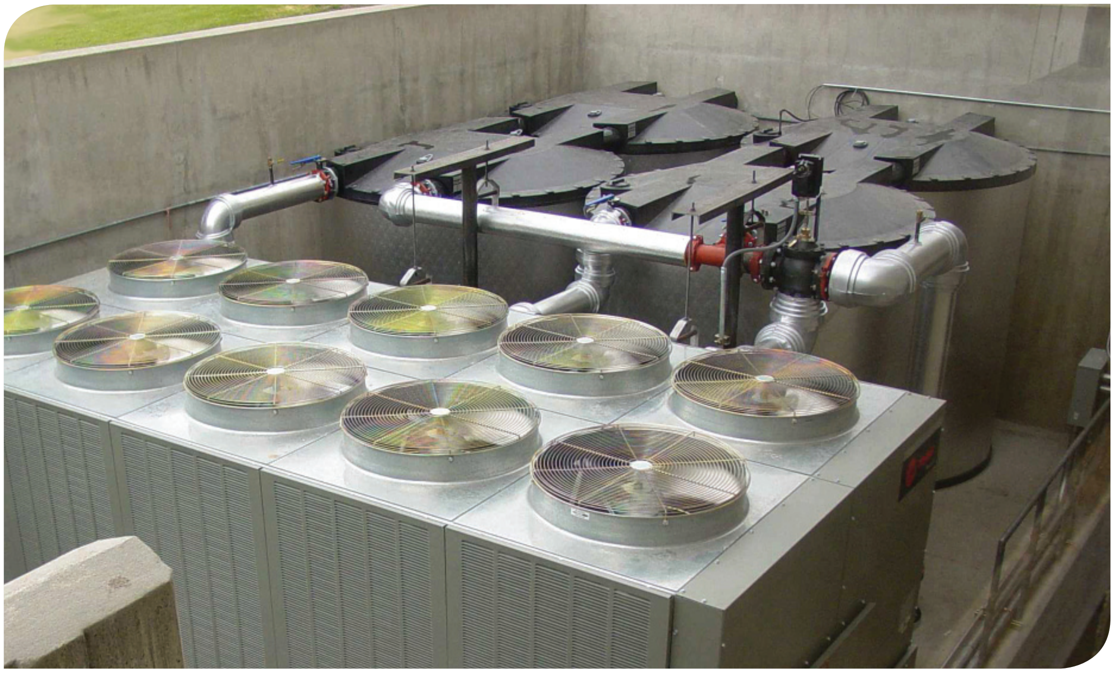
Power constraints. You may design your system to ride through a power disturbance or an outage with the chiller off to meet the critical loads or the minimum amount of cooling. Or, the system size can be dictated by on-site power generation or available utility power.

Energy saving strategy. Partial storage means the chiller(s) will be supplemented with ice melting during the discharge period. Partial storage is usually selected for long on-peak windows (6-8 hours or more) and lowest first cost. Partial storage can have the lowest life-cycle cost especially when rebates are unavailable, and/or when the chiller is already purchased or being retrofitted for ice making. Partial storage is an excellent peak shaving strategy when high on-peak demand charges ($8 or higher) and/or ratchet clauses are in place.

Full storage means that the chiller(s) will be off during the discharge period. Full storage is used for short on-peak windows (2-4 hours) and maximum load-shifting strategies, especially when rebates are based on shifted ton or shifted kW. Full storage provides more benefit when a large difference between on- and off-peak kWh charges (such as a $0.10 difference per kWh) drive the strategy to maximum load shift.

Space limitations. Sometimes the number of tanks is determined by the amount of available space. This is more of a concern on water-cooled systems that can utilize more tanks than with smaller, air-cooled systems. But given the financial incentives of off-peak cooling, previously unavailable space may become available.

Knowing either the number of tanks or the chiller size allows easy preliminary selection using the information on pp. 30-31. The number of hours to charge the tanks narrows the list of possibilities. When more about the project is known, CALMAC IcePick and Trane chiller selection software (TOPSS™) are used for final system design.



Four tanks occupy the space initially planned for a second chiller.

How much chiller?

Determining how much of the on-peak load should be met with ice storage is arbitrary, and is typically dictated by the cooling load profile and the objectives of the designer or building owner. A common starting point is 30 to 40 percent of the design day cooling load. As more of the building load is served by ice storage, on-peak chiller capacity and building electrical demand are reduced. However, more ice needs a larger chiller to charge the tanks in the same length of time. There is a balance to be struck.

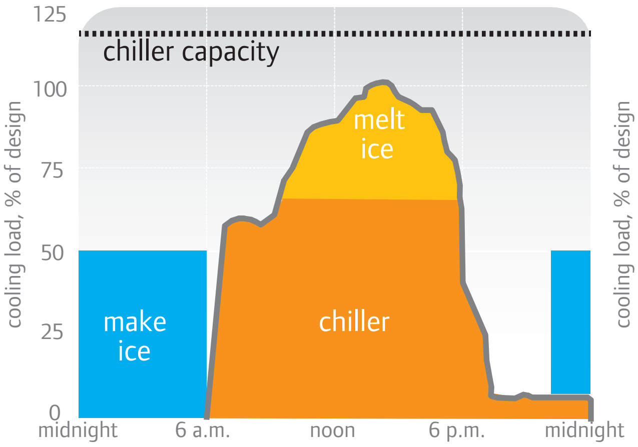
Greater ice storage capacity requires greater chiller ice-building capacity. One solution that's easy to find mathematically is the ice storage capacity that results in a chiller working as hard as it can during the day, while still being able to charge all the tanks at night. While this selection results in the smallest chiller net capacity, it does not necessarily represent the best life-cycle cost system. TRACE software can help you determine if a larger system is economically justified.

Possible starting points:

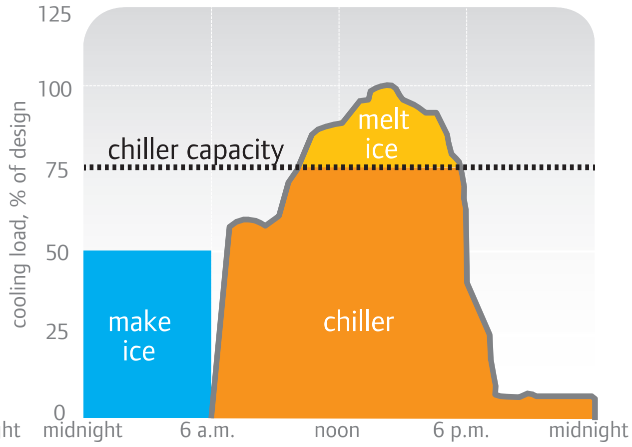
- Maximum number of tanks your chiller can charge in the amount of available hours (maximum freeze time)
- Smallest chiller needed on a design day, with or without an ice contribution (minimum melt rate)
- Electrical constraint for the chiller on a design day
- Maximum number of tanks you are prepared to put on site

Visualize the options

The following two figures show a load profile and two different options for the amount of the design day load that is to be met with the stored ice.



conventional chiller sizing



downsized chiller sizing

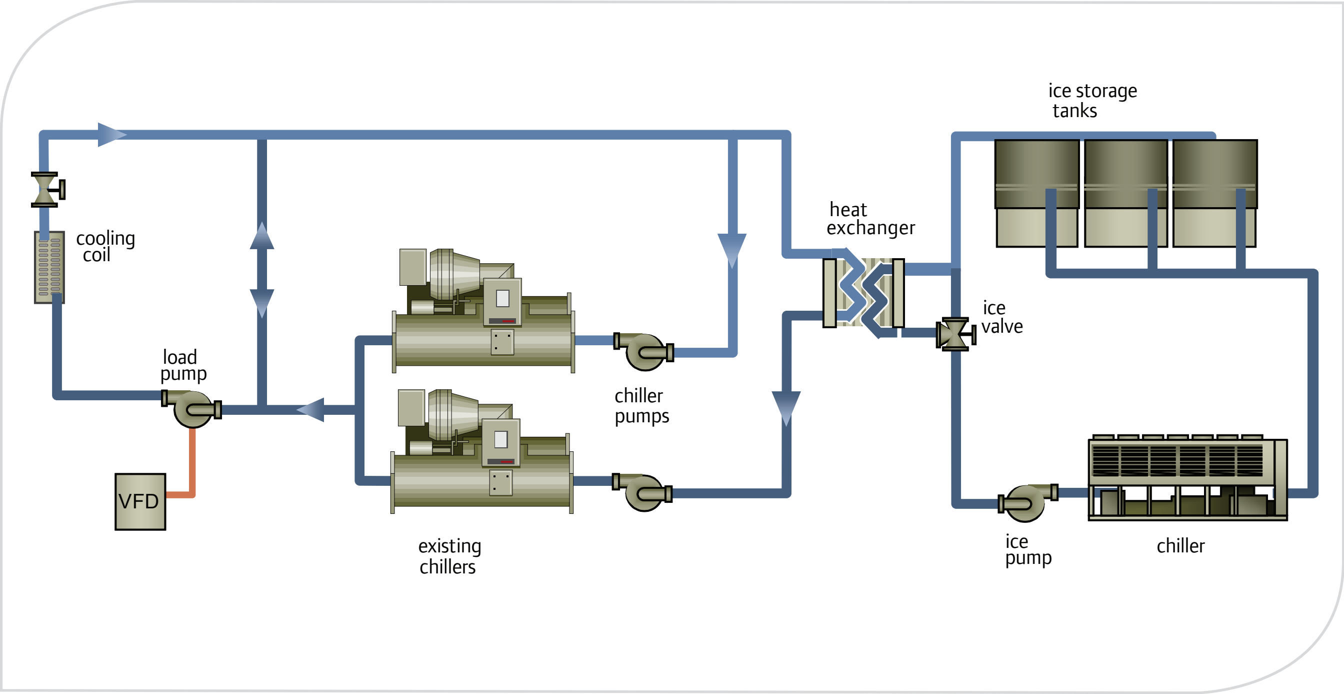
Adding ice to a chilled-water system

Ice plant as a system component

While existing air-cooled chillers can often be retrofit for making ice, other types of chilled-water systems can benefit by adding a self-contained ice plant to the system. Below is an example of an ice-enhanced air-cooled chiller plant installed upstream of one of two existing centrifugal chillers, separated by a heat exchanger to isolate glycol. If the flows are suitable, the new plant could be upstream of both existing chillers.

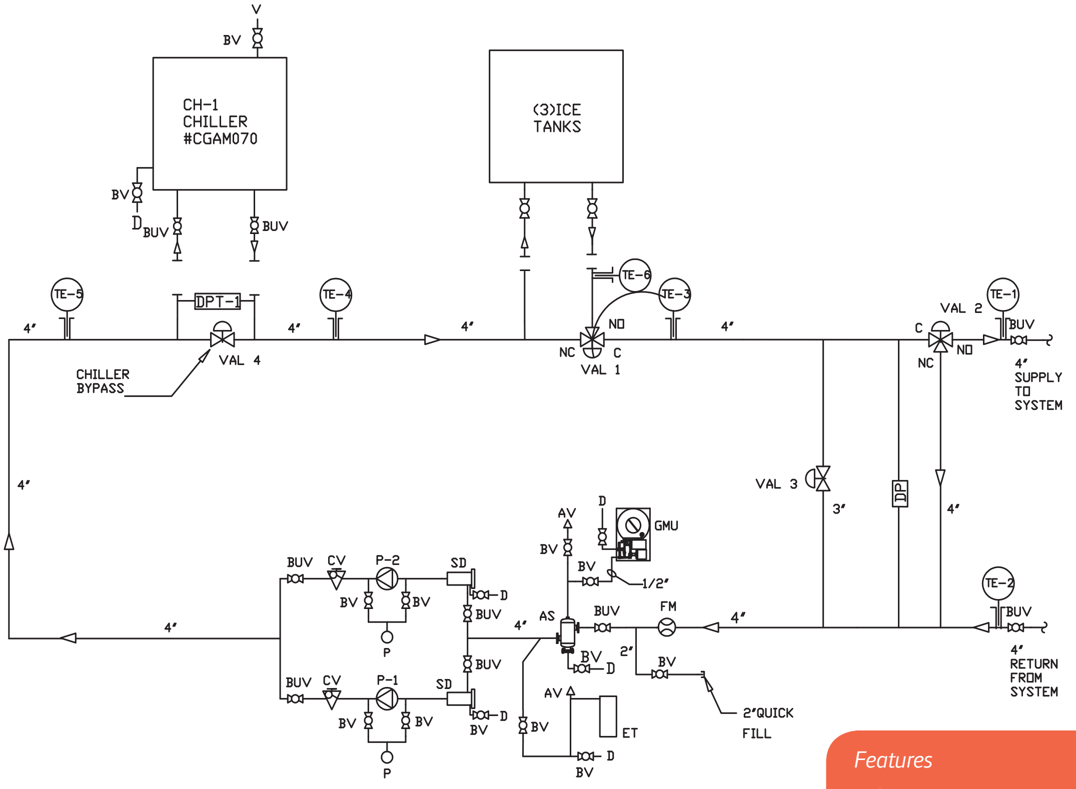
Benefits of adding ice to an existing chilled-water system include redundancy for one or more chillers, expansion of the system, maximum reuse of existing components and better system efficiency. Existing chillers do not need retrofitting and can handle cooling loads while the new ice chiller charges the tanks.

Consider the location of the heat exchanger to balance with ice plant flow rates and capacity. Locating the heat exchanger upstream of existing chiller(s) provides easier load-shifting and ice-priority control, while a downstream ice plant location improves chiller efficiency.



Standard configurations

Variable flow cooling, constant flow charging



TAG	ITEM
AS	AIR SEPARATOR
AV	AUTO AIR VENT
BUV	BUTTERFLY VALVE
BV	BALL VALVE
CH	CHILLER
CV	CHECK VALVE
DPT 1	DP SWITCH
DPT 2	DP SWITCH
D	DRAIN
ET	BLADDER EXPANSION TANK
FLX	FLEX CONNECTOR
FM	FLOW METER
GMU	GLYCOL MAKEUP UNIT
P	PRESSURE GAUGE
P/T	PRESSURE AND TEMPERATURE GUAGES
P1	PUMP 1
P2	PUMP 2
TE-1	SENSOR
TE-2	SENSOR
TE-3	SENSOR
TE-4	SENSOR
TE-5	SENSOR
TE-6	SENSOR
SD	SUCTION DIFFUSER
V	VENT
VAL 1	TANK MOD 3WAY
VAL 2	SYSTEM DIV 3WAY
VAL 3	VP BYPASS 2WAY NC
VAL 4	CHILLER ISO 2WAY NC

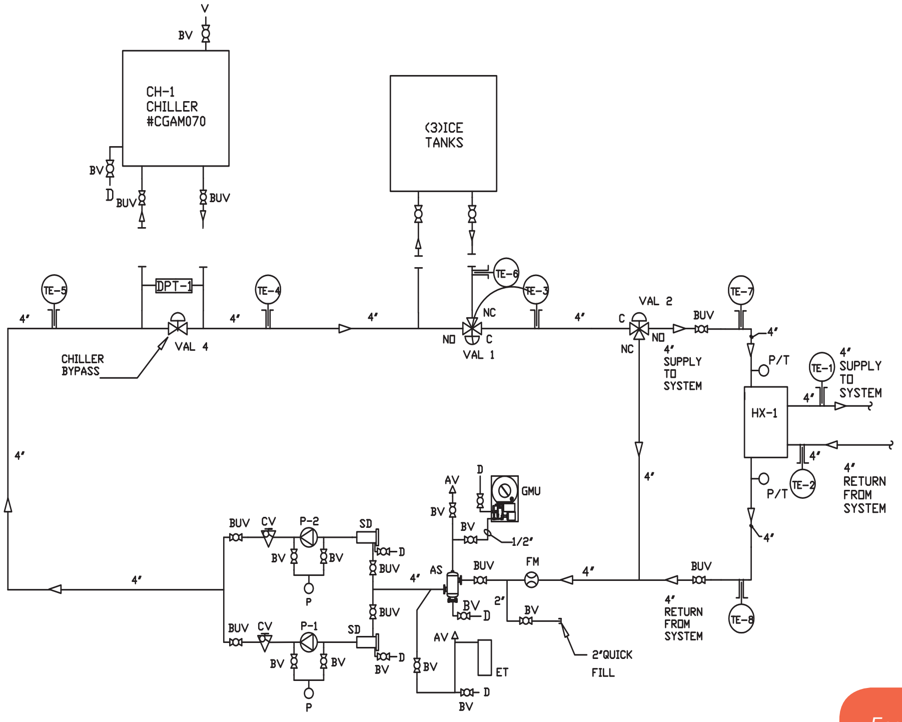
Features

- Lower pump energy than constant flow
- Load bypass during charge mode charges tanks quickly
- Variable Frequency Drive (VFD) eliminates need for triple duty valve for system balancing
- VFD communicates with system controller for power management and reporting

Considerations

- Cost of VFD on pump
- Building load during charge cycle should be kept to a minimum either by:
  - ignoring calls for cooling, or
  - installing a separate cooling system for critical spaces, or
  - delaying charge until after loads diminish, reducing the amount of time available for charging tanks.

Decoupled with heat exchanger



TAG	ITEM
AS	AIR SEPARATOR
AV	AUTO AIR VENT
BUV	BUTTERFLY VALVE
BV	BALL VALVE
CH	CHILLER
CV	CHECK VALVE
DPT 1	DP SWITCH
D	DRAIN
ET	BLADDER EXPANSION TANK
FLX	FLEX CONNECTOR
FM	FLOW METER
GMU	GLYCOL MAKEUP UNIT
P	PRESSURE GAUGE
P/T	PRESSURE AND TEMPERATURE GUAGES
P1	PUMP 1
P2	PUMP 2
TE-1	SENSOR
TE-2	SENSOR
TE-3	SENSOR
TE-4	SENSOR
TE-5	SENSOR
TE-6	SENSOR
TE-7	SENSOR
TE-8	SENSOR
SD	SUCTION DIFFUSER
V	VENT
VAL 1	TANK MOD 3WAY
VAL 2	SYSTEM DIV 3WAY
VAL 3	N/A
VAL 4	CHILLER ISO 2WAY NC
HX	HEAT EXCHANGER

Features

- Easier to plug into an existing decoupled system, possibly with an existing air-cooled chiller, reuse distribution pump
- Cost of glycol is lower with the shorter glycol loop, a consideration as systems get larger
- Water in the coils rather than glycol

Considerations

- Cost of heat exchanger
- Cooling during charge mode is more complicated and therefore not supported by this phase of prepackaged system controls
- Care must be taken to avoid freezing water on the load side of the heat exchanger – a tempering loop may be preferred

Supports the way you work

For the Engineer

Making it all happen without blowing the budget is critical. Trane and CALMAC worked together to create system drawings and control sequences to help you—whether you select one of our packaged systems, or make a custom design of your own.

For selecting the right size system, IcePick software takes you from a design day load profile to the smallest chiller, or other combinations of ice and chiller to meet the design day load with capacity to spare. Another software tool, IceCycle from Trane, helps determine the final charge temperature based on the chiller, the flow rate, and the number of tanks. This tool can be used to determine:

- if the chiller and tanks operate within their flow constraints during the charging mode,
- the final charge temperature for a full charge based on the flow rate, chiller and tanks,
- the max discharge tons and stored ton-hours, and
- if the tanks can be charged in the amount of time available.

(Data on p. 24 provides information for the chiller performance entries for IceCycle and IcePick.)

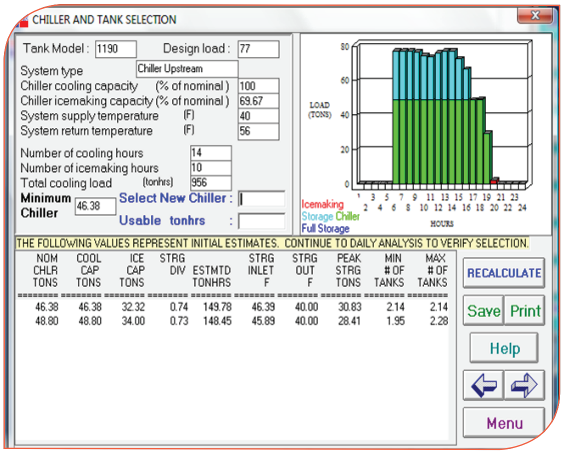
Once you have IcePick and IceCycle results, the chiller selection software will provide performance at the average charge temperature and allow you to test stability, performance, and percent glycol required for the selected chiller at the final charge temperature.

The beauty of a prepackaged EarthWise System is that it efficiently passes knowledge and expertise to the people who make it happen. While this makes us choose specific, detailed configurations, it also allows for an advanced starting point—reducing the risk and confusion of doing something for the first time.

Trane and CALMAC give you tools for calculating system payback, optimizing control algorithms, modeling system performance, and provide BIM drawings to support efficient design practices.

CALMAC IcePick design day chiller size starting point

With the design day load profile, this software finds combinations of chiller and tanks.



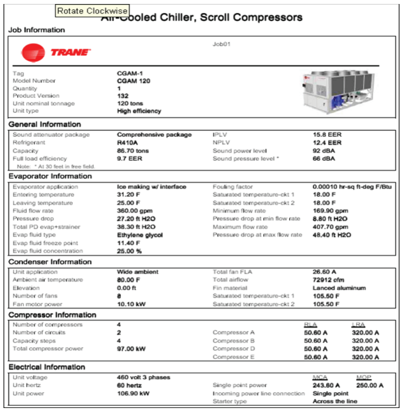
Tank Model : 1190
Design load : 77
System type: Chiller Upstream
Chiller cooling capacity (% of nominal) 100
Chiller icemaking capacity (% of nominal) 69.67
System supply temperature (F) 40
System return temperature (F) 56
Number of cooling hours 14
Number of icemaking hours 10
Total cooling load (tonhrs) 956
Minimum Chiller 46.38
Select New Chiller :
Usable tonhrs :

THE FOLLOWING VALUES REPRESENT INITIAL ESTIMATES. CONTINUE TO DAILY ANALYSIS TO VERIFY SELECTION.

NOM CHLR TONS	COOL CAP TONS	ICE CAP TONS	STRG DIV	ESTMTD TONHRS	STRG INLET F	STRG OUT F	PEAK STRG TONS	MIN # OF TANKS	MAX # OF TANKS
46.38	46.38	32.32	0.74	149.78	46.39	40.00	30.83	2.14	2.14
48.80	48.80	34.00	0.73	148.45	45.89	40.00	28.41	1.95	2.28

Chiller selection software

Trane official product selection software (TOPSS®) provides detailed capacity and flow information.



Air-Cooled Chiller, Scroll Compressors

Job Information

Job01

Tag	CGAM-1
Model Number	CGAM 120
Quantity	1
Product Version	132
Unit nominal tonnage	120 tons
Unit type	High efficiency

General Information

Sound attenuator package	Comprehensive package	IPLV	15.8 EER
Refrigerant	R410A	NPLV	12.4 EER
Capacity	86.70 tons	Sound power level	92 dBA
Full load efficiency	9.7 EER	Sound pressure level *	66 dBA

Note: * At 30 feet in free field.

Evaporator Information

Evaporator application	Ice making w/ interface	Fouling factor	0.00010 hr-sq ft-deg F/Btu
Entering temperature	31.20 F	Saturated temperature-ckt 1	18.00 F
Leaving temperature	25.00 F	Saturated temperature-ckt 2	18.00 F
Fluid flow rate	360.00 gpm	Minimum flow rate	169.90 gpm
Pressure drop	27.20 ft H2O	Pressure drop at min flow rate	8.80 ft H2O
Total PD evap+strainer	38.30 ft H2O	Maximum flow rate	407.70 gpm
Evap fluid type	Ethylene glycol	Pressure drop at max flow rate	48.40 ft H2O
Evap fluid freeze point	11.40 F		
Evap fluid concentration	25.00 %		

Condenser Information

Unit application	Wide ambient	Total fan FLA	26.60 A
Ambient air temperature	80.00 F	Total airflow	72912 cfm
Elevation	0.00 ft	Fin material	Lanced aluminum
Number of fans	8	Saturated temperature-ckt 1	105.50 F
Fan motor power	10.10 kW	Saturated temperature-ckt 2	105.50 F

Compressor Information

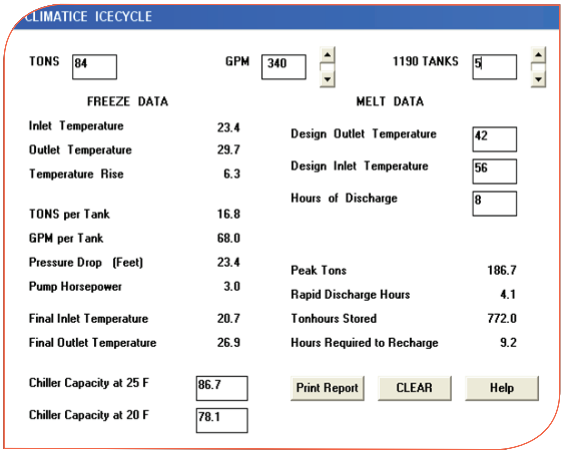
			RLA	LRA
Number of compressors	4			
Number of circuits	2	Compressor A	50.60 A	320.00 A
Capacity steps	4	Compressor B	50.60 A	320.00 A
Total compressor power	97.00 kW	Compressor D	50.60 A	320.00 A
		Compressor E	50.60 A	320.00 A

Electrical Information

			MCA	MOP
Unit voltage	460 volt 3 phases			
Unit hertz	60 hertz	Single point power	243.60 A	250.00 A
Unit power	106.90 kW	Incoming power line connection	Single point	
		Starter type	Across the line	

IceCycle from Trane

Focuses on balancing flows between chiller(s) and tanks, final temperature, and time to charge.



TONS 84
GPM 340
1190 TANKS 5

FREEZE DATA

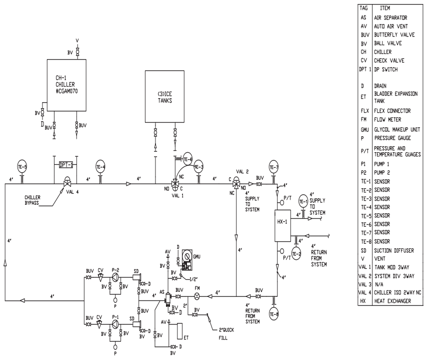
Inlet Temperature	23.4
Outlet Temperature	29.7
Temperature Rise	6.3
TONS per Tank	16.8
GPM per Tank	68.0
Pressure Drop (Feet)	23.4
Pump Horsepower	3.0
Final Inlet Temperature	20.7
Final Outlet Temperature	26.9
Chiller Capacity at 25 F	86.7
Chiller Capacity at 20 F	78.1

MELT DATA

Design Outlet Temperature	42
Design Inlet Temperature	56
Hours of Discharge	8
Peak Tons	186.7
Rapid Discharge Hours	4.1
Tonhours Stored	772.0
Hours Required to Recharge	9.2

Schematics with Bills of Material

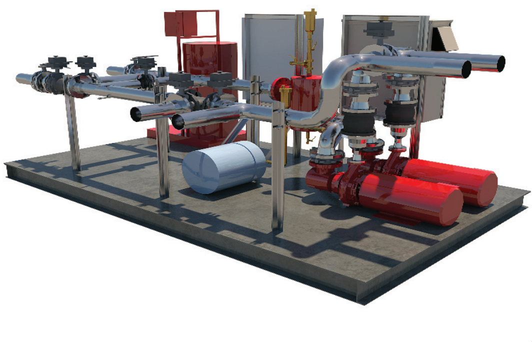
Layouts of four sizes of completion skids, with and without the optional heat exchanger, are available.



TAG	ITEM
AS	AIR SEPARATOR
AV	AUTO AIR VENT
BUV	BUTTERFLY VALVE
BV	BALL VALVE
CH	CHILLER
CV	CHECK VALVE
DPT 1	DP SWITCH
D	DRAIN
ET	BLADDER EXPANSION TANK
FLX	FLEX CONNECTOR
FM	FLOW METER
GMU	GLYCOL MAKEUP UNIT
P	PRESSURE GAUGE
P/T	PRESSURE AND TEMPERATURE GUAGES
P1	PUMP 1
P2	PUMP 2
TE-1	SENSOR
TE-2	SENSOR
TE-3	SENSOR
TE-4	SENSOR
TE-5	SENSOR
TE-6	SENSOR
TE-7	SENSOR
TE-8	SENSOR
SD	SUCTION DIFFUSER
V	VENT
VAL 1	TANK MOD 3WAY
VAL 2	SYSTEM DIV 3WAY
VAL 3	N/A
VAL 4	CHILLER ISO 2WAY NC
HX	HEAT EXCHANGER

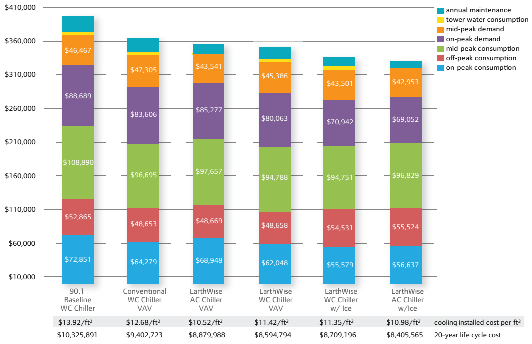
BIM drawing files

Chillers, tanks and system completion skids available in .dwg and Revit formats.



TRACE modeling software and support

TRACE energy analysis software can take your load design entries and do what-if scenarios for several options.



90.1 Baseline WC Chiller	Conventional WC Chiller VAV	EarthWise AC Chiller VAV	EarthWise WC Chiller VAV	EarthWise WC Chiller w/ Ice	EarthWise AC Chiller w/Ice	
$13.92/ft²	$12.68/ft²	$10.52/ft²	$11.42/ft²	$11.35/ft²	$10.98/ft²	cooling installed cost per ft²
$10,325,891	$9,402,723	$8,879,988	$8,594,794	$8,709,196	$8,405,565	20-year life cycle cost

For the System Installer

System installers can either stick-build the system using our suggested systems, or purchase a system completion skid from Trane Creative Solutions. With the system completion skid, system installers can take advantage of a prepackaged EarthWise System—reducing the risk and confusion of doing something for the first time. Simpler selection, submittals, and ordering processes save time and reduce errors. Prepiped pumping and accessories on a factory-built and -commissioned completion skid reduce startup time on the job.

In addition, CALMAC IceBank tanks are available with tank connection piping already completed. You have the option of two or three packs with same end connections or opposite end connections for reverse return piping (recommended) arrangements.

System completion skids

Pre-engineered pump modules also include ancillary equipment such as valves, sensors, expansion tanks and a glycol management system.

IceBank packages

For systems with multiple tanks, installation is quicker with a crane and combinations of two or three 1190 tanks installed as one group.

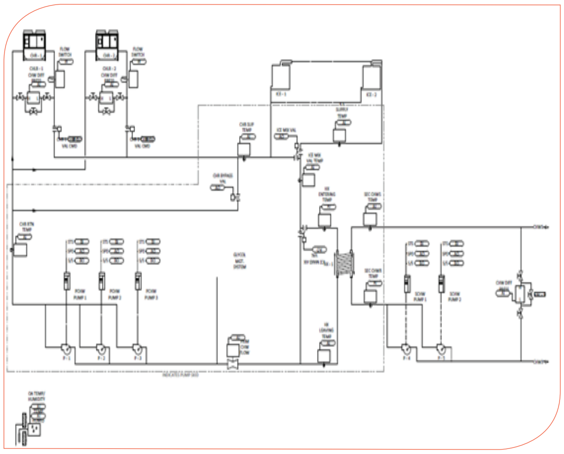
For the Controls Programmer

We've taken several steps to streamline the controls installation and compress the time it takes to complete the programming phase of the project.

Standardized controls programming provides a common, repeatable experience for the building operator and service organization and saves time. The graphical programming is done at both the sub-system and system level, complete with graphics and dashboards. In addition, the sub-system controls are preloaded and shipped with the system completion skid.

Pre-packaged Solutions (PPS)

Controls wiring diagrams



Sequences of operation

TRANE

		Issue Date	Supersedes
		10/17/11	
Purpose: Ice on pipe internal melt VPF: Two (2) CGAM Air-Cooled Chillers Upstream of Ice Storage Tanks, Two (2) Variable Secondary Loop Manifolded pumps, and Pump Skid with: Three (3) Variable Primary Flow Manifolded N+1 Pumps, Chiller Minimum Flow Bypass Valve, Heat Exchanger System General Descriptions	PPS System: HY0104	Page 1 of 4	
Controller: UC600	Contact: Pre-Packaged Solutions Team	Document File Name HY0104 Sequence_EN.docx	

Sequence of Operation
Ice on pipe internal melt VPF:
Two (2) CGAM Air-Cooled Chillers Upstream of Ice Storage Tanks, Two (2) Variable Secondary Loop Manifolded pumps, and Pump Skid with: Three (3) Variable Primary Flow Manifolded N+1 Pumps, Chiller Minimum Flow Bypass Valve, Heat Exchanger

System General Descriptions

The EarthWise Ice Enhanced Air-Cooled Chiller Plant consists of the following:

- Two (2) air cooled CGAM chillers with
  - Chiller evaporator differential pressure transmitter
  - Evaporator supply isolation valve
- Glycol primary loop application
- Pump skid:
  - Three (3) manifolded primary pumps with VFD
  - Chiller Minimum Flow Bypass Valve
  - Ice making/Heat Exchanger diverting valve
  - Ice tank mixing valve
  - Chiller(s) bypass valve
  - Primary loop flow meter
  - Chilled Water temperature sensors
    - Chiller(s) leaving supply temperature (matched sensors 1)
    - Ice tank mixing valve leaving temperature (matched sensors 1)
    - Ice tank supply temperature
    - Heat Exchanger production side entering temperature (matched sensors 2)
    - Heat Exchanger production side leaving temperature (matched sensors 2)
    - Secondary loop supply temperature (optional - matched sensors 3)
    - Secondary loop return temperature (optional - matched sensors 3)
    - Chiller(s) entering return temperature
  - Glycol makeup unit
  - BAS Controller
- Ice Tanks (quantity TBD) with inventory meter
- Secondary (building) loop differential pressure transmitter
- Two (2) Secondary loop chilled water pumps with VFD

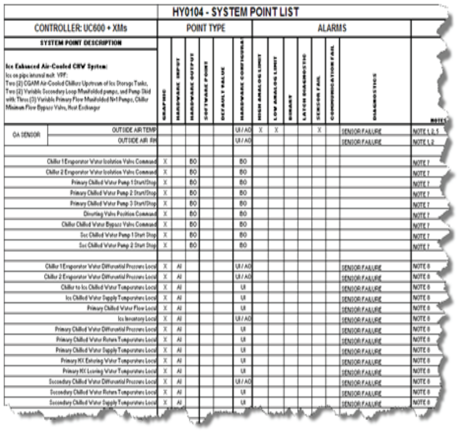
The BAS controller provides stand-alone control or control from a higher level BAS and provides start/stop and lead/lag/standby control for the variable flow chilled glycol pumps, variable flow secondary loop chilled water pumps and controls the pump speed via the VFD speed control signal to maintain the chilled water system differential pressure setpoint (adj.); controls the chiller/ice plant modes of operation, and chiller/ice plant sequencing. The BAS controller also provides control for the Chiller Minimum Flow Bypass Valve and the ice making diverting valve to maintain minimum flow through the chiller along with the appropriate flow to the building load for specific modes of operation.

Chiller / Ice Plant Control Enable
The BAS shall enable the system via calendar scheduling and operating strategy (demand limit or load shift) as determined by the Chiller/Ice Plant Control (CIPC) or the cooling mode on a call for optimal start, night setback or timed override operation of any system air handling unit.

Upon a call for plant operations the CIPC determines the startup mode of operation.
Temperature Based

- During utility OFF peak and occupied mode, the plant shall start in:
  - The chiller only mode when the outdoor air temperature is above 60 Deg. F (Adj.)
  - The ice only mode when the outdoor air temperature is below 60 Deg. F (Adj.)
- During utility ON peak and occupied mode, the plant shall start in:
  - The chiller & ice mode when the outdoor air temperature is above 60 Deg. F (Adj.)

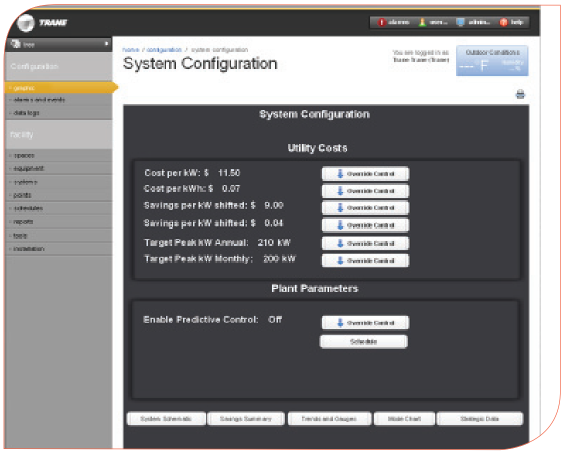
I/O point summaries



HY0104 - SYSTEM POINT LIST

CONTROLLER: UC600 + XMs		POINT TYPE						ALARMS							
SYSTEM POINT DESCRIPTION **Ice Enhanced Air-Cooled CHW System:** Ice on pipe internal melt VPF: Two (2) CGAM Air-Cooled Chillers Upstream of Ice Storage Tanks, Two (2) Variable Secondary Loop Manifolded pumps, and Pump Skid with Three (3) Variable Primary Flow Manifolded N+1 Pumps, Chiller Minimum Flow Bypass Valve, Heat Exchanger		GRAPHIC	HARDWARE INPUT	HARDWARE OUTPUT	SOFTWARE POINT	DEFAULT VALUE	HARDWARE CONFIGURA	HIGH ANALOG LIMIT	LOW ANALOG LIMIT	[illegible]	LATCH DIAGNOSTIC	SENSOR FAIL	COMMUNICATION FAIL	DIAGNOSTICS	NOTES
OA SENSOR	OUTSIDE AIR TEMP						UI / AO	X	X			X		SENSOR FAILURE	NOTE 1, 2, 5
	OUTSIDE AIR RH						UI / AO							SENSOR FAILURE	NOTE 1, 2
	Chiller 1 Evaporator Water Isolation Valve Command	X		BO			BO								NOTE 7
	Chiller 2 Evaporator Water Isolation Valve Command	X		BO			BO								NOTE 7
	Primary Chilled Water Pump 1 Start/Stop	X		BO			BO								NOTE 7
	Primary Chilled Water Pump 2 Start/Stop	X		BO			BO								NOTE 7
	Primary Chilled Water Pump 3 Start/Stop	X		BO			BO								NOTE 7
	Diverting Valve Position Command	X		BO			BO								NOTE 7
	Chiller Chilled Water Bypass Valve Command	X		BO			BO								NOTE 7
	Sec Chilled Water Pump 1 Start Stop	X		BO			BO								NOTE 7
	Sec Chilled Water Pump 2 Start Stop	X		BO			BO								NOTE 7
	Chiller 1 Evaporator Water Differential Pressure Local	X	AI				UI / AO							SENSOR FAILURE	NOTE 8
	Chiller 2 Evaporator Water Differential Pressure Local	X	AI				UI / AO							SENSOR FAILURE	NOTE 8
	Chiller to Ice Chilled Water Temperature Local	X	AI				UI							SENSOR FAILURE	NOTE 8
	Ice Chilled Water Supply Temperature Local	X	AI				UI							SENSOR FAILURE	NOTE 8
	Primary Chilled Water Flow Local	X	AI				UI							SENSOR FAILURE	NOTE 8
	Ice Inventory Local	X	AI				UI / AO							SENSOR FAILURE	NOTE 8
	Primary Chilled Water Differential Pressure Local	X	AI				UI							SENSOR FAILURE	NOTE 8
	Primary Chilled Water Return Temperature Local	X	AI				UI							SENSOR FAILURE	NOTE 8
	Primary Chilled Water Supply Temperature Local	X	AI				UI							SENSOR FAILURE	NOTE 8
	Primary HX Entering Water Temperature Local	X	AI				UI							SENSOR FAILURE	NOTE 8
	Primary HX Leaving Water Temperature Local	X	AI				UI							SENSOR FAILURE	NOTE 8
	Secondary Chilled Water Differential Pressure Local	X	AI				UI / AO							SENSOR FAILURE	NOTE 8
	Secondary Chilled Water Return Temperature Local	X	AI				UI							SENSOR FAILURE	NOTE 8
	Secondary Chilled Water Supply Temperature Local	X	AI				UI							SENSOR FAILURE	NOTE 8

Configuration screen



System Configuration

System Configuration

Utility Costs

Cost per kW: $ 11.50
Cost per kWh: $ 0.07
Savings per kW shifted: $ 9.00
Savings per kW shifted: $ 0.04
Target Peak kW Annual: 210 kW
Target Peak kW Monthly: 200 kW

Plant Parameters

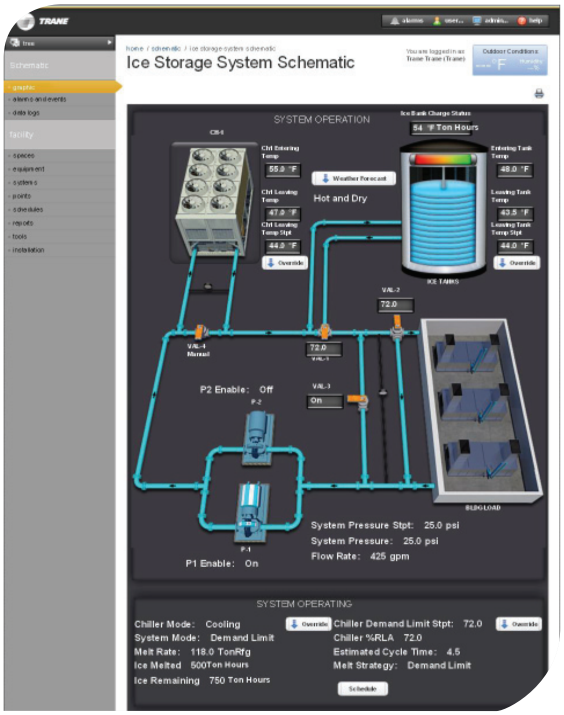
Enable Predictive Control: Off

For the Building Operator

An operator selects the expected daily load profile based on the day type and weather forecast to determine how the plant will operate.

More advanced information about the system and how it is operating can be accessed from other interface screens. Scheduling modes of operation is accomplished by a simple-to-use interface accessed through the dashboard.

The dashboard on the right can include a link from the chiller and ice plant screen to the air handlers. Air handler at-a-glance information can be mapped to this screen, if desired.



Ice Storage System Schematic

You are logged in as Trane Trane (Trane)

Ice Bank Charge Status: 54 °F Ton Hours

Chl Entering Temp: 55.0 °F

Chl Leaving Temp: 47.0 °F

Chl Leaving Temp Stpt: 44.0 °F

Hot and Dry

Entering Tank Temp: 48.0 °F

Leaving Tank Temp: 43.5 °F

Leaving Tank Temp Stpt: 44.0 °F

VAL-2: 72.0

VAL-1: 72.0

VAL-3: On

P2 Enable: Off

P1 Enable: On

System Pressure Stpt: 25.0 psi

System Pressure: 25.0 psi

Flow Rate: 425 gpm

Chiller Mode: Cooling

System Mode: Demand Limit

Melt Rate: 118.0 TonRfg

Ice Melted 500Ton Hours

Ice Remaining 750 Ton Hours

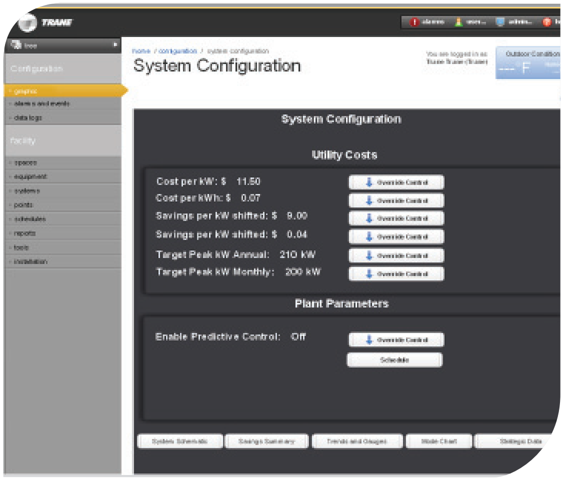
Chiller Demand Limit Stpt: 72.0

Chiller %RLA 72.0

Estimated Cycle Time: 4.5

Melt Strategy: Demand Limit

Configuration screen



System Configuration

System Configuration

Utility Costs

Cost per kW: $ 11.50

Cost per kWh: $ 0.07

Savings per kW shifted: $ 9.00

Savings per kW shifted: $ 0.04

Target Peak kW Annual: 210 kW

Target Peak kW Monthly: 200 kW

Plant Parameters

Enable Predictive Control: Off

At-a-glance gauges

Ice Storage Dashboard

You are logged in as Trane Trane (Trane)

Chiller temps: Entering 55.0 °F, Leaving 47.0 °F; Delta T 8.0 °F; Setpoint 43.5 °F

Tank temps: Entering 48.0 °F, Leaving 43.5 °F; Delta T 4.5 °F; Setpoint 43.5 °F

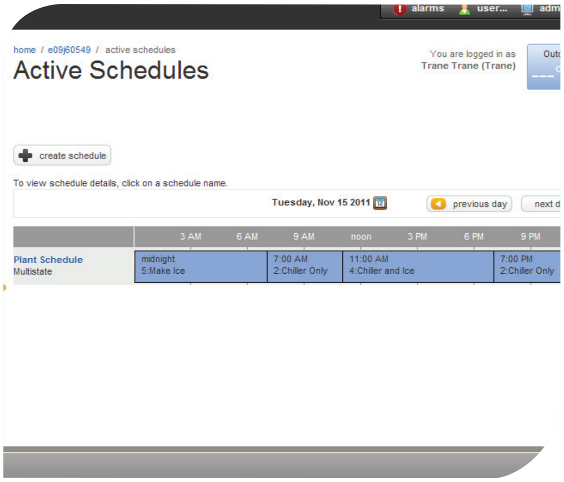
System temps: Return 54.0 °F, Supply 44.0 °F; Delta T 10.0 °F; Setpoint 43.5 °F

Chiller load: MIN 50, MAX 250

Ice inventory: MIN 500, MAX 2,000

Building load: MIN 40, MAX 400

Scheduling application



home / e09j60549 / active schedules

Active Schedules

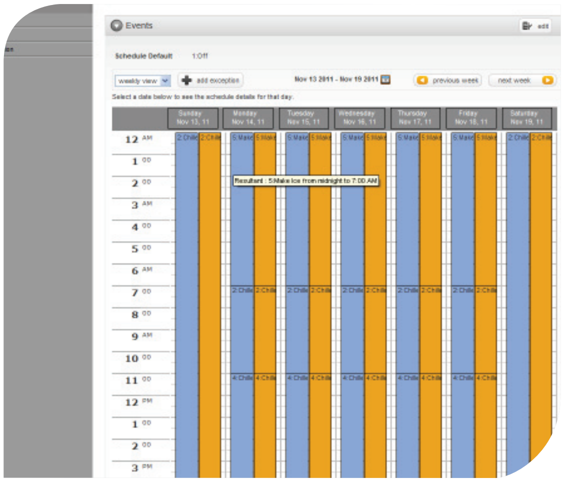
You are logged in as Trane Trane (Trane)

To view schedule details, click on a schedule name.

Tuesday, Nov 15 2011

Plant Schedule Multistate	midnight 5:Make Ice	7:00 AM 2:Chiller Only	11:00 AM 4:Chiller and Ice	7:00 PM 2:Chiller Only

Scheduled versus actual mode



Schedule Default 1:Off

Nov 13 2011 - Nov 19 2011

Select a date below to see the schedule details for that day.

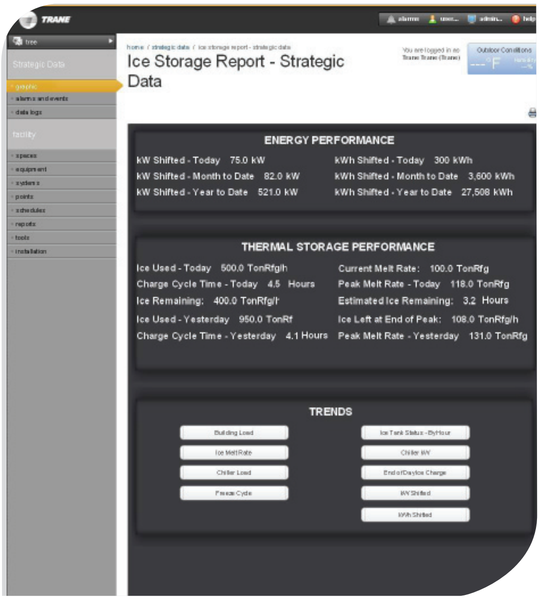
Resultant : 5:Make Ice from midnight to 7:00 AM

For the Owner

Preprogrammed displays demonstrate how the system saves money when operating and provides opportunities to further optimize system operation.

You want to know that your system is saving money as predicted. One of the common "complaints" about this system is that it saves more money than predicted.

Performance summary



Ice Storage Report - Strategic Data

ENERGY PERFORMANCE

kW Shifted - Today 75.0 kW
kW Shifted - Month to Date 82.0 kW
kW Shifted - Year to Date 521.0 kW
kWh Shifted - Today 300 kWh
kWh Shifted - Month to Date 3,600 kWh
kWh Shifted - Year to Date 27,508 kWh

THERMAL STORAGE PERFORMANCE

Ice Used - Today 500.0 TonRfg/h
Charge Cycle Time - Today 4.5 Hours
Ice Remaining: 400.0 TonRfg/h
Ice Used - Yesterday 950.0 TonRf
Charge Cycle Time - Yesterday 4.1 Hours
Current Melt Rate: 100.0 TonRfg
Peak Melt Rate - Today 118.0 TonRfg
Estimated Ice Remaining: 3.2 Hours
Ice Left at End of Peak: 108.0 TonRfg/h
Peak Melt Rate - Yesterday 131.0 TonRfg

For the Occupants

A lobby or entrance hall is an optimal place to display the great work your facility is doing to reduce energy costs. Students, employees or customers can see the benefits and learn about the EarthWise System you've installed.

Graphics illustrate the system operation and performance at a moment in time. The economic dashboard estimates system savings.

Savings calculations

Savings Summary

Year to Date Savings $ 7,500.00
Month to Date Savings $ 950.00
Today's Savings $ 85.00

System Components

Fundamentally, the EarthWise Ice-enhanced Air-cooled Chiller Plant consists of air-cooled chiller(s), a system completion module, ice tanks and controls. The following pages provide details on each of these components.

Air-cooled Chillers

CGAM air-cooled scroll chiller	20-130 tons
RTAC air-cooled screw chiller	140-500 tons


Model CGAM

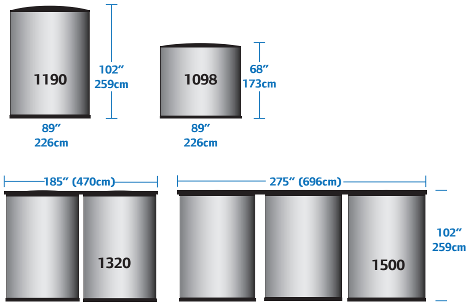

Model RTAC

Chiller performance data

based on 25% ethylene glycol in the evaporator loop

	operating conditions						chiller flow and pressure drop						combined capacity and efficiency				
Evap (F) Ambient (F)	evap. 40/54 ambient 95		evap 42/56 ambient 95		evap 48/56 ambient 95		min flow	PD@ min flow	flow @3x nom tons	PD@3x nom ton flow	max flow	PD@ max flow		48-38	56-48	melt mode at 95°F ambient	
	tons	unit kW	tons	unit kW	tons	unit kW	gpm	ft of H_2O	gpm	ft of H_2O	gpm	ft of H_2O	tanks	melt tons	chiller tons	kW/ton	EER
CGAM020	18.3	22.8	18.9	23.0	20.5	23.5	29.1	6.4	60.0	25.7	69.7	32.9	1	23.5	20.5	0.534	22.5
CGAM026	23.3	29.4	24.1	29.7	26.1	30.3	37.2	7.4	78.0	31.9	89.4	41.0	1	30.6	26.1	0.534	22.5
CGAM030	26.1	32.9	27.0	33.2	30.0	33.9	41.8	9.4	90.0	43.1	100.3	52.5	1	35.3	30.0	0.519	23.1
CGAM035	30.9	39.1	32.0	39.4	34.6	40.2	49.1	6.5	105.0	27.9	117.7	34.4	2	41.2	34.6	0.530	22.6
CGAM040	35.2	44.7	36.5	45.1	40.0	46.2	56.7	9.1	120.0	38.8	136.1	49.5	2	47.1	40.0	0.530	22.6
CGAM052	45.6	57.6	47.2	58.1	51.3	59.6	73.5	7.9	156.0	33.4	176.4	42.1	3	58.8	51.3	0.541	22.2
CGAM060	52.5	65.1	54.4	65.6	59.5	66.9	83.9	8.0	180.0	34.3	201.4	42.3	3	70.6	59.5	0.514	23.3
CGAM070	61.7	76.9	63.9	77.6	69.6	79.4	99.4	7.6	210.0	33.0	238.6	42.2	3	82.4	69.6	0.522	23.0
CGAM080	70.5	85.4	73.0	86.1	79.5	88.0	114.7	7.4	240.0	30.3	275.3	39.2	4	94.1	79.5	0.507	23.7
CGAM090	79.6	96.3	82.3	97.2	89.5	99.4	128.3	6.7	270.0	27.9	307.8	35.8	4	105.9	89.5	0.509	23.6
CGAM100	89.3	107.4	92.5	108.2	100.7	110.4	144.4	7.3	300.0	30.1	346.6	39.6	4	117.6	100.7	0.506	23.7
CGAM110	97.2	119.8	100.7	120.8	109.4	123.4	156.5	7.5	330.0	32.3	375.7	41.3	5	129.4	109.4	0.517	23.2
CGAM120	106.2	132.0	109.9	133.2	119.3	136.3	169.9	8.6	360.0	38.3	407.7	48.8	5	141.2	119.3	0.523	22.9
CGAM130	114.9	137.9	118.9	139.1	129.2	142.1	183.7	8.9	390.0	40.9	440.8	51.0	6	152.9	129.2	0.504	23.8
RTAC140S	122.3	160.6	128.1	164.1	146.4	175.5	193.0	3.8	420.0	18.4	709.0	51.9	6	164.7	146.4	0.564	21.3
RTAC140H	124.9	157.8	131.1	161.0	150.8	171.7	202.0	3.2	420.0	14.2	741.0	44.0	6	164.7	150.8	0.544	22.1
RTAC155S	134.2	174.7	140.5	178.5	160.8	191.0	215.0	4.0	465.0	19.1	785.0	54.1	7	182.4	160.8	0.557	21.6
RTAC155H	138.7	171.2	145.4	174.7	167.0	186.1	217.0	3.2	465.0	15.3	796.0	44.4	7	182.4	167.0	0.533	22.5
RTAC170S	148.7	190.4	155.3	194.4	175.9	206.9	202.0	3.2	510.0	21.2	741.0	43.9	7	200.0	175.9	0.550	21.8
RTAC170H	151.1	184.8	158.4	188.6	181.8	200.9	241.0	3.3	510.0	15.1	883.0	44.9	7	200.0	181.8	0.526	22.8
RTAC185S	163.3	210.7	170.3	215.2	192.6	229.5	226.0	3.5	555.0	21.9	796.0	44.3	8	217.6	192.6	0.559	21.4
RTAC185H	169.4	206.9	176.8	211.0	199.8	224.0	217.0	3.5	555.0	23.8	796.0	48.1	8	217.6	199.8	0.537	22.4
RTAC200S	178.6	231.8	186.3	236.8	210.4	253.0	241.0	3.3	600.0	21.1	883.0	44.9	9	235.3	210.4	0.568	21.1
RTAC200H	185.8	228.3	193.9	233.0	218.7	247.7	241.0	3.5	600.0	22.9	883.0	48.7	9	235.3	218.7	0.546	22.0
RTAC225S	199.0	256.8	207.0	262.1	231.4	278.9	223.0	3.7	675.0	35.1	796.0	48.1	10	294.1	231.4	0.531	22.6
RTAC225H	201.9	250.9	210.4	256.1	236.7	272.6	241.0	3.5	675.0	28.9	883.0	48.6	10	294.1	236.7	0.514	23.4
RTAC250S	218.6	281.3	227.4	287.3	254.1	306.0	241.0	3.5	750.0	35.6	883.0	48.6	11	323.5	254.1	0.530	22.7
RTAC250H	223.8	276.9	233.1	282.6	261.2	300.3	241.0	3.5	750.0	35.6	883.0	48.6	11	323.5	261.2	0.514	23.4
RTAC275S	240.4	309.1	250.6	315.5	281.9	335.6	309.0	3.4	825.0	25.2	1134.0	46.7	13	352.9	281.9	0.529	22.7
RTAC275H	245.4	299.3	256.7	305.6	292.3	325.6	375.0	3.5	825.0	17.3	1374.0	47.6	13	352.9	292.3	0.505	23.8
RTAC300S	270.8	352.1	282.0	359.7	316.1	383.0	339.0	3.4	900.0	25.1	1243.0	47.1	15	411.8	316.1	0.526	22.8
RTAC300H	277.8	342.7	290.0	350.0	327.3	372.7	375.0	3.4	900.0	20.7	1374.0	47.5	15	411.8	327.3	0.504	23.8
RTAC350S	308.4	401.5	321.1	410.4	359.5	437.8	375.0	3.4	1050.0	28.3	1374.0	47.5	17	441.2	359.5	0.547	21.9
RTAC350H	312.3	377.8	325.8	385.0	367.9	407.6	404.0	3.5	1050.0	24.8	1483.0	48.5	17	441.2	367.9	0.504	23.8
RTAC400S	365.9	474.1	380.4	484.0	424.3	514.3	404.0	3.5	1200.0	32.3	1483.0	48.5	19	470.6	424.3	0.575	20.9
RTAC400H	376.3	464.3	392.0	473.9	440.6	503.6	461.0	3.6	1200.0	25.3	1690.0	49.3	19	470.6	440.6	0.553	21.7
RTAC450S	403.8	523.9	419.6	535.0	466.9	568.7	422.0	3.5	1350.0	37.5	1548.0	48.7	21	529.4	466.9	0.571	21.0
RTAC500H	442.1	574.1	459.4	586.5	511.6	624.9	461.0	3.6	1500.0	39.3	1690.0	49.3	23	588.2	511.6	0.568	21.1

CALMAC IceBank® 1190



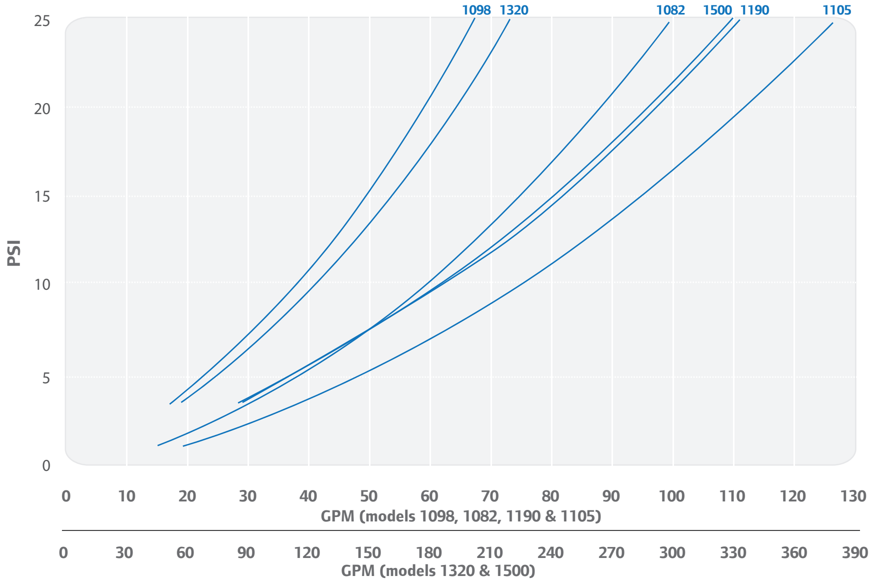
Specifications

Dimensions (L x W x H)	89″ x 91″ x 102″
Filled weight	16,900 lbs
Floor loading	391 lb/sq. ft.
Inlet/outlet flange connection size	4″
Manufacturer product line	IceBank®
Maximum operating pressure	90 psi
Maximum operating temperature	100°F
Net usable capacity*	162 ton/hr
Shipping weight	2000 lb
Volume of water ice	1655 gal
Volume of solution in heat exchanger	157 gal

*Typical value, varies with conditions

Pressure drop curves

Based on 25% ethylene glycol. Contact Trane or CALMAC representative for other fluids or concentartions.



CALMAC IceBank tank weights and dimensions

Model	Nominal (net usable) ton-hrs*	Flange size (in.)	Shipping weight (lb)	Filled weight (lb)	Floor loading (lb/ft2)	Width (in.)	Length (in.)	Height (in.)
1500C	486	4	6000	50600	391	89	273	102
1320C	324	4	4000	34000	391	89	181	102
1190	162	4	2000	16900	391	89	92	102
1105	105	4	1315	10885	360	73 ¾	76 ½	102
1098	98	4	1275	10235	237	89	92	69 ½
1082	82	4	1065	8580	283	73 ¾	76 ½	84 ½
1045	41	2	580	4380	150	73 ¾	76 ½	48

To access AutoCAD or Revit drawing files visit http://calmac.com/products/icebankc_specs.asp

*Typical value, varies with conditions

Maximum operating pressure for all tanks is 90 psi
Dimensions can change, contact CALMAC for up-to-date specifications
Dimensions reflect the larger of same side or reverse side connections
Models 1190, 1098, 1105 and 1082 tanks can be ordered with two, three, or four flanges with headers underneath the lid.
Models 1320 and 1500 are pre-piped packages of two and three 1190 tanks, respectively, and require a crane for rigging. All other models can be installed by forklift.
A-style tanks have a 2-inch flanged connection with forklift bases. These are used for the small project, replacement market. A 2-inch flange simplifies installation.
C-style tanks have a 4-inch flanged connection without a forklift base. The C-style tanks have the option to be manufactured with two, three or four flanges.
This option works because under the lid is a connecting header.

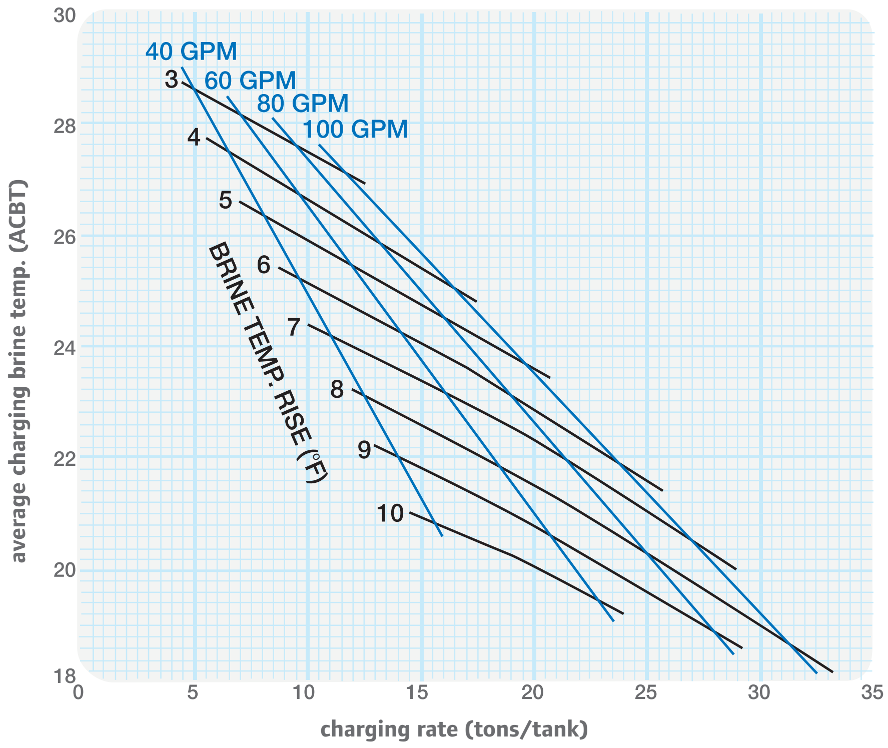
IceBank Performance in Charge Mode (Model 1190)

The table below shows the capacity that can be absorbed by the tank at various average charging temperatures. Both CALMAC IcePick and Trane IceCycle software incorporate this information into the calculations. The table below illustrates the balance that must be struck between chiller and tank sizing.

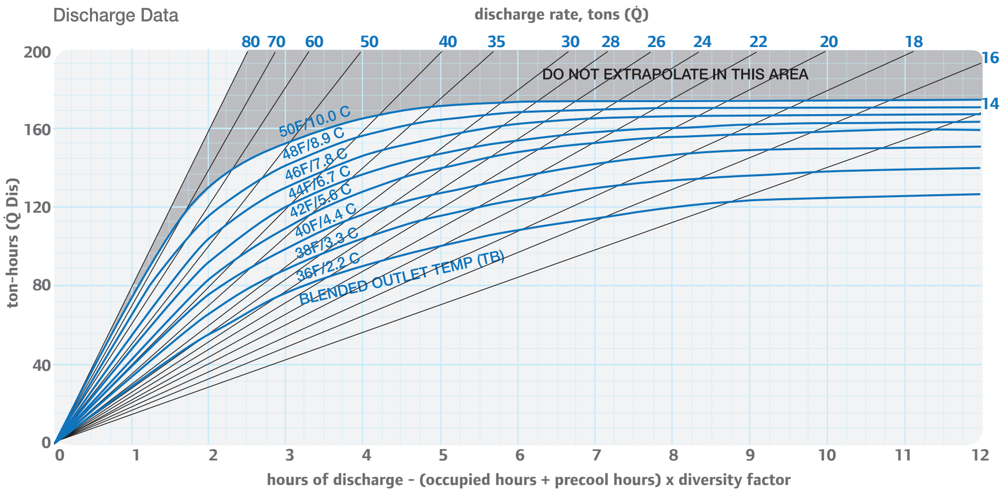
Minimum charging brine temperature to IceBank for full charge (ºF)

	tons/tank						
Average charging temperature (ºF)	5	10	15	20	25	30	35
28	25.7	25.1					
27	24.7	24.3	23.8				
26		23.4	22.9				
25		22.7	22.1	21.4			
24		22.1	21.4	20.7			
23			20.8	20.1	19.3		
22			20.1	19.5	18.6		
21			19.5	18.9	18.1	17.6	
20				18.3	17.7	17.2	
19					17.3	16.7	
18						16.1	15.8

Charging rate by flow rate

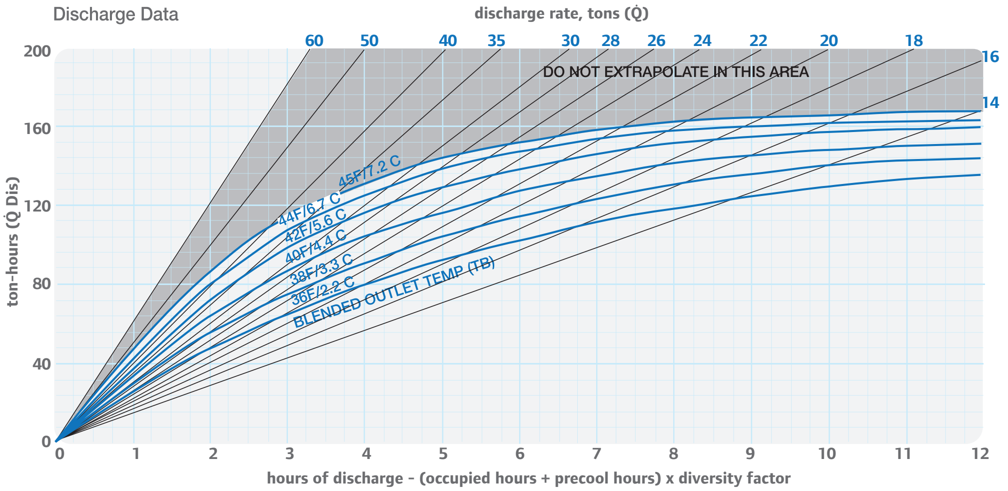


IceBank Performance in Discharge Mode (Model 1190)



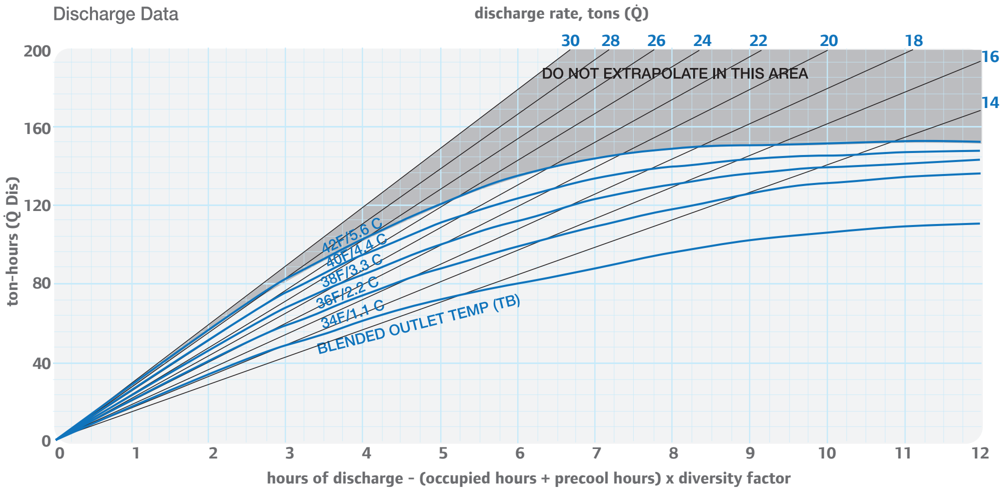
storage inlet
temperature
(Tin)

60°F



storage inlet
temperature
(Tin)

50°F



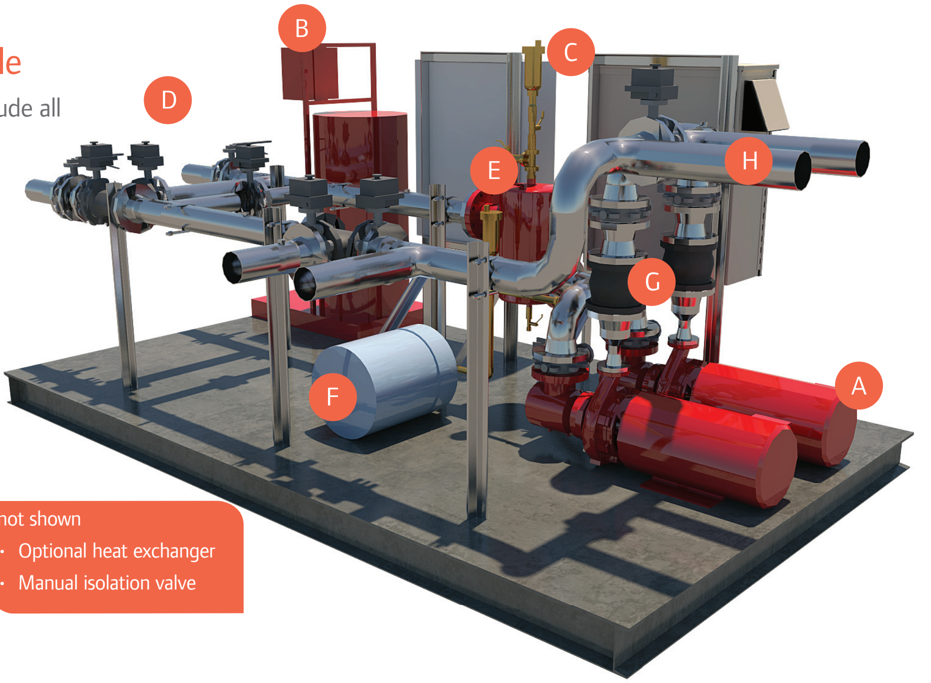
storage inlet
temperature
(Tin)

45°F

System Completion Module

System completion components include all system hydronics specialties:

- A Pumps
- B Integral glycol feeder system
- C Control and electrical panels
- D Motorized control valves
- E Air separator
- F Expansion tank
- G Pump strainers
- H All connective piping



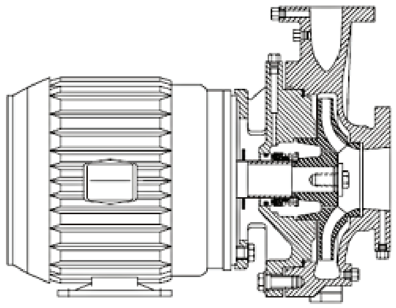
not shown
- Optional heat exchanger
- Manual isolation valve

Standard module electrical data

				pump FLA			controls (amps)			208V			460V			575V		
skid type	pumps run-ning	pump impeller size	HP	208V	460V	575V	208V	460V	575V	skid MCA	RDE	skid MOP	skid MCA	RDE	skid MOP	skid MCA	RDE	skid MOP
No HEX, 1 Chiller	1	3x1.5x8	20	54	25	20.9	6.94	3.14	2.5	74.4	90.0	125.0	34.4	45.0	50.0	28.6	35.0	45.0
1 HEX, 1 Chiller	1	3x2x13	15	42	19	17.2	6.94	3.14	2.5	59.4	70.0	100.0	26.9	35.0	45.0	24.0	30.0	40.0
No HEX, 2 Chiller	2	3x1.5x8	20	54	25	20.9	6.94	3.14	2.5	128.4	150.0	175.0	59.4	70.0	80.0	49.5	60.0	70.0
1 HEX, 2 Chiller	2	3x2x13	15	42	19	17.2	6.94	3.14	2.5	101.4	125.0	125.0	45.9	60.0	60.0	41.2	50.0	50.0
No HEX, 1 Chiller	1	3x2.5x8	30	80	36	32.7	6.94	3.14	2.5	106.94	150.0	175.0	48.1	60.0	80.0	43.4	60.0	70.0
1 HEX, 1 Chiller	1	4x3x11.5	20	54	25	20.9	6.94	3.14	2.5	74.4	90.0	125.0	34.4	45.0	50.0	28.6	35.0	45.0
No HEX, 2 Chiller	2	3x2.5x8	30	80	36	32.7	6.94	3.14	2.5	186.9	225.0	250.0	84.1	100.0	110.0	76.1	90.0	100.0
1 HEX, 2 Chiller	2	4x3x11.5	20	54	25	20.9	6.94	3.14	2.5	128.4	150.0	175.0	59.4	70.0	80.0	49.5	60.0	70.0
No HEX, 1 Chiller	1	4x3x8	30	80	36	32.7	6.94	3.14	2.5	106.94	150.0	175.0	48.1	60.0	80.0	43.4	60.0	70.0
1 HEX, 1 Chiller	1	4x3x11.5	20	54	25	20.9	6.94	3.14	2.5	74.4	90.0	125.0	34.4	45.0	50.0	28.6	35.0	45.0
No HEX, 2 Chiller	2	4x3x8	30	80	36	32.7	6.94	3.14	2.5	186.9	225.0	250.0	84.1	100.0	110.0	76.1	90.0	100.0
1 HEX, 2 Chiller	2	4x3x11.5	20	54	25	20.9	6.94	3.14	2.5	128.4	150.0	175.0	59.4	70.0	80.0	49.5	60.0	70.0
No HEX, 1 Chiller	1	4x3x8	40	104	47	39	6.94	3.14	2.5	136.9	175.0	225.0	61.9	80.0	100.0	51.3	70.0	90.0
1 HEX, 1 Chiller	1	5x4x11.5	25	68	31	25.4	6.94	3.14	2.5	91.9	110.0	150.0	41.9	50.0	70.0	34.3	45.0	50.0
No HEX, 2 Chiller	2	4x3x8	40	104	47	39	6.94	3.14	2.5	240.9	300.0	300.0	108.9	125.0	150.0	90.3	100.0	125.0
1 HEX, 2 Chiller	2	5x4x11.5	25	68	31	25.4	6.94	3.14	2.5	159.9	200.0	225.0	72.9	90.0	100.0	59.7	70.0	80.0

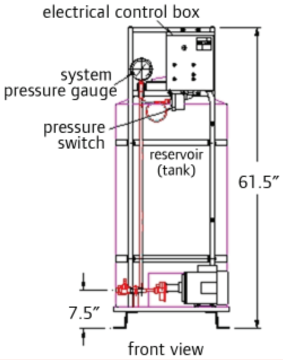
Dimensions and performance data*

								bypass					skid				
skid type	total head (ft)	skid head (ft)	external head (ft)	pipe mains size	system flow (GPM)	pressure drop (ft/100′)	velocity (ft/sec)	line size	flow (GPM)	PD (ft/100′)	velocity (ft/sec)	pipe size	length	width	height	dry weight (lb)	operating weight (lb)
No HEX, 1 Chiller	166	86	80	4″	239	3.85	6.02	3	80	2	3.47	3″	12′	7′	70″	5650	6677
1 HEX, 1 Chiller	109	109	N/A	4″	239	3.85	6.02	3	N/A	N/A	N/A	N/A	17′	7′	86″	8647	10219
No HEX, 2 Chiller	166	86	80	6″	478	1.85	5.31	3	80	2	3.47	3″	12′	7′	78″	7077	8617
1 HEX, 2 Chiller	109	109	N/A	6″	478	1.85	5.31	3	N/A	N/A	N/A	N/A	17′	7′	86″	9846	11794
No HEX, 1 Chiller	167	87	80	5″	408	3.38	6.54	4	136	1.39	3.43	4″	12′	7′	78″	6574	7859
1 HEX, 1 Chiller	110	110	N/A	5″	408	3.38	6.54	4	N/A	N/A	N/A	N/A	17′	7′	100″	9678	11618
No HEX, 2 Chiller	167	87	80	8″	816	1.29	5.24	4	136	1.39	3.43	4″	12′	7′	92″	9013	11573
1 HEX, 2 Chiller	110	110	N/A	8″	816	1.29	5.24	4	N/A	N/A	N/A	N/A	17′	7′	100″	12251	15049
No HEX, 1 Chiller	161	81	80	6″	440	3.38	6.54	4	263	4.58	6.63	4″	12′	7′	80″	7362	8865
1 HEX, 1 Chiller	104	104	N/A	6″	440	3.38	6.54	4	N/A	N/A	N/A	N/A	17′	7′	100″	11433	13916
No HEX, 2 Chiller	161	81	80	8″	880	1.48	5.65	4	263	4.58	6.63	4″	17′	7′	96″	9100	11660
1 HEX, 2 Chiller	104	104	N/A	8″	880	1.48	5.65	4	N/A	N/A	N/A	N/A	17′	7′	100″	13406	16554
No HEX, 1 Chiller	161	81	80	6″	525	2.19	5.83	5	314	2.1	5.03	5″	12′	7′	80″	7546	9085
1 HEX, 1 Chiller	104	104	N/A	6″	525	2.19	5.83	5	N/A	N/A	N/A	N/A	17′	7′	100″	11994	14842
No HEX, 2 Chiller	161	81	80	8″	1050	2.04	6.74	5	314	2.1	5.03	5″	17′	7′	100″	9430	11990
1 HEX, 2 Chiller	104	104	N/A	8″	1050	2.04	6.74	5	N/A	N/A	N/A	N/A	17′	7′	105″	14027	17540



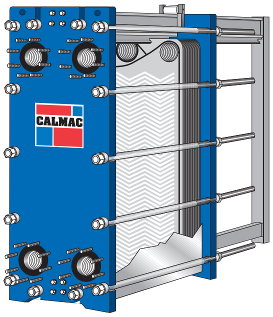
Pumps with TR200 communicating VFD

- Motor mounted horizontal end suction
- Heavy-duty, grease-lubricated ball bearings
- Self-lubricating silicon carbide mechanical seal



Glycol management system (standard)

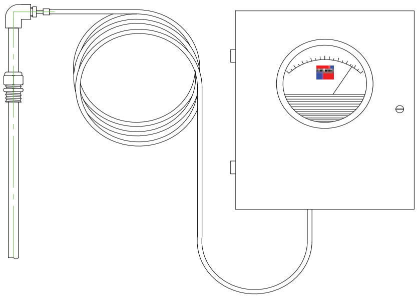
CALMAC glycol management system maintains the proper volume of coolant in a building's circulating loop by monitoring the system pressure and adding coolant from a reservoir when the pressure drops below a setpoint.



CALMAC heat exchangers

Sized for the application and featuring

- True counter-current design for close temperature approach
- Unique interlocking plate design to help ensure a tight seal
- Deep set gasket grooves to improve reliability
- Bolted construction for strength and accessibility



Inventory meter (optional)

- Indoor or outdoor field installation
- White-faced magnehelic display
- Factory-calibrated 4-20 mA output for remote monitoring

(Tracer SC controls include Btu inventory calculations as standard.)

Quick Select Guide

These charts are meant to be used in the preliminary planning stages, before all information about the project is known. Once more detail is available, other tools such as Trane TOPSS™ chiller selection software, CALMAC IcePick® and Trane IceCycle should be used to verify system performance and completion of the project design.

Using the quick select chart

The purpose of this chart is to show the relative amount of time needed to charge a certain number of tanks with a specific chiller cooling 25 percent by weight ethylene glycol. For example, in an existing installation with a known chiller, this chart solves for the number of tanks that chiller could charge, given the number of hours available to charge them. Or, in an installation with a space constraint for tanks, this chart solves for the minimum size chiller required to charge the tanks in the number of hours available to charge them.

This information is presented for single chiller installations with ice storage. While it is not expected that a majority of jobs will only have one chiller, nor is it a system requirement, it allows for this simple representation of system size and performance.

Quick select for single-chiller installations

CALMAC 1190 tanks	hours to charge												
	5	6	7	8	9	10	11	12	13	14	15	16	
1	CGAM52	CGAM52	CGAM40	CGAM30	CGAM30	CGAM26	CGAM26	CGAM26	CGAM20	CGAM20	CGAM20	CGAM20	3″
2	CGAM100	CGAM100	CGAM100	CGAM70	CGAM60	CGAM60	CGAM52	CGAM52	CGAM40	CGAM40	CGAM40	CGAM30	
3	RTAC155	CGAM130	CGAM100	CGAM90	CGAM80	CGAM70	CGAM70	CGAM60	CGAM60	CGAM60	CGAM60	CGAM50	4″
4	RTAC200	RTAC170	RTAC140	CGAM130	CGAM110	CGAM100	CGAM90	CGAM80	CGAM70	CGAM70	CGAM70	CGAM60	
5	RTAC275	RTAC200	RTAC170	RTAC155	RTAC140	CGAM130	CGAM110	CGAM100	CGAM90	CGAM90	CGAM80	CGAM80	
6	RTAC300	RTAC250	RTAC200	RTAC170	RTAC155	RTAC140	CGAM130	CGAM110	CGAM100	CGAM100	CGAM90	CGAM80	
7	RTAC350	RTAC275	RTAC250	RTAC200	RTAC170	RTAC155	RTAC140	RTAC140	CGAM130	CGAM110	CGAM100	CGAM100	
8	RTAC400	RTAC300	RTAC275	RTAC225	RTAC200	RTAC185	RTAC170	RTAC155	RTAC140	CGAM130	CGAM130	CGAM110	5″
9		RTAC350	RTAC300	RTAC275	RTAC225	RTAC200	RTAC185	RTAC170	RTAC155	RTAC140	RTAC140	CGAM130	
10		RTAC400	RTAC350	RTAC300	RTAC275	RTAC225	RTAC200	RTAC185	RTAC170	RTAC155	RTAC155	RTAC140	
11			RTAC400	RTAC300	RTAC275	RTAC250	RTAC225	RTAC200	RTAC185	RTAC170	RTAC170	RTAC155	6″
12			RTAC400	RTAC350	RTAC300	RTAC275	RTAC250	RTAC225	RTAC200	RTAC185	RTAC185	RTAC170	
13				RTAC400	RTAC350	RTAC300	RTAC275	RTAC250	RTAC225	RTAC200	RTAC185	RTAC185	
14				RTAC400	RTAC350	RTAC300	RTAC300	RTAC275	RTAC250	RTAC225	RTAC200	RTAC200	
15					RTAC400	RTAC350	RTAC300	RTAC275	RTAC275	RTAC250	RTAC225	RTAC200	
16					RTAC400	RTAC400	RTAC300	RTAC300	RTAC275	RTAC275	RTAC250	RTAC225	
17					RTAC400	RTAC400	RTAC350	RTAC300	RTAC300	RTAC275	RTAC250	RTAC250	8″
18						RTAC400	RTAC400	RTAC350	RTAC300	RTAC300	RTAC275	RTAC250	
19						RTAC400	RTAC400	RTAC400	RTAC300	RTAC300	RTAC275	RTAC275	

Using the charge and melt data

For a given chiller model, this table provides system performance when paired with a typical number of CALMAC IceBank model 1190 tanks. This information was extracted by Trane IceCycle using the assumptions shown, which incorporates CALMAC performance data. While this is only one configuration, it can help to illustrate the following:

- peak capacity (tons) of the system during a 10-hour discharge window
- ton-hours of ice assisted chiller for a 10-hour discharge window
- hours to recharge given the chiller capacity and the flow rate
- approximate system completion skid size based on the flow rate

If your system doesn’t line up with these assumptions, consult Trane TOPSS™ and IceCycle software.

Charge and melt data

	chiller capacity[1] at leaving temp. (°F)		no. of tanks	capacity (tons)			ton-hours		hours	nominal flow[5] (gpm)	skid size
Chiller model	25	20	CALMAC 1190	chiller + ice	chiller[2]	ice melt[3]	stored[3]	chiller + ice[4]	recharge time	flow	completion module
CGAM 20	14.6	13.1	1	45	21	23.5	150	363	10.4	60	3″
CGAM 26	19.1	17.3	1	58	27	30.6	150	420	8.1	78	3″
CGAM 30	21.2	19.1	1	65.8	31	35.3	150	455	7.4	90	3″
CGAM 35	25.0	22.6	2	77.0	35.8	41.2	300	658	12.1	105	3″
CGAM 40	27.4	24.5	2	88.5	41	47.1	300	714	11.0	120	3″
CGAM 52	37.3	33.6	3	111.7	53	58.8	450	979	12.2	150	4″
CGAM 60	42.30	38.0	3	132.2	62	70.6	450	1066	10.8	180	4″
CGAM 70	50.20	45.2	3	154.4	72	82.4	450	1170	9.2	210	4″
CGAM 80	56.7	51.0	4	176.3	82	94.1	600	1422	10.7	240	4″
CGAM 90	65.50	58.1	4	198.4	93	105.9	600	1525	9.4	270	4″
CGAM 100	71.8	64.5	4	221.8	104	117.6	600	1642	8.6	300	5″
CGAM 110	78.80	70.9	5	242.6	113	129.4	750	1882	9.7	330	5″
CGAM 120	86.60	78.1	5	264.4	123	141.2	750	1982	8.9	360	5″
CGAM 130	92.9	83.7	6	286.5	134	152.9	900	2236	9.9	390	5″
RTAC140	104.3	93.0	6	319.1	154	164.7	900	2444	8.9	420	5″
RTAC155	114	101.6	7	350.1	168	182.4	1050	2727	9.4	465	6″
RTAC170	123.9	110.3	7	381.8	182	200.0	1050	2868	8.7	510	6″
RTAC185	137.8	123.1	8	418.6	201	217.6	1200	3210	9	555	6″
RTAC200	151.1	135	9	447.5	212	235.3	1350	3472	9.2	600	6″
RTAC250	179.4	160.5	10	555.6	262	294.1	1500	4115	8.6	750	6″
RTAC275	200.5	179.1	11	616.9	293	323.5	1650	4584	8.5	825	8″
RTAC300	226.4	202.5	13	684.1	331	352.9	1950	5262	8.9	900	8″
RTAC350	254.4	227.8	15	779.3	368	411.8	2250	5925	9.1	1050	8″
RTAC375	280.5	251.4	17	847.1	406	441.2	2550	6609	9.3	1125	8″
RTAC400	307.2	275.3	19	916.1	446	470.6	2850	7305	9.5	1200	8″
RTAC450	335.4	301.4	21	1012.1	483	529.4	3150	7977	9.6	1350	8″
RTAC500	367.4	330.5	23	1117.1	529	588.2	3450	8739	9.6	1500	8″

[1] Calculated at 80°F entering air temperature with 25% ethylene glycol solution

[2] Calculated at 95°F entering air temperature and 50°F upstream chiller leaving solution temperature

[3] Calculated at 50°F entering fluid temperature and 10°F ΔT

[4] Chiller ton-hours at 95°F entering air temperature and 50°F upstream chiller leaving solution temperature for ten hours plus stored ton-hours from ice at average discharge temperature

[5] 3 gpm per nominal chiller ton

Controls

Ice-enhanced, Air-cooled Chiller Plant EarthWise Systems include an optional system completion module, preprogrammed control sequences, operator graphics, reports, drawings and guide specifications.

BACnet communicating system controller (Tracer SC) and sub-system controller (UC600)

Preprogrammed sequences

- One chiller, no heat exchanger
- Two chillers, no heat exchanger
- One chiller with heat exchanger and two distribution pumps
- Two chillers with heat exchanger and two distribution pumps

Control functions

- System scheduling
- Six modes of operation
  - Off
  - Chiller only - single and multiple chiller
  - Ice only
  - Chiller and ice
  - Make ice
  - Make ice and cool
- System mode determination
- Chiller plant demand limiting
- Ice inventory 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
- Failure modes and recovery
- Heat exchanger sequencing and control (option)
- Pump control for water loops (option)

Information displayed at sub-system controller and at system controller

- Ton hours used last ice discharge cycle
- Ton hours stored last ice build cycle
- Peak kW
- Estimated savings

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