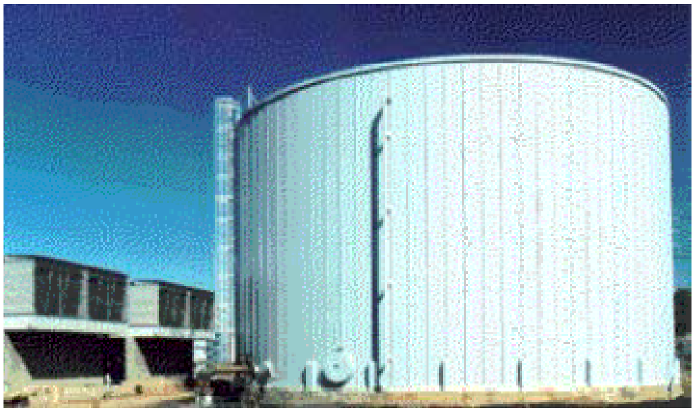
HVAC - Central System – Thermal Storage

General

Thermal storage is a cost saving technique, and in some cases, energy saving technology.



Commercial cooling can account for as much as 40% of peak demand on a hot summer day. Cool storage can shift some or all of the on-peak demand to off-peak hours. With cool storage (chilled water or ice storage), cost is saved by:

- Reducing electric demand charges through decreasing or eliminating chiller operation during peak demand periods;
- Operating chillers at night and displacing energy use from peak to off-peak periods when the energy is at a lower cost.

Hot water storage for domestic service water is a common example. It assures a supply during peak occupant demand times, and reduces cost in the same manner as cool storage. Storing hot water for space heating is less common, except where electric energy is used for heating.

Advantages

There are a number of advantages for end-users and utilities.

- Users gain by reducing their utility bills - largely through peak-shaving; reduced equipment size, space and weight; reduced compressor kW due to operating at more hours at full load and at nighttime lower condensing temperatures; availability of cold air distribution when ice is used; possible backup cooling or heating redundancy in event of power failure; when chilled water storage is used, availability of an added fire-protection water source.

- The utilities can gain from reduced peak use, improved load factors, added off-peak sales, deferred peak-capacity expansion costs, and improved competitive position over gas-fired alternatives.

Disadvantages

- May increase first cost of HVAC system;
- More complicated system design;
- Requires well-trained maintenance crew;
- Possible ambient heat gain to storage tanks;
- Specifying engineer has little incentive to use as it costs more to design and the firm may have little or no experience with the technology;
- Some of the risks include night-time loads greater than planned, insufficient storage provided so on hot days demand is not saved, improper controls supplied, operator inattention or unskilled, condensation on ducts with low temperature supply air when a fan is out of service.

Applications

Cooling, not heating, is a main concern of commercial building owners. Many buildings are populated with people, heat-emitting office and production equipment, and ample lighting -- all generating so much heat that cooling is required during most of the working hours all year. Most of these hours occur during the peak hours defined by the electric rate structure. Cool storage can shift all or most of this use to lower-cost off-peak hours resulting in lower operating cost without sacrificing comfort...and in some cases, increasing comfort.

The best cool storage applications are in any building:

- being charged on a time-of-use electric rate schedule;
- having high on-peak demand charges, with relatively low or no off-peak demand charge;
- that has peak cooling loads during utility on-peak hours;
- has very few comfort or process cooling hours per day, week or month, but with high peak loads during those few hours (such as churches);
- requiring low humidity control where ice storage can be used.

Air conditioning applications that can best benefit are office buildings, schools and college buildings, religious institutions, laboratories, large retail stores, libraries, museums, and the public use areas (meeting rooms, exhibit halls, convention centers) of hotels and public assembly buildings.

Other applications include:

- Industrial processes with batch cooling requirements;
- Facilities where low humidity can be achieved with the low water temperature achieved from ice storage;
- Buildings where space is at such a premium that the small ducts used with low air temperature distribution are advantageous, such as retrofit of older, historic buildings;
- Facilities where the cold storage can be tied into existing ammonia or other refrigeration systems.

There are some applications which may seem to be cool storage candidates, but should be avoided if these conditions exist:

- No benefit from off-peak operation;
- Speculative designs built on low-first cost premises;
- Likelihood of little or no attention to providing and keeping trained operators;
- Seasonal projects where the staff changes from season to season.

Technology Types

Depending on the needs of the building or process and the electric rate structure, there are several types of cool storage designs that may be employed on a given project:

- Full storage (load shifting)- discharging stored capacity without any concurrent chiller operation;
- Partial storage (load leveling)- discharging storage to meet cooling loads with concurrent operation of some chiller(s) piped in parallel with storage);
- Full recharge - recharging storage with chiller operation;
- Partial recharge - recharging storage with chiller capacity while simultaneously providing capacity to the cooling load;

- Standby - no normal use of storage, with chillers serving the cooling loads as they would in the absence of storage. Storage used when power outages occur.

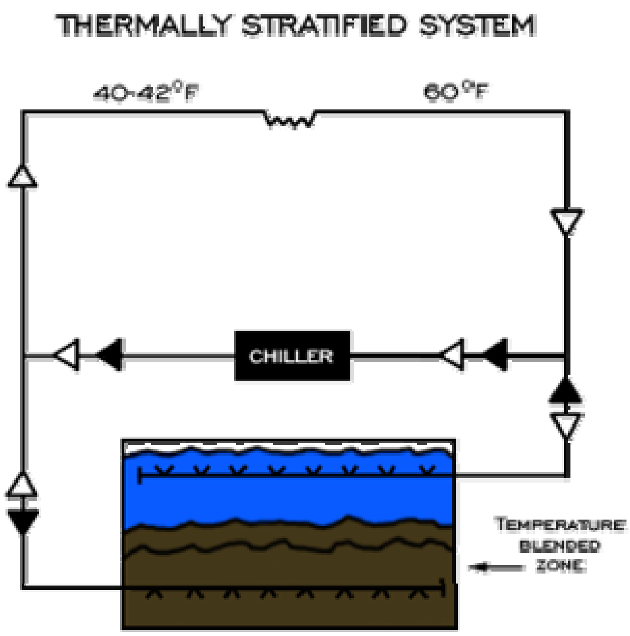
Storage capacity is usually defined in ton-hours which is the sum of the actual tons required each hour for the design day. It can be achieved using either chilled water storage or ice storage.

Chilled water storage typically requires more space (25 to 50 liters per m^2 of conditioned space) than ice storage (3 to 6 liters per m^2).

Chilled Water Storage

Chilled water storage is most common on very large projects (typically over 5'000m^2) where ample space is available. The steel or concrete tank(s) can be located either above- or below-ground.

In some cases, the stored water can serve to provide some or all the fire protection water storage. The complexities of assuring thermal stratification make chilled water storage more attractive where the storage tank is very large (and deeper than about 6m).



Adding chilled water storage is also an option for an existing facility to meet immediate growth needs while postponing new chiller acquisitions.

Ice Storage

There are two basic types - Ice Building Systems (static systems) and Ice Harvesting Systems (dynamic systems). The main advantage of ice storage is that it requires less space, can provide colder air to the building, and reduces duct and fan size; with an offsetting disadvantage of consuming more chiller energy.

Ice storage, being more compact, is most common on smaller commercial buildings or where space for the storage is limited. Ice storage systems, while requiring more refrigeration, can produce lower temperature chilled water, enabling the use of smaller chilled water pumps, piping, and coils. In general, static systems are more compact, simpler, and less costly than dynamic systems. As a result, static or Ice Builder systems seem more popular. The most prevalent ice storage systems are:

- Ice on coil in an open water side system (requires some periodic water treatment);
- Ice on coil using brine in a closed (pressurized) water side system, and
- Ice maker systems (ice harvester including spray-slush-ice).

Other system types (such as encapsulated ice, icefalls, eutectic salt storage) are variations being developed and commercialized.

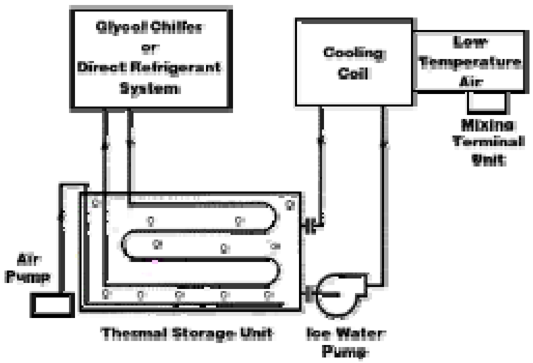
Ice on Coil Systems

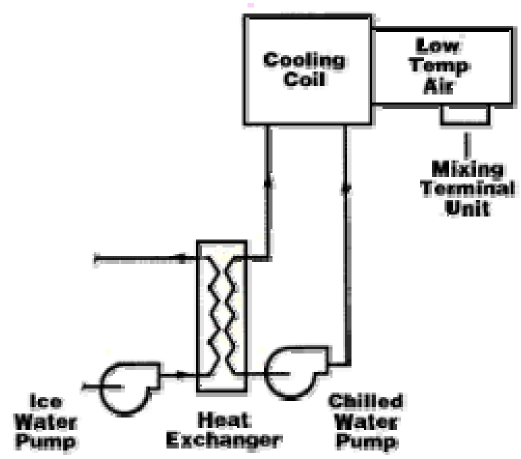
Open System -

Cold refrigerant or a brine solution is circulated through pipe coils submerged in an open water tank as shown below. During the charge cycle, ice forms on the pipe coils until a satisfactory thickness (typically 2" to 3") is achieved.

During normal operation, chilled water is circulated to the load, and the ice remains in storage. During the discharge cycle, the chilled water flows through the storage tank(s) and is chilled by the melting ice.

Where a closed circulating system is required, a heat exchanger is used between the circulating ice water and building chilled water as shown in the following:

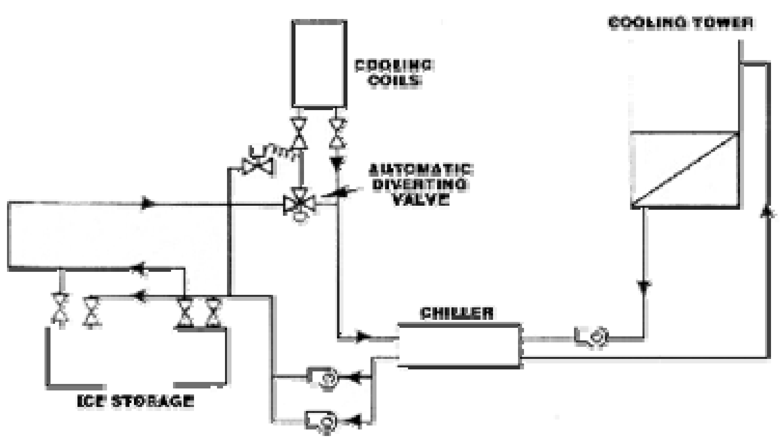




Closed System -

Another popular variation is the modular ice storage system using glycol brine.

This system utilizes one or more polyethylene tanks and tubes. Cold brine in a closed circulating system flows in a counter flow arrangement through the tubes, freezing the water in the tanks. In the charge cycle, an automatic diverting valve bypasses the cooling coils and the refrigerated brine builds ice.



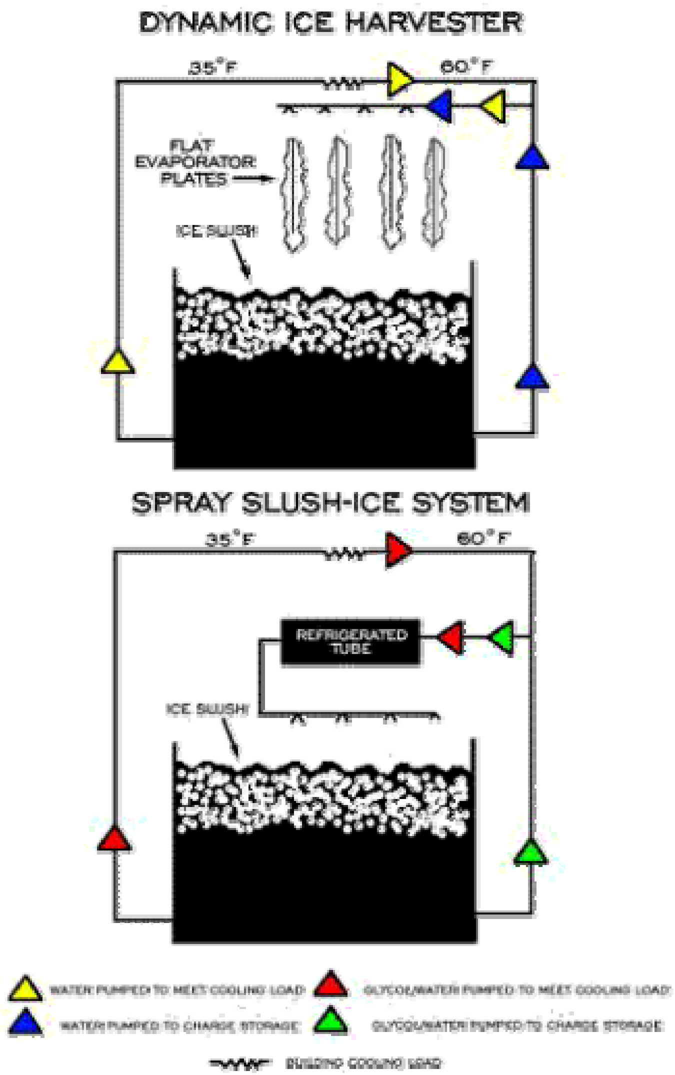
Modular Ice Storage System using brine

Ice Maker Systems -

These are typically either a dynamic ice harvester or a spray slush-ice system.

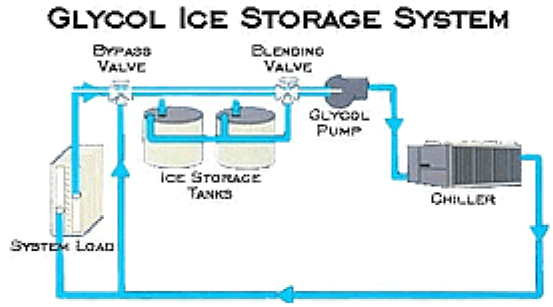
Dynamic ice harvesters use a water supply and refrigerated plates or tubes suspended over the storage tank. Ice forms on the refrigerated surfaces and is periodically ejected into the storage tank.

Spray slush-ice systems are similar except use a water/glycol solution and refrigerated tubes to generate an icy slush.



Glycol Storage

Glycol systems freeze water by circulating ethylene or propylene glycol through storage tanks.



Material used courtesy of Trane:
a Division of American Standard, Inc.

The glycol ice storage system is very simple. Few accessories are needed, and conventional water chillers are used.

Instead of water, a glycol solution (in this case, 25% ethylene glycol) is - pumped through the chiller, coils and ice storage tanks in the chilled water loop. The -4 to -5°C ethylene glycol produced by the packaged chiller freezes the water contained inside the ice storage tanks.

Advantages:

Glycol ice storage systems present the system designer with numerous benefits.

First is the ability to use a standard packaged chiller. They offer an opportunity to reduce pump horsepower, and they require few accessories.

The choice of either modular storage tanks or encapsulated ice systems not only offer application flexibility, but costs and reliable performance as well. Simple control schemes can be used, and like all ice storage systems - volume and space requirements per ton-hour of storage are considerably lower than those for chilled water storage.

Glycol ice storage systems enjoy a low installed cost since the same packaged chiller that provides space cooling also doubles as the "ice maker." The storage tanks themselves are the only significant cost burden of these systems. In fact, glycol ice storage systems may yield reduced chiller costs.

Disadvantages:

Glycol ice storage systems are not without their problems. The most significant of these is the need to design a heat transfer system that uses ethylene (or propylene) glycol rather than water.