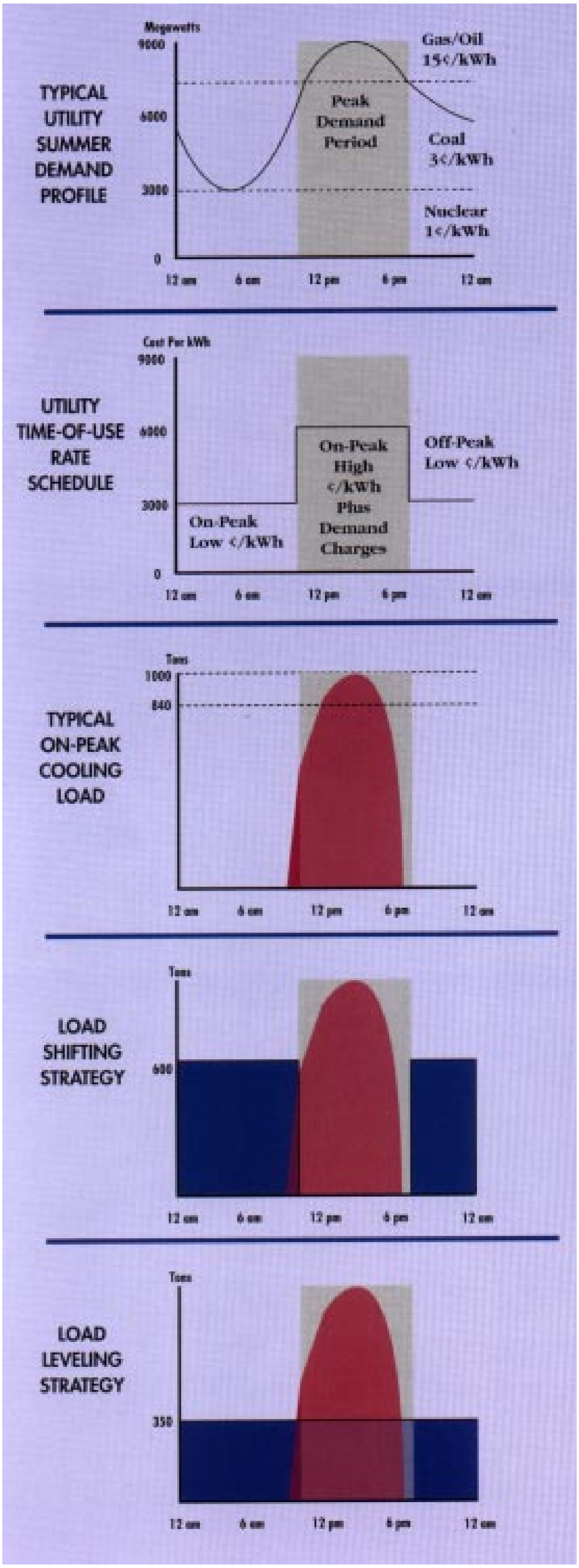


THERMAL ENERGY STORAGE

Thermal energy storage has been used for cooling since the earliest days of mechanical refrigeration. In the past, it has been economically feasible with certain classic cooling applications such as churches, theatres, and dairies to utilise the stored cooling effect of small refrigeration systems, operated over long periods of time, to meet large cooling requirements of short duration.

In recent years, the picture has changed dramatically. This concept has gained greater interest, primarily due to changes in utility pricing policies. Utilities are instituting time-of-use rate schedules to encourage the shifting of electrical demand to off-peak, low electrical demand periods of the day, periods during which utilities have excess generating capacity.

Large comfort and process cooling loads are prime candidates for electrical load shifting. By shifting electrical demand to off-peak hours in these situations, it is possible to obtain on-peak cooling at close to off-peak costs.

A typical cooling system load profile is presented at the left. While this system has a peak cooling requirement of 1,000 tons, the average demand is 840 tons for the 10 on-peak hours. Therefore, the total cooling requirement is 8,400 ton-hours.

A load shift TES strategy stores the entire on-peak cooling requirement during off-peak hours. In this case, 8,400 ton-hours must be stored in 14 hours. This approach shifts all refrigeration energy requirements to off-peak hours and reduces the size of the refrigeration system from 1,000 tons to 600 tons.

A load levelling strategy is also illustrated. This approach distributes the cooling system's electrical requirements over 24 hours, thereby significantly reducing on-peak electrical demand. In this example, it is possible to satisfy the 8,400 ton-hour cooling requirement with a 350-ton refrigeration system.

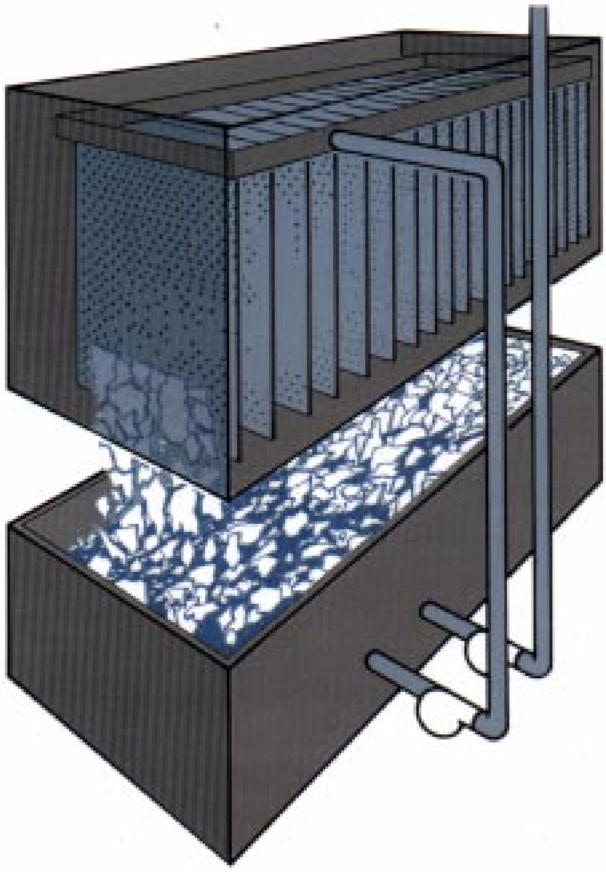
ICE HARVESTER/CHILLER TECHNOLOGY

The Avalanche ice harvester/chiller has been developed specifically to meet the requirements of large commercial/industrial cooling systems. It is an ice-based system which builds and stores ice, utilising low cost, off-peak electrical energy. The stored ice is then employed to meet "on-peak" cooling requirements.

The Avalanche is a dynamic ice harvesting product which separates ice production from ice storage. Ice is built on patented TempPlate' evaporator plates which are positioned above the water/ice storage tank. Periodically, as the ice reaches a thickness of ¼" it is released into the tank for storage.

In addition, the Avalanche is a very efficient, low temperature water chiller. This capability is particularly useful in load levelling applications. Avalanche can be used with common refrigerants like R-22, R-717, etc.

Capacity range for a single Avalanche unit is 35-TR to 550-TR and multiple units can be used for larger capacities.



ADVANTAGES OF THE AVALANCHE SYSTEM

Reduces Energy Costs
The Avalanche ice harvester/chiller can significantly reduce air conditioning energy costs, in comparison to chillers sized to meet the peak load, by reducing demand charges and taking advantage of favourable off-peak energy rates.

Simplified Operation
Ice is not stored on the ice-making surface; therefore it is not necessary to melt the complete ice inventory every day to maintain high operating efficiency.

High Operating Efficiency
Because ice thickness does not exceed ¼", refrigerant suction remains high, improving the operating efficiency of the compressor.

Simple Tank Design
Unlike ice-on-coil systems which contain miles of carbon steel pipe in the tank, the Avalanche system only has ice and water in the tank.

Daily Cycle/Weekly Cycle
Because ice is not stored on the ice-building surface, the Avalanche can build ice during all off-peak hours, which might include the entire weekend. This flexibility is prohibitively expensive for ice-on-coil systems which must have more coil added in the tank.

Load Levelling Strategy
The Avalanche is also a highly efficient, low temperature water chiller. It is particularly well suited for load levelling applications where it generally runs as an ice maker at night and as a chiller during the day (on peak).

Lower Initial Investment
Because the Avalanche ice-based system can provide chilled water as cold as 34'F, it is possible to obtain considerable savings in the design of the air-side equipment.

LIQUID OVERFEED REFRIGERATION SYSTEM

Liquid overfeed refrigeration systems are employed with the Avalanche ice harvester/ chiller. The main advantages of liquid overfeed are high operating efficiency, high system reliability, and low operating costs.

Major Cause of Compressor Failure

Liquid slugging of compressors, a common cause of compressor failure, is completely eliminated in liquid overfeed systems. The low pressure receiver totally protects the compressor from liquid refrigerant.

Longer Compressor Life

Compressors last longer due to ideal suction gas conditions. Compressors run cooler due to low suction gas superheat.

Efficient Ice Building

Evaporator surface is fully utilised with liquid overfeed due to the elimination of a superheat zone in the evaporator.

Energy-Efficient Ice Harvesting

Liquid overfeed systems are ideally suited for ice harvesting operations. Ice can be harvested with a minimum application of hot gas, resulting in high operating efficiencies.

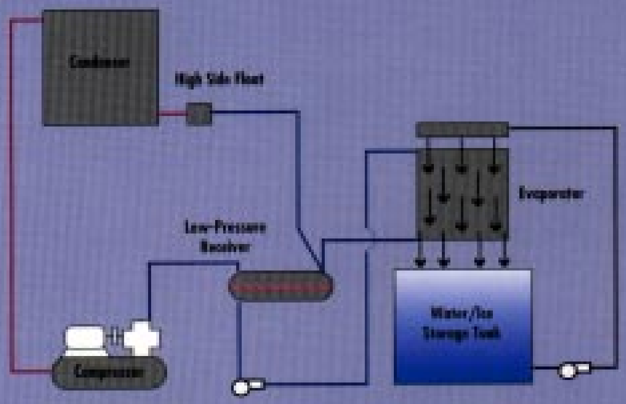
“Hands-Off” Operation

Liquid overfeed systems tolerate variations in refrigerant flow and load conditions without the need of frequent adjustments to maintain peak operating efficiency.

Eliminates Flash Gas Problems

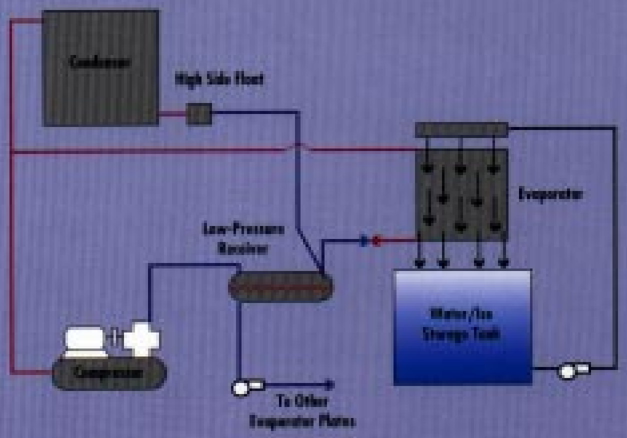
Refrigerant distribution is not subject to disturbance due to the presence of flash gas. All flash gas is separated from the liquid refrigerant at the low pressure receiver.

ICE BUILDING/CHILLING MODE



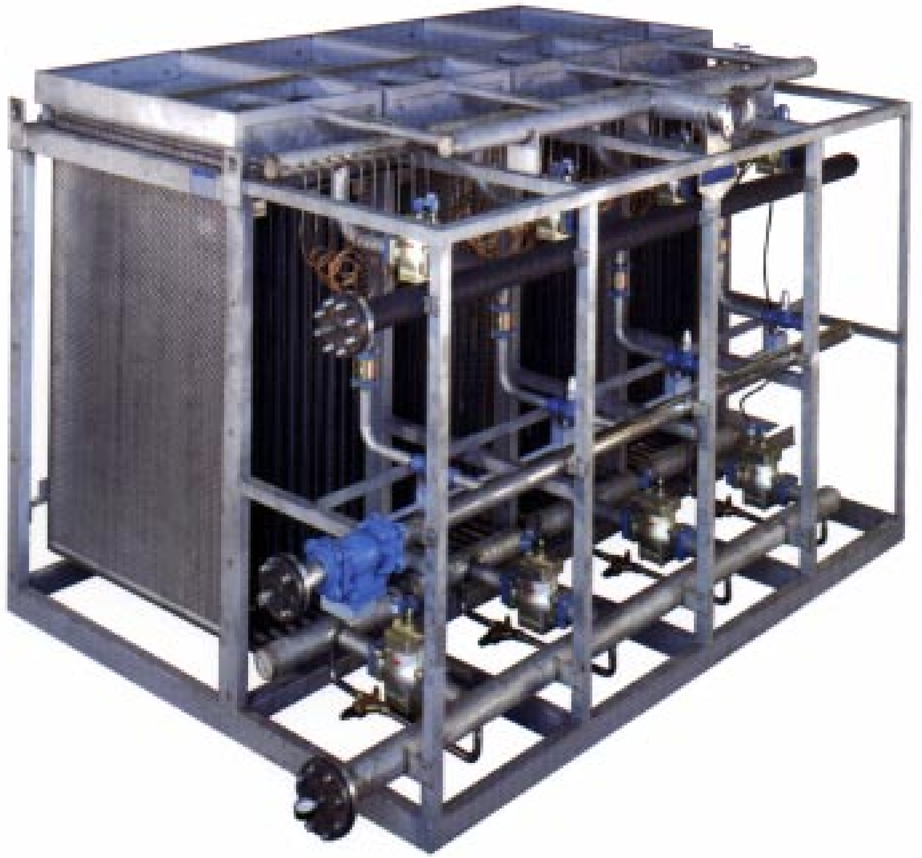
Refrigerant is pumped from the low-pressure receiver to the Avalanche evaporator plates. Top-feeding refrigerant distribution totally wets the internal surface of the evaporator, building uniformly thick ice on the external surface of the evaporator. Both liquid and vaporized refrigerant return to the low pressure receiver where liquid separates from vapor and recirculates. Dry suction gas is compressed, condensed, and returned to the low pressure receiver.

ICE HARVESTING MODE



Periodically, a portion of the hot refrigerant gas is applied to the evaporator plates for a few seconds. The condensing of the hot gas releases the 1/4" thick sheet of ice from the evaporator, allowing the ice to fall into the storage tank where it breaks into small pieces. The condensed refrigerant returns to the low-pressure receiver and recirculates.

QUALITY CONSTRUCTION



Ti h d u As vt a il aa In c e h

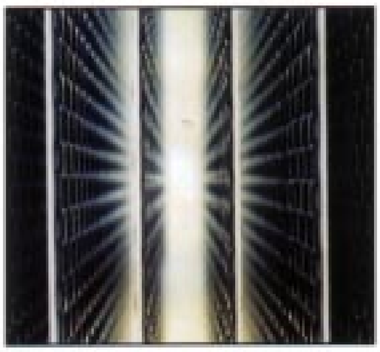
refrigeration standards. This can be seen in the liquid overfeed refrigeration system, the selection of industrial quality refrigeration components, and the extensive use of stainless steel in its construction.

Paul Mueller Company, the inventor and developer of the inflated evaporator plate technology, has been producing Mueller Temp-Plate for over 40 years. The evaporator plate is a time-tested and proven product.

The refrigerant valves employed in the Avalanche are designed and built to meet the most severe demands of critical industrial refrigeration applications. They are designed to provide many times the cycle life of commercial quality valves.

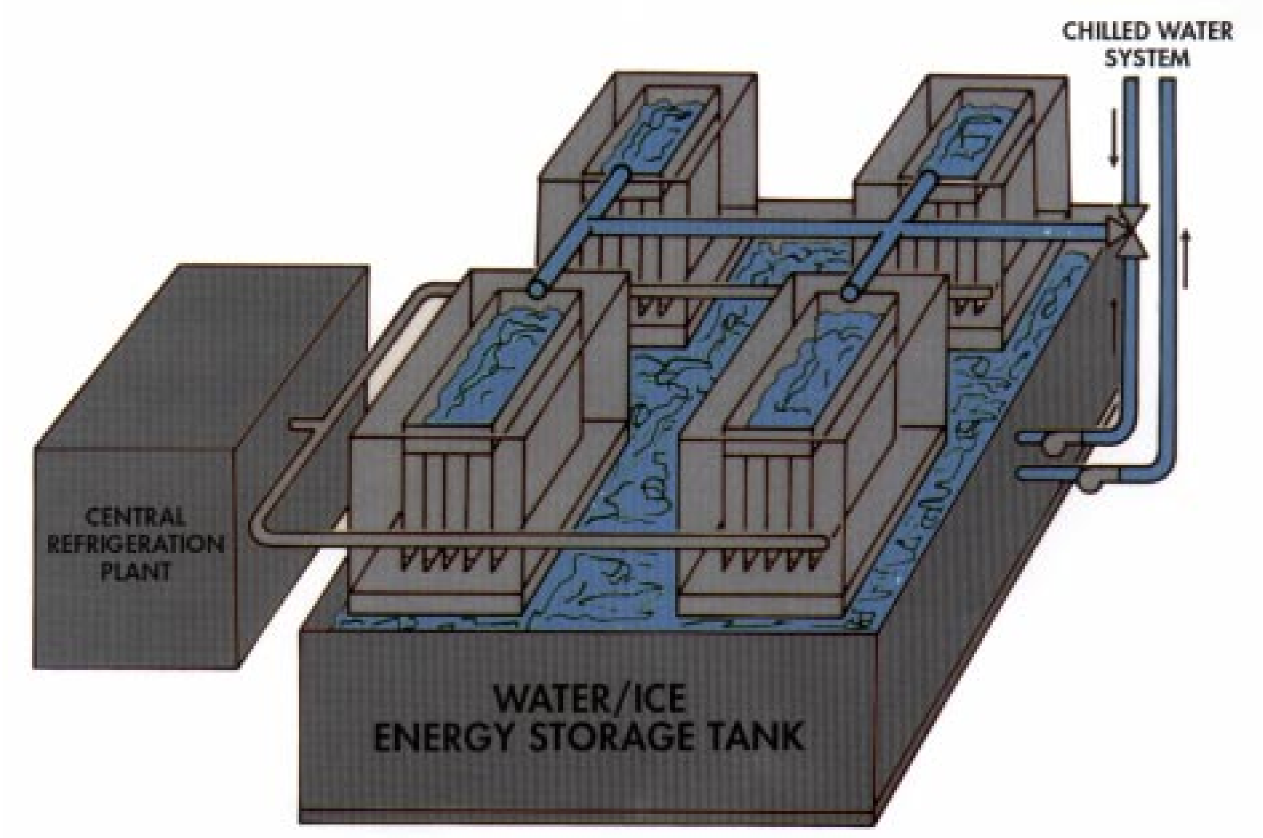
A solid state programmable logic controller provides complete automatic control of the Avalanche in both ice harvesting and chiller modes. Avalanche status information can also be provided for input to energy

Industrial Quality
Refrigeration Valves



Stainless Steel
Evaporator Surface

ICE HARVESTER/CHILLER WITH CENTRAL REFRIGERATION PLANT



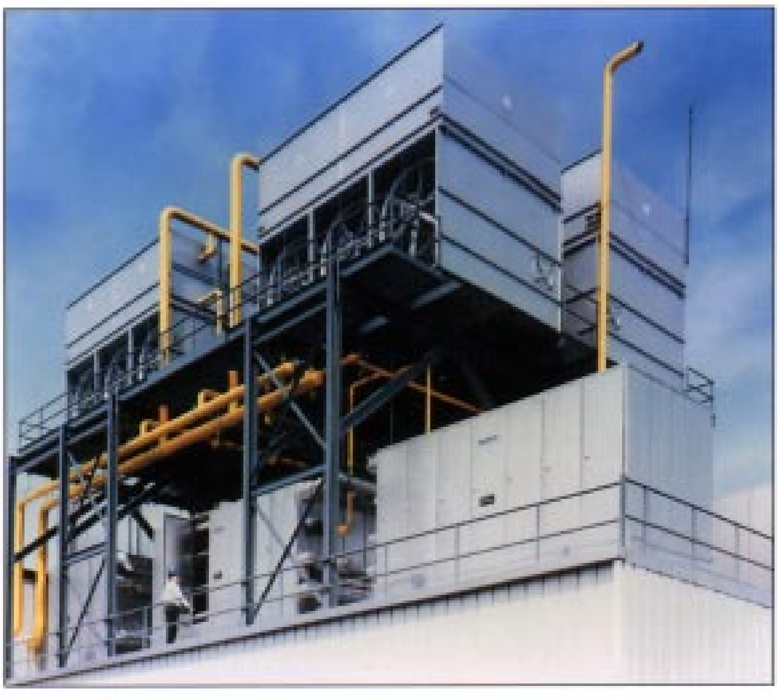
Each Avalanche module can be used with its dedicated refrigeration unit or multiple modules can be used with a central refrigeration plant. The central refrigeration plant configuration is suitable for larger systems requiring ice production capacities of 400 tons or more.

Utilisation of a central refrigeration plant for large installations permits greater latitude in selection of compressors, which in turn can improve the overall system reliability and operating efficiency.

Application engineers are available to work with you in developing the design of an Avalanche system specifically engineered to your thermal energy storage requirements. Computer programs are also available for equipment sizing, tank sizing, and annual energy analysis.

Two 150-TR units installed at a northeastern electric utility's administration building

ICE HARVESTER/CHILLER TYPICAL INSTALLATIONS



Above:
A 420-TR ice-making capacity Avalanche system provides inlet air cooling for the 36MW gas turbine at a cogeneration facility in California, improving the turbine's hot weather generating capacity by 10%.

Left:
A 650-TR stand-alone ammonia refrigeration/ice thermal storage Avalanche system installed at a manufacturing facility in Wisconsin.