INDUSTRY FOCUS: SUPERMARKETS

ENERGY SAVINGS

WITH CALMAC'S THERMAL STORAGE SYSTEMS

THERMAL ENERGY STORAGE IN SUPERMARKETS

Permits fewer compressors and less on-peak operating time...provides significant first cost and operating cost reduction

Currently, low and medium temperature supermarket refrigeration is an inherently inefficient and expensive process. The extreme temperature lifts involved dramatically increase the power required per ton (kw) of cooling with correspondingly high energy and electrical demand implications.

Thermal energy storage devices, which have been so successfully applied in the commercial air conditioning business, have seen only limited applications in supermarkets. One reason is that the temperatures available from the ice based cooling storage are not capable of directly providing the lower temperatures needed in these systems. However, innovative application of existing technology, along with recently developed storage materials, now allow supermarkets to benefit from the use of thermal energy storage. In addition, environmental concerns over refrigerant losses now encourage the use of secondary coolant (brine) systems in supermarket design. This creates even more opportunities for savings by utilizing thermal energy storage.

1 - The first application utilizes CALMAC's conventional ICE BANK® equipment, using ice as the storage material which provides cooling to the condenser of the low temperature equipment. This allows the system to operate at much lower condenser temperatures during the day, perhaps about 45-50°F (7-10°C). The capacity and efficiency of the low temperature equipment is substantially improved. Because more energy is required to compress a high temperature gas, the stored cooling is displacing the most inefficient segment of the low temperature refrigeration cycle. This, in essence, is a stored "cascade" system, which creates zero on-peak electrical demand for the upper stage. The storage device is sized to absorb all of the low stage condenser heat rejection, which is the total of the evaporator and compressor energy. The medium temperature compressors need enough capacity at night to: recharge the thermal storage tank with ice; continue to meet the needs of the low temperature system; and provide for the normal medium temperature loads. Additionally this allows the use of R-22 for low temperature applications.

2 - A second alternative provides outstanding first cost reduction as well as lower energy and demand charges. The process is simple and requires substantially less space for storage tanks. In this approach, cooling, stored in conventional CALMAC ICE BANK® tanks, is used to sub-cool the refrigerant condensed by the low temperature compressors (See Figure 1). Each Btu or watt of stored cooling provides an equal increase in the refrigeration effect of the condensed refrigerant. For equal mass flows, a compressor will have added capacity, requiring fewer compressors or less operating time. For low temperature systems, where the refrigerant expands to higher vapor fractions, this increase can be substantial. For example, if R-502 is expanded to -26°F (-32.2°C) from a sub-cooled temperature of about 45°F (7.2°C) instead of 100°F (37.8°C) saturated, its refrigeration effect will be increased by over 40 %, assuming a saturated vapor at the evaporator exit. Sub-cooled refrigerants also provide stable operating characteristics, even with lowered condensing temperatures, since their temperatures are well below saturation and therefore any pressure drop induced vapor flashing can be eliminated. This is also a very efficient process. The added cooling capacity has been provided by equipment operating at much more favorable conditions (See Figure 2). The stored cooling is manufactured at night with significantly reduced condenser temperatures. Evaporator temperatures needed to produce the ice, usually about 20°F (-6.7°C), are also considerably higher than when meeting the load directly. Once again, the medium temperature equipment is

required for recharging the storage device. However, since we are only providing enough cooling storage for part of the load, it is likely that enough excess capacity will be available, during off-peak hours, from the existing medium temperature compressors. This also greatly reduces the first costs.

The process is quite simple. During the off-peak hours, a pump circulates a glycol/water coolant through a chiller barrel cooled by the medium temperature equipment. This fluid then passes through the heat exchanger within the storage tank and freezes the surrounding water to ice. During the on-peak period, the glycol/water solution cooled by the stored ice is then circulated to a sub-cooling heat exchanger for the low temperature equipment. It is important to remember that the increased capacity is limited to the amount of sub-cooling available. Also, the condensed refrigerant lines must be well insulated so that the sub-cooled refrigerant maintains its temperature until delivered to the expansion devices. This approach is suitable for most of the common or proposed refrigerants. However for refrigerants that possess limited latent heats of vaporization (e.g. ammonia), the attainable benefit is quite small since the ratio of available sub-cooling to total latent heat is minimal.

3 - The third application is being driven by the environmental concerns over refrigerant losses in supermarkets. Recent studies report that an average of 25% of the refrigerant in a supermarket is lost each year. The impacts on our atmosphere are well known. Coolant (brine) based systems are now being installed to reduce the refrigerant emissions. These systems usually circulate a coolant to the medium and high temperature boxes. In the past there was no way to economically meet these loads directly with a storage device. However, CALMAC's 40 years of research and development experience in thermal energy storage has now made possible the manufacturing of low cost , reliable eutectic salts. These systems are designed in a similar fashion as our commercial air-conditioning

Figure 1
Subcooling adds refrigeration effect

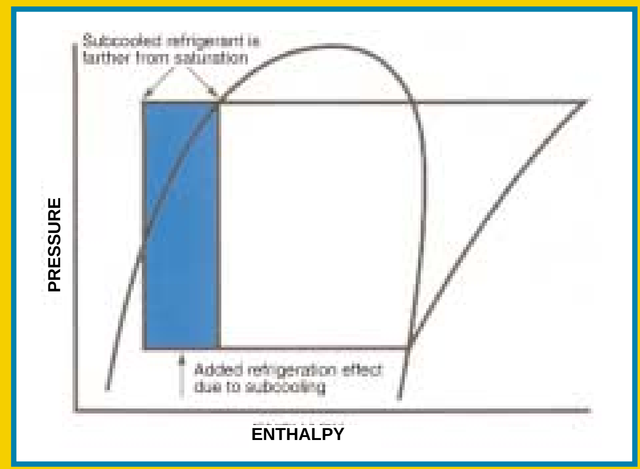
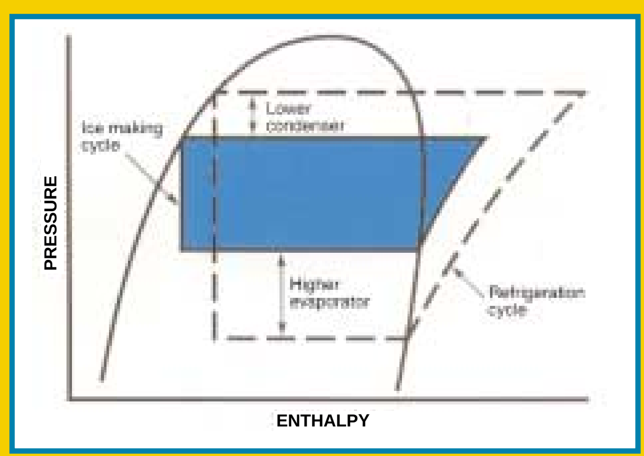


Figure 2
Comparison of Ice Storage Cycle to Low Temperature Cycle



systems with the exception that they have a lower temperature Phase Change Material (PCM) in the storage tank (see Figures 3 and 4). Coolant is chilled by an evaporator and circulated thru a heat exchanger in our ICE BANK® tanks which freezes the PCM. While charging the storage tanks, we are also able to cool the cases. **During on-peak hours, the chiller can be turned off and the storage tanks now meet the loads.** The high latent heat materials utilized in these devices freeze at stable and consistent temperatures, well below the phase change temperature of simple water. These materials are capable of supplying secondary coolant temperatures as low as 16°F to 20°F (-9° C to -7° C), meeting many supermarket cooling loads directly. This development greatly broadens the application of thermal energy storage in supermarkets by increasing efficiency and further reducing electrical costs.

Additionally, the applications described above can be concurrently applied. The low temperature eutectic salts can provide even lower condenser temperatures as described in Section 1, and more sub-cooling as described in Section 2.

Typical Coolant Based System Layout

Figure 3:
Ice Making Mode
while meeting load

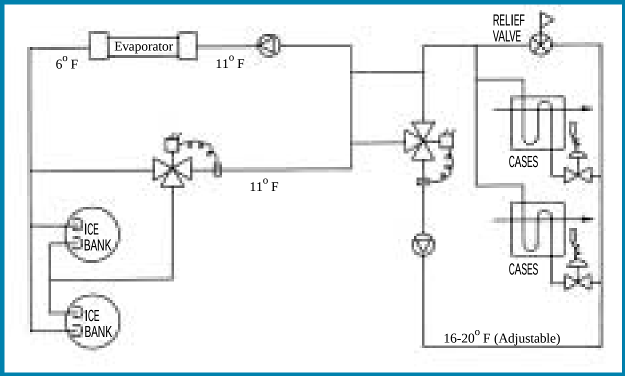
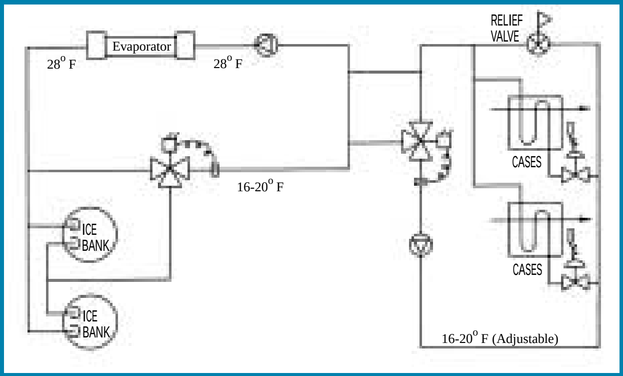


Figure 4:
Discharge Mode
during On-Peak
Hours



The supermarket industry is intensely competitive and CALMAC's thermal storage products are ready to help. CALMAC's sales and engineering staff is available to assist in selecting the equipment that will maximize your electrical demand savings and energy efficiency.

CALMAC CORP.
3-00 Banta Place • Fair Lawn, NJ 07410 • 201.797.1511

Visit our Web Page at: http://www.calmac.com
E-Mail us at: info@calmac.com

IB-155-Aug 2015