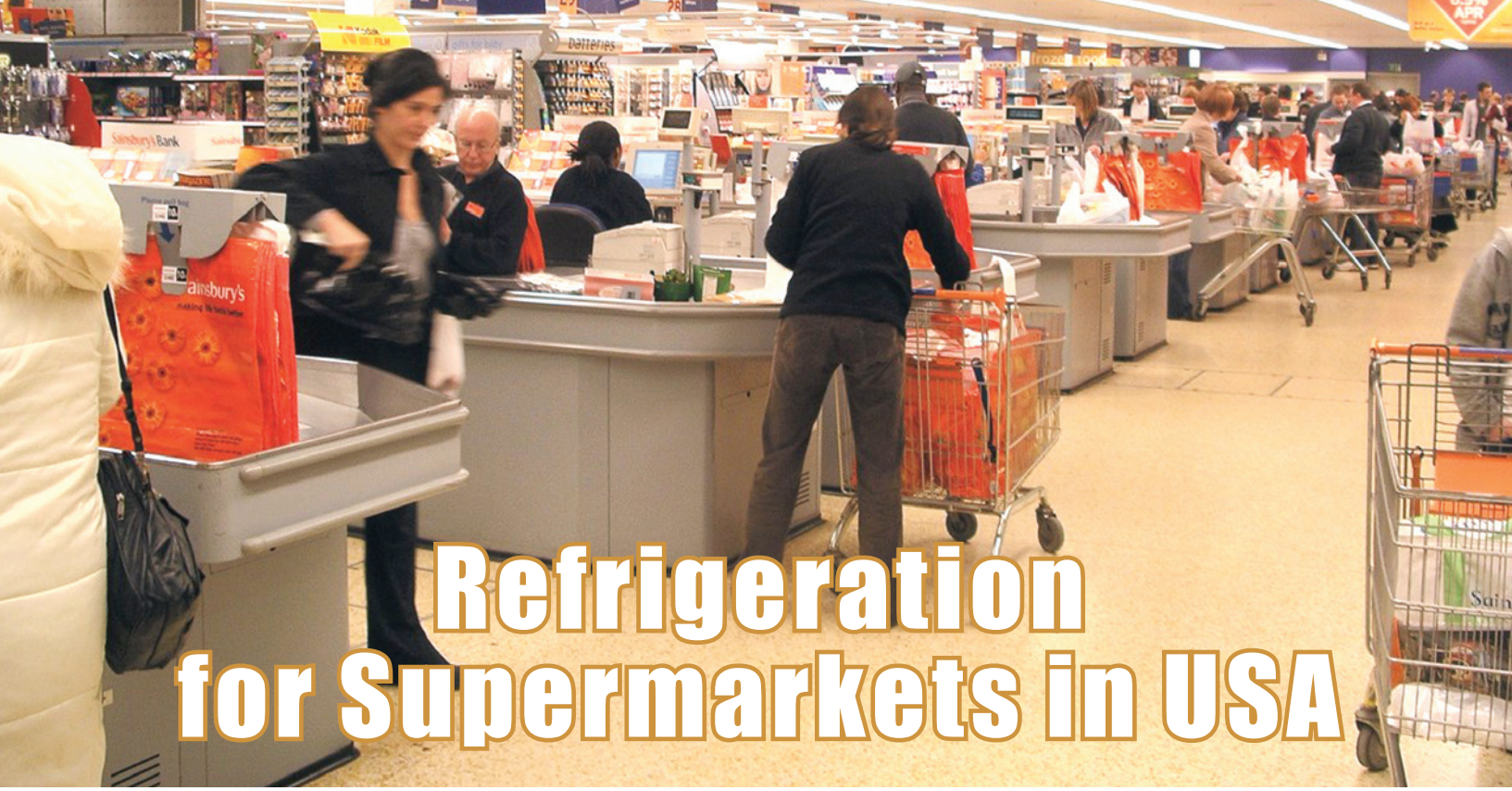

Refrigeration for Supermarkets in USA

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A visit to the supermarket is an experience in itself, considering these are no longer just a simple *Farmer's Market* but a sophisticated venue to shop in style and comfort. The food retail market is mature, with fierce competition on price and quality. Supermarket retailers use sophisticated methods to target existing customers and develop new opportunities, increasingly focused on families and the cash-rich, time-poor younger generation that is attracted to high quality, high margin products such as prepared meals. Most supermarket chains are regional either in the southeast USA, east coast or west coast based. Only Wal- Mart is a national chain with super centers all over the country and growing rapidly.

Some of the supermarkets in US are open 24/7, while others are open late into the night for busy professionals and working single parents to shop. Safety, security and ease of shopping is foremost in the design and layout of aisles and various sections of the supermarket. Pre-prepared meals are served hot; plus bakeries cater for all types of occasions from weddings to birthdays; fresh meat sections offer seasonal meats and fish, whilst the produce section offers seasonal fruits and vegetables from all over the world. From 2007, Indian mangoes will also be sold in US supermarkets alongside Mexican and Chilean fruits. The wine selection in some up class supermarkets offer expensive tastes and variety; all supermarkets sell beer and wine along with a wide selection of cheese and fast finger foods.

Supermarkets in US are usually a stand alone structure with an adjoining shopping complex; the supermarkets are an anchor store that attracts large number of people to ancillary businesses. The design drivers are layout design that is integrated with internal traffic and external appearances. Supermarkets have all types of refrigerated displays for dairy, meats, frozen foods, produce and non-refrigerated displays for detergents and cleaning fluids, soaps, shampoos etc.

Supermarkets are 5,000m^2 to 15,000m^2 in size, very well lighted with 1000 lux each lighting in aisles, tall ceilings and fully air conditioned. Many supermarkets also have natural skylights to further reduce the lighting loads during bright sunny days. The steel structures are designed to include provisions for services, plant rooms, large storage facilities, meat cutting rooms, walk-in cold rooms and offices plus staff

About the Author

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changing rooms and cafeteria. Tall ceilings provide a stratification effect with well insulated ceilings and walls. The fronts of the supermarkets usually have partial glass panes with bright signage and automatic sliding doors. The sides are all fully enclosed in brick construction.

Air conditioning systems for supermarkets are roof top package units with cooling and heating to maintain a comfortable temperature and cater to the overall heat load of lighting, equipment, people and products. The roof top units vary in capacity depending on the size of the supermarkets, ranging from 25 to 40 tons each. US installations continue to use R-22 as a preferred refrigerant, however many use R134a and R-410a refrigerants too. The air distribution is through round or rectangular ducting with grilles.

To comply with Clean Air Act, supermarkets are phasing out use of ozone depleting refrigerants. The industry is using either R-404a, R-507c or CO_2 gases for their refrigeration needs. New system concepts utilize less piping runs and use centralized refrigeration plants to reduce the percent of gas emission.

Distributed Refrigeration Systems

Distributed refrigeration is a technology that puts refrigeration equipment closer to the food display cases, eliminating the need for excessive refrigerant piping throughout the store to reach a mechanical room sited away from the food display. These systems are usually very quiet in operation and aesthetically hidden behind the cases so that they blend with the overall interior decor of the supermarkets. Distributed refrigeration is quite popular in many US supermarkets. They may tend to add additional heat loads for the air conditioning systems but with adequate air flow planning it falls within acceptable limits.

A distributed refrigeration system may have anywhere between 3 to 8 scroll or semi-hermetic compressors, ranging from 3HP to 6HP. Capacity control is required for such systems. The condensers are remote roof top based. And the compressor cooling is normally through fans. The additional heat load from the compressors is managed by adequate air conditioning loads in the supermarket.

Advantages of a distributed refrigeration system are:

- Reduced refrigerant charge by 60-80%
- Uses approximately 50-75% less refrigerant piping
- Eliminates or decreases the need for Evaporator Pressure Regulating valves
- Requires approximately 50-75% fewer brazed joints
- Lessens the liklihood of leaks
- Eliminates the need for mechanical enclosures
- Lowers installation costs
- Can be air or water cooled
- Uses off-cycle, electric or hot gas defrost controls
- Provides back-up protection with multiple compressors

Secondary-Loop Refrigeration Systems

Secondary-loop refrigeration segregates refrigerant-containing equipment to a separate, centralized location and uses benign fluids to transfer heat from the food display cases. These benign fluids are trade named Dynalene and Pekasol-50.

Dynalene-HC is an inhibited solution of potassium formate salt. It is low in toxicity and in non-flammable. Dynalene-HC can be used for low supply temperatures ranging from –4°C to –32°C. Low temperature secondary coolants have been successfully used for medium temperature applications.

Pekasol-50 is also an inhibited solution of potassium formate and potassium acetate salts. It is low in toxicity and is non-flammable. Concentration of Pekasol-50 is measured by using a hydrometer. For low temperature applications from –4 to –32°C the concentration varies between 40% to 85% by weight, respectively. Dynalene-HC is manufactured by Dynalene Heat Transfer Fluids in Pennsylvania and information related to Pekasol-50 can be obtained from Brine-Tec International in Georgia USA.

For medium temperature secondary coolants an inhibited Propylene Glycol is used that is low in acute oral toxicity. The fluid is non-flammable in solutions up to 80% glycol in water. The concentration is determined using a refractometer. A refractometer is a device which directly indicates fluid freezing point by measuring the index of refraction of light through the fluid. Hand-held refractometers are appropriate for use with glycol-based fluids. For medium temperature applications, concentration is based on a supply temperature of –10 to –4°C and solution concentration of 40% to 30% respectively.

Several supermarkets have adopted the secondary loop systems primarily for medium temperature applications in dairy cooling. Centralized systems allow for ease of leak detection in the systems and maintenance and servicing compressors and controls. All refrigeration racks use a PLC microprocessor technology to manage the compressor loading and temperature monitoring.

Difference between Direct Expansion and Secondary Loop Systems

A typical supermarket direct expansion system contains up to 2100 kgs. of refrigerant per store, moving through thousands of meters of piping with hundreds of joints. The possibilities of leaks are high. In contrast secondary loop uses only 150 to 200 kgs. of refrigerants

continued on page 98

continued from page 94

which circulates within the store's mechanical room/ center. There it cools a secondary fluid chosen according to case and walk-in temperature requirements, which moves through the store's piping at much lower pressure (50-60 psig) to do the actual cooling. As a result:

- Primary refrigerant leak is minimized.
- Code requirements for refrigerated closed occupied space are satisfied.
- Environmental impact is negligible.
- Refrigerant costs are cut up to 85% through use of less primary refrigerant and lower cost of secondary coolants.
- Thermal expansion valves, except a couple in the mechanical rooms, evaporator pressure regulators and other components are eliminated, as is the cost of monitoring and maintaining them.
- The cost of expensive POE oil is reduced.
- No high pressure testing is required.
- The use of nitrogen is eliminated for cleaning or brazing.
- Average product temperature is maintained in a stable condition compared to fluctuations in direct expansion system.

Mechanical Enclosures

The concept of "mechanical enclosures" also known as "machine house" is quite common in most US supermarkets. Machine houses are designed for ease of installation and reduced cost to the operators. They house between 6 to 12 compressors, either screw type, open drive or reciprocating type suitable for a medium temperature of 2°C and a low temperature of –20°C. Capacity control is essential and they are all interlinked with a micro-processor PLC technology with input and output boards. The PLC is designed for oil management, compressor control and unloading, head pressure control and temperature control of all cases and cold rooms. The micro-processors can be simple type or very sophisticated with graphs for daily recording of the temperature and vital statistics of the refrigeration system.

Photo 1 : Inside view of a prefabricated machine house showing factory installed compressors, refrigeration piping, electricals, lighting, etc. complete in all respects.

Photo 2 : Steel channel base and galvanised steel rolled sections form the structural skeleton for a prefabricated machine house.

Machine houses are self-contained packages with parallel racks, factory installed, complete with centralized pre-piping, pressure-tested compressor racks, defrost valving and pre-wired electrical control panels. Machine houses are either roof mounted or floor mounted; easily accessible for maintenance and replacement of components. They are built from structural steel and formed galvanized wall posts and roof joists to withstand snow, rains and high wind loads. Machine houses can also include energy management systems, electrical distribution systems for the supermarket, emergency generators, fire alarm systems, electrical circuit breakers, approved by local authorities such as ETL and UL. Heat reclaim water storage tanks are also mounted and pre-piped for quick on-site water connections and maximum energy savings.

Advantages of Parallel Rack Systems

- No variation in product temperatures if one compressor is down.
- Dissimilar horsepower compressors allows optimum temperature consistency and energy savings with maximum capacity control.
- Compressor unloading feature also allows energy savings.
- Multiple types of defrost system, air electric and hot gas defrosts.
- Mechanical or electrically controlled oil delivery systems recover oil from refrigerants and deliver to the compressor for lubrication.
- Suction accumulators prevent liquid from entering compressors.

continued on page 100

- Single point power supply with step down transformer affords ease of installation and reduced costs.

Refrigerated Display Cases

Each refrigeration system whether from a machine house, a secondary loop or a distributed system is connected to 48 to 60 feet of display cases. The inside of the supermarkets are designed for appeal, therefore cases play a very important part in the display of all foods to attract customers.

Display cases also known as "merchandisers" are single deck and multi deck for produce, meat, deli and dairy products. Island cases are also installed for deli/meat and frozen products. Service merchandisers are meant for serving meats, cheese and prepared food in the supermarkets. The cases have curved glass and protective rear sliding door with mirrors for maximum effect and display of the foods. Gravity coils are used in service cases for low air flow across seafood and meats to maintain freshness, accurate temperature and longer shelf life.

Fresh vegetable cases are provided with mist producing sprinklers to maintain humidity and freshness.

In the frozen section, reach-in cases are 60 door long and they contain frozen ice cream, frozen meats and vegetables and pizzas.

All cases have a bumper system and kickplates to provide protection and durability.

The cases are all steel construction for increased life; the wire shelves are in white epoxy for cleanliness and strength.

Defrost may be electric or hot gas type.

Refrigeration systems also support the cold rooms in a supermarket ranging from 5 to 8 cold rooms maintained at 2°C and –20°C temperature, suitable for fresh foods and frozen foods.

Conclusion

The emphasis continues to be to lower cost per square meter of supermarket space whether it is equipment costs, cases, refrigeration systems, energy costs, or operating costs because supermarket business is very competitive and low margin business. Therefore, equipment manufacturers are constantly looking for ways to reduce emission, energy and capital costs. This leads to innovation and product development that is a key to all supermarket equipment suppliers. ❖