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Rows of refrigerated display cases at Sainsburyís, one of the major UK chains of supermarkets. Photo courtesy of Henry Technologies.

Refrigeration Systems for European Supermarkets

A brief history

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Until the mid 1970's, supermarket display cases either had an integral refrigeration system or were served by remote condensing units, usually aircooled. Such systems are still occasionally installed today, generally only in small stores but they do have recognised disadvantages.

Integral refrigerated cases generate both noise and heat. Customer comfort is compromised by the background noise which may occasionally become intrusive. Heat is dumped within the supermarket confines and in warm ambient conditions this increases the cost to aircondition the supermarket. Conversely, the condensing temperature is artificially high in cooler ambient periods, as it's governed by the heated in-store temperature. This also leads to higher running costs.

Remote air-cooled condensing units are usually sized to cope with the load at the maximum ambient conditions. During night time and winter temperatures the compressors may be over-sized for the application. This leads to inefficiencies in the operation of the plant.

Both systems will also suffer from the complete loss of refrigeration in the event of a compressor failure.

Development in the 70' s

Demand for improved flexibility, lower operating cost and energy conservation led to the parallel compressor refrigeration 'rack' system. This uses multiple compressors linked with a common discharge line and a common suction line.

Refrigeration load is matched by simply turning the compressors on and off. Compressor capacity control systems allow a multitude of different loads to be achieved. For example a fourcompressor rack with one compressor fitted with 50% capacity control allows the load to vary from 12.5% to 100% in eight discrete steps.

It was common to find two semihermetic compressor racks fitted in a supermarket. A medium temperature rack provided refrigeration for the fresh produce, typically operating on R12, and a low temperature rack refrigerated the frozen food, employing R502 as the coolant. Four to six compressors per rack linked in parallel was common place. See Photo below.

A typical Semi-Hermetic rack.

The racks were usually located in a plant room, with remote air cooled condensers directly above on the roof. The liquid refrigerant would be fed back to a large receiver, often fitted on the rack, before being distributed to both the display cases and cold rooms. A ring main system would run around the store with branches feeding the individual cases and cold room evaporators. Likewise the suction returns would be linked into a ring main before feeding back to the compressor rack.

Improved energy efficiency was gained in a number of ways:

- refrigeration load was closely matched by cycling the compressors.
- discharge pressure was permitted to float, allowing minimum condensing pressures to be maintained.
- waste heat is dumped to the atmosphere or used as low grade energy to heat water and not discharged into the store.

The rack would seldom perform at full capacity; therefore a compressor failure would not lead to a loss of refrigeration at the cases or cold rooms. A standby compressor was occasionally included in the rack to provide additional security.

Development in the 80's

The Montreal Protocol relating to climate change began the phase out of CFC refrigerants, including R12 and R502. This led to R22 being employed.

Due to its properties, R22 is not ideally suited for low temperature applications. Excessively high discharge temperatures had to be overcome. This saw the advent of two-stage racks. Two such designs were common place:

- internally compounded compressors. For example a multi cylinder machine using four cylinders for first stage compression and cylinders 5 and 6 for the second stage.
- externally compounded with compressors linked in series, the discharge of the LT compressor feeding into the suction of the HT compressor.

Liquid injection and sub-coolers would also be fitted to ensure discharge temperatures remained at safe levels.

The 80's also saw the use of large R22 screw compressors being used on supermarket installations.

Development in the 90's and beyond

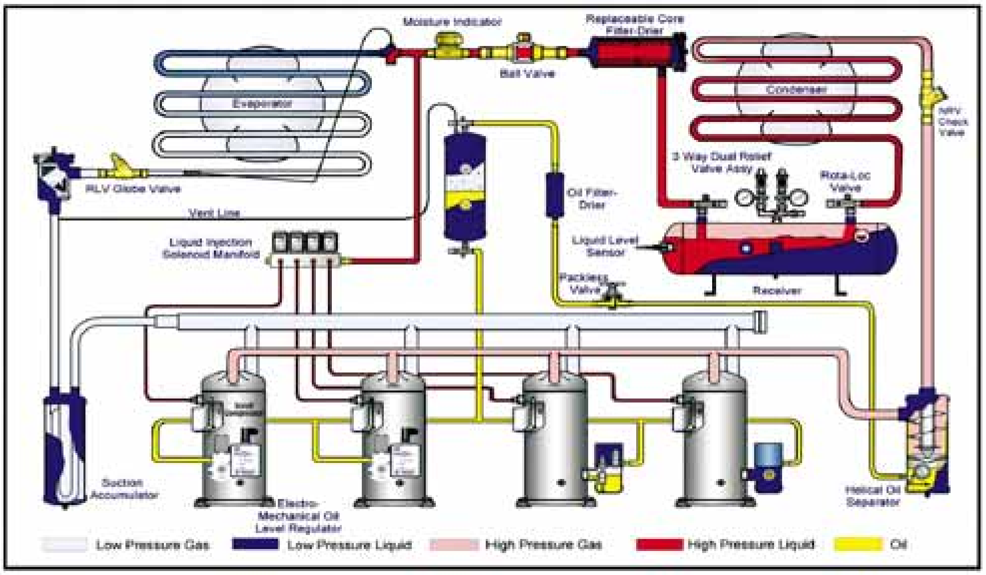
HFC's came to be seen as the medium to long term future for the commercial refrigeration system. Today the majority of European supermarkets run on HFC's such as R404A and R507. The 90's also saw the introduction of the refrigeration Scroll compressor. These hermetic compressors are commonly commonly used on supermarket racks in the UK. Occasionally, over 100 compressors can be used in one large store. Racks of 3 to 12 compressors are either located in plant rooms or externally in weatherproof housings.

A typical Scroll rack.

Sophisticated controls permit load sharing so that all compressors see a similar duty. Telemetry is used to permit long range monitoring and fault response. Data-logging provides a record of critical operating parameters.

Designing Parallel Racks

Parallel systems require an oil control system to ensure the correct oil level is maintained in each compressor crankcase. The system consists of three main components: An oil separator fitted in the common discharge line to remove the oil being discharged from the compressors. The separator feeds the oil to an oil reservoir storage tank of sufficient capacity to allow for fluctuations in the amount of oil lying in the system. Finally the oil is fed to an oil level regulator fitted to each compressor to maintain the correct crankcase oil level.



Piping for oil control in rack systems.

The company the author works for pioneered the oil control system we see today. Various types of regulators and oil separators are available to suit the needs of specific compressor styles and rack designs.

Optical Electronic oil regulator

Mechanical oil regulators rely on a ball float and needle valve to maintain the correct crankcase oil level. Electro-mechanical regulators employ a magnetic reed switch operated by a cylindrical float. The reed switch sends an electrical signal to open and close a solenoid valve to maintain the correct oil level. A low level alarm reed switch is also included for compressor safety. Optical electronic oil level regulators (see photo) operate with the use of an infrared light. A beam is transmitted into a glass prism; if vapour is present the light is reflected back, if liquid is present the light is absorbed into the fluid. The sensor returns a signal accordingly, thus enabling the electronic controller to inject oil in a controlled, pulsed manner. If the oil level is not satisfied within two minutes an alarm signal is generated. This can be used to stop the compressor, thus preventing catastrophic failure.

Helical oil seperator

Highly efficient helical-style oil separators are also frequently used to maximise the system efficiency by ensuring minimum oil carry-over into the system. Efficiency levels above 95% can be achieved.