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SATELLITE COMPRESSORS

IN REFRIGERATION

INTRODUCTION

In the past individual or single compressor systems were used for most medium and low temperature applications. Until, with refrigeration technology development, multiple or parallel refrigeration systems were introduced into the industry. By making use of these multiple compressor systems overall performance and efficiency can be optimised by load sharing between the compressors and staggering the run times of these compressors. However, there are few instances where the energy savings potential of multiple similar compressors is decreased. One of these cases, for example, is extremely low temperature freezer rooms and cabinets that fall below the average design temperature of the overall low temperature system requiring refrigeration. Another instance is on the medium temperature side where you have an isolated high temperature system requiring refrigeration but the majority of the system is running at a much lower design suction temperature. In order to enhance the overall system performance and energy consumption, satellite compressors are introduced by connecting the isolated high or low temperature users to an individual compressor installed on the common frame of the multiplex system. These satellite compressors then have their own suction header and share the discharge header with the rest of the multiplex system, thereby sharing a common condenser and liquid receiver.

HOW DOES IT WORK

In the refrigeration industry there are many cooling applications that require different design suction temperatures, be it cold and freezer rooms or refrigerated cabinets. In the commercial and industrial refrigeration sector satellite compressors are typically used in supermarket, processing plants and warehouses but are not limited to only these examples. In order to understand the concept, advantages, operation and necessity of satellite compressors, the traditional single compressor system will firstly be detailed. Following this, the parallel system application development and requirement for multiple rooms and

DESIGN CONSIDERATIONS

cabinets will be elaborated

<u>Overall System Design:</u>

For a single compressor system, it is important to select the compressor to cover the maximum load required for the system in question. The compressor is sized to handle the worst-case scenario design criteria, but in practice this does not always apply, as the refrigeration load varies with the ambient temperature on a cold winters night the load would be considerably lower than that of a hot summers day. During the low demand periods the evaporator pressure regulator valves will be allowing less refrigerant through from the

evaporators to the suction line of the compressor. This can result in major compressor inefficiencies if only one large compressor is used, as the compressor will decrease the pressure in the suction line and in turn increase the compressor pumping pressure which could damage the compressor itself. Control systems were introduced to single compressor systems like cycling the compressor on and off as well as making use of load by-pass systems. The above-mentioned methods assist in protecting the compressor, but cycling the compressor wastes a lot of energy and results in a shorter compressor lifetime. Load by-passing also wastes energy and compressor pumping power.

A solution to the issues highlighted is connecting smaller compressors in parallel to meet the total required refrigeration load. This type of system is also referred to as a multiplex, which is multiple compressors piped to common suction and discharge manifolds (also called manifolding), and this technique has many benefits. The manifolded compressors are all installed on a common frame which includes all the necessary piping, control valves, and electrical wiring to control compressors and refrigeration.

One of the major benefits is reduced operating costs due to efficient capacity control and reduced power consumption. These benefits are achieved by staggering the starting sequences of the compressors to match the required capacity and power. Another reason why it could be beneficial to have a parallel compressor configuration is better part load efficiency. The control system of the parallel rack senses the common suction header pressure of all the compressors combined by means of pressure sensors, and turns the compressors on and off as the load requirement changes. This results in significant energy savings and operating cost reductions especially in supermarket applications.

There are some instances where the requirements for certain parts of the complete system falls outside the normal operation of the whole, such as;

- Falling between the low and medium temperature system ranges
- Requiring lower than the average low temperature system
- Requiring higher than the average medium temperature system

These systems have traditionally been handled by separate individual single compressor refrigeration systems, however all the pitfalls mentioned before could apply to such systems. Developments in refrigeration solved this issue by making use of a satellite compressor to handle these intermediate and super cold refrigerated systems. Parallel compressor systems often have a satellite compressor installed, these can be small or large and, in most scenarios dedicated to the lowest temperature evaporator. This ensures that the entire system is not running at the lower suction temperature of the lowest temperature evaporator.

The satellite compressor improves efficiency of the entire multiplex rack, by allowing the main system to run at a lower compression ratio which in turn equates to a higher efficiency. The satellite compressor can be valved into the multiplex rack where the rack can assist the satellite compressor in pulling down to the required design suction temperature. Here a check valve should separate the parallel system from the satellite compressor. Satellite compressor can also have a variable speed drive or unloader installed to control the capacity depending on the application and requirement.

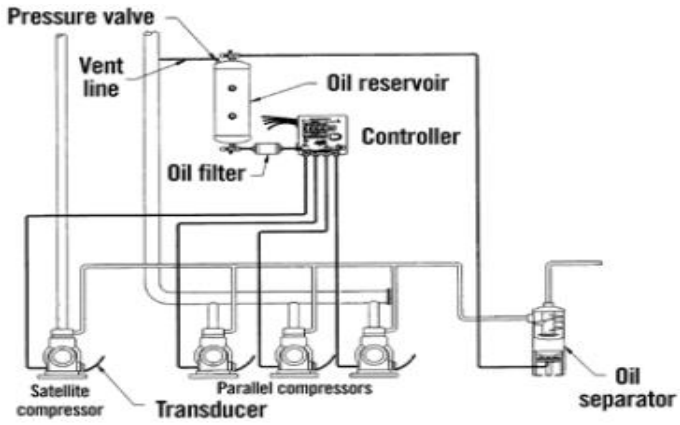


Figure 1: Typical Parallel Rack with a Satellite Compressor.

By integrating a satellite compressor, the need for a second condenser, receiver and additional equipment needed for a separate refrigeration system is eliminated. Another other benefit is that it is no longer required to size the main parallel system to accommodate the super low temperature and as a result the system runs more optimally with regard to suction pressures. Therefore, there could be significant savings by utilizing satellite compressors as the system operational costs are reduced for the main parallel system and the size of the compressors could also be reduced.

Rack Controllers:

It is also vital to select the correct multiplex rack controller that can accommodate a secondary suction header and that is capable of controlling the satellite compressor as well as the rest of the parallel compressors.

Oil Level Control:

The main purpose for the oil in a refrigeration system is to properly lubricate all the moving parts of a refrigeration compressors. An oil reservoir stores excess oil and through an oil separator, which serves to minimize the oil that enters the system, an equilibrium in the system is achieved between the oil entering and exiting the system. Any change in the overall operating system that disturbs the oil leaving the system versus the oil returning will be corrected by the oil control system.

The oil control system is made up of several devices working together to provide a constant supply of recirculated oil to the compressors, like the oil separator, oil reservoir, oil check valve, oil level control and the actual oil charge in the system.

Figure 2: Oil Level Control Device

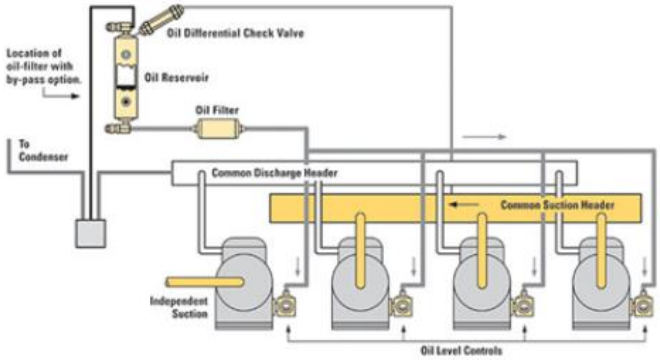


Figure 3: Oil System Depiction on a parallel rack

The oil level control will receive oil from the reservoir at 20psi above the suction pressure, the oil flow will then be controlled to compressors to maintain the minimum required oil level for safe operation.

When a satellite compressor is installed on a parallel system for a lower suction temperature system, a suction pressure regulating valve of 15psi lower than the design suction pressure is used to step down the oil pressure feeding the oil level control(s) of the satellite. The outlet of the regulating valve of the satellite compressor is adjusted to maintain the same differential of that of the main system. The minimum and maximum of the pressure differential is 10psi and 30psi respectively. Due to the fact that the suction pressure of the main system will continuously change due to the load it is recommended to use a 25psi pressure differential.

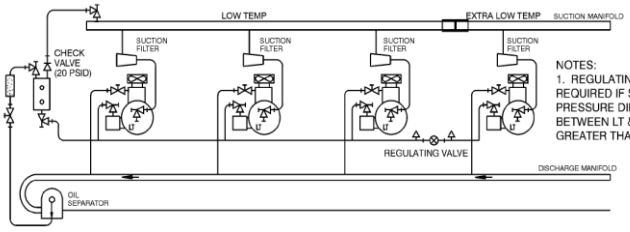


FIGURE 1

For a system with a high temperature satellite compressor the reservoir is routed to the main suction manifold, however the check valve needs to be sized to increase the oil feed pressure 10psi above the satellite compressor suction pressure. This pressure is then stepped down with the regulating valve to 20psi above main suction pressure.

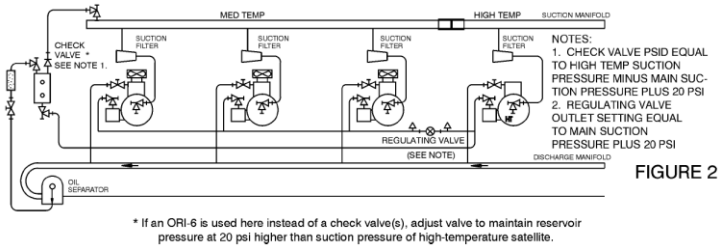


FIGURE 2

* If an ORI-6 is used here instead of a check valve(s), adjust valve to maintain reservoir pressure at 20 psi higher than suction pressure of high-temperature satellite.

Looking into a supermarket refrigeration system application particularly as an example, one of the largest energy consumption sectors in a supermarket is the refrigeration portion as the products sold require cold storage and refrigerated display. Typical energy consumption for the refrigeration portion could be as much as half of the overall energy consumption of the total supermarket store, and refrigeration compressors and condensers take up to 30 to 35% of that.

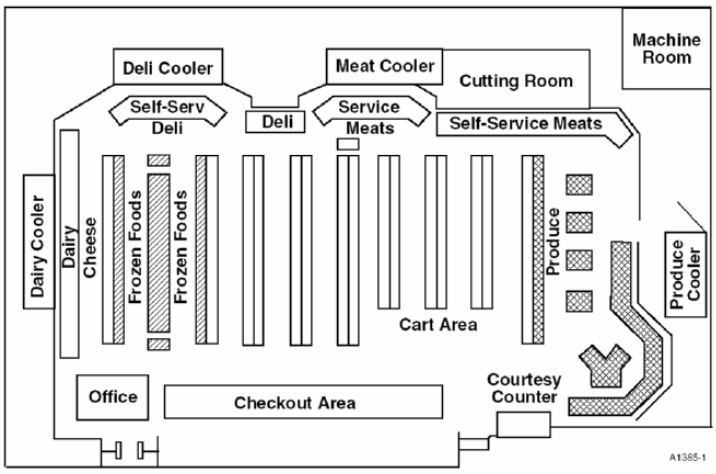
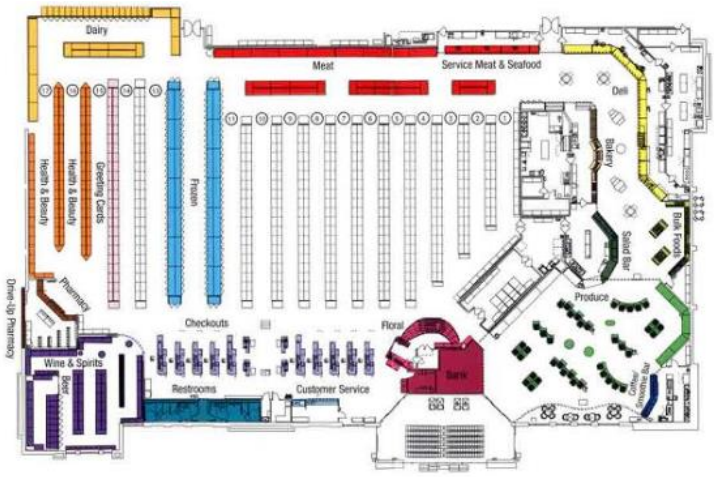


Figure 4: Typical Supermarket Store Layout



Typically, three to five compressor racks are installed to supply refrigeration capacity to the users in the supermarket. For the low temperature application there is usually 1 or 2 racks designed at a suction temperature of -25°C, and in some cases, there will be a few refrigeration cabinets or freezer rooms that have lower suction temperatures of around -30°C and in other cases much higher temperatures of -10°C. For these isolated systems it makes more sense to save on energy and implement a better design philosophy by connecting these systems to a satellite compressor, where the suction manifolds will be separate from that of the main parallel system but it will share the discharge manifold with the main system in order to have a common condenser and liquid receiver. It is imperative however that the condenser and liquid receiver be sized to incorporate the additional load of the satellite compressor. For the medium temperature application, the same principle applies for installing a satellite compressor for an isolated system(s) with a significantly higher or lower design suction temperature than the main parallel system. The use of rack controllers with advanced control algorithms allow the compressors to match and supply the required refrigeration capacity accurately.

ADVANTAGES OF VARIABLE SPEED DRIVES

The positives of incorporating satellite compressors into a multiplex system are that the overall system performance and energy efficiency of the parallel refrigeration system can be increased and maintained.

DISVANTAGES OF VARIABLE SPEED DRIVES

The negative part of a satellite compressor system is that that compressor is still sized for the maximum required load and will be too large for the low demand scenarios.

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