INTRODUCTION

The phase out of CFC and HCFC refrigerants and the unknown future of their replacement refrigerants have led the supermarket industry to look to alternative, long term, energy efficient solutions. Carbon dioxide (R 744) is rapidly becoming the industry choice for an alternative refrigerant due to its favorable environmental properties (ODP = 0, GWP = 1). Many of these systems are installed using CO₂ as a secondary fluid, circulated through the store to the cases while an HFC refrigerant is still used as the primary refrigerant at the compressor rack.

Another natural choice for refrigerant is ammonia, R717(ODP = 0, GWP = 0). Ammonia has been used since the beginning of mechanical refrigeration due to its efficiency and ease of availability. These applications were typically industrial systems with more than 10,000 lbs of charge. Due to the size of the typical installation, it was not considered as an alternative to synthetic refrigerants in commercial applications. However, new technology in the past ten years has allowed ammonia systems to be designed with significantly lower charges. Low charge systems make it easier to manage the safety of an ammonia system for operators and those who are around the system.

SuperValu approached MYCOM Mayekawa to develop a low charge ammonia/CO₂ chiller that would be part of a CO₂ cascade refrigeration system for an Albertson’s test store in Carpinteria, California, which would use 100% natural refrigerants. This collaborative effort would bring the most trusted names in supermarket refrigeration together to show the strength of an all natural refrigerant store, particularly in energy efficiency.

ABOUT THE SYSTEM

MYCOM designed and built the ammonia chiller portion of the refrigeration system for SUPERVALU’s Carpinteria store. The MYCOM unit consisted of the compressors, condensers, and CO₂ heat exchanger that supplied liquid CO₂ to the CO₂ refrigerant skid for distribution to the store.

The design approach for the unit was to develop a skid that was bulletproof and could be used to prove the concept of using ammonia in a supermarket application. Easily available industrial components were used for ease of replacement and familiarity to the service base in the area.
The ammonia unit needed to supply the store with a refrigeration capacity of 860 kbtu/hr (~71TR). This was achieved using a MYCOM M Series reciprocating compressor. The M Series is MYCOM’s next generation reciprocating compressor, specially designed to be used for natural refrigerants with high efficiency. The compressor is coupled to a 125 HP motor with variable frequency drive. The VFD can match load conditions in the store to make sure the system is always operating most efficiently.

Many energy efficiency design elements were included in the skid to reduce energy consumption. The ammonia system uses a flooded plate/shell heat exchanger to condense the CO2 vapor returning from the store back to a liquid. The flooded design increases efficiency over a direct expansion system, and the plate/shell heat exchanger allows for a narrow temperature (7°F or -14°C TD) difference to raise the suction temperature (13°F or -10°C SST) on the compressor to save energy.

A key design element of the skid was to keep the charge of the unit low so that the risk of an ammonia release was mitigated by the small amount of ammonia in the system. Unlike federal guidelines for systems over 10,000 lbs of ammonia, the State of California’s limit is 500 lbs (227 kg). This makes the amount of ammonia in the system critical. For this unit, even with a flooded design, the charge of the unit during start up was 250 lbs (113 kg).

The safety of the skid was a critical design element since this unit was being placed in a retail location. Ammonia sensors can give early warnings of a release and shut down the compressors to mitigate a release. High powered fans blow the ammonia up and away from the unit in the event of a release. To prevent over pressurization of the unit, pressure can be blown down from high points in the system to the low side. This system attempts to reduce the high pressure points of the system into the low pressure side to prevent the relief valves from lifting. In addition, the base pan of the unit is fully welded to prevent ammonia from spilling onto the roof and into the store in an ammonia loss situation.

**RESULTS**

**Environmental Impact:** Using ammonia as a refrigerant eliminates the need for synthetic refrigerants that negatively impact the ozone and have a large greenhouse gas impact. The skid is also designed for energy efficiency and consumes less power than a comparably sized Freon system.

**Safety:** Safety is a concern whenever ammonia is used due to its strong smell and potential for harm in high concentrations. The low ammonia charge (250 lbs or 113 kg) and integrated safety systems manage this risk. The safety system on the unit has the same safety design elements as units 10 times as large.

**Costs:** This unit was designed and constructed as a test system to prove the viability of using ammonia in a supermarket environment. This is not a standard production unit, and it contains a number of elements that increase the cost. There is a fully redundant compressor, motor, and VFD. This not only raises the initial cost of the unit but the life cycle cost as well. Future development will focus on standardizing the skid to further reduce costs.

**Energy Efficiency:** The strength of ammonia refrigerating systems is their energy efficiency. The combination of the flooded heat exchanger, energy efficient compressor, ammonia as a refrigerant, and water cooled condensing show a preliminary energy advantage of over 30%, compared to a conventional Freon type system. This is an incredible leap forward in efficiency and uses a natural refrigerant to achieve it.

**SUMMARY**

The collaborative effort to bring ammonia to a supermarket setting, spearheaded by SUPERVALU at their Carpinteria Albertsons store, demonstrates that ammonia is an environmentally friendly, energy efficient alternative to synthetic refrigerants. Preliminary energy savings of using an ammonia/CO2 system are 30% greater than for conventional systems. This represents a significant increase over previous systems.

While there are still concerns over the safety of using ammonia in supermarkets, the energy values are worthy of serious consideration.