REFRIGERATION REVIEW

Refrigerant Options for the Future

The most widely used refrigerants depend somewhat on the application. Large industrial refrigeration systems for distribution centers, poultry processing facilities, and manufacturing facilities such as the Smuckers uncrusted peanut butter and jelly sandwich plant in Longmont, CO, and breweries such as Coors in Elkton, VA, continue to use ammonia as the refrigerant of choice. This is simply because ammonia is more efficient, environmentally-friendly, and self-alarming. Public refrigerated warehouses (PRWs) contain a wide mixture of types and applications of refrigerants. These can vary from straight ammonia, to cascade ammonia/CO_2, cascade "freon"/CO_2, and straight "freon." Companies like Nestle have gone almost exclusively to cascade ammonia/CO_2, while small facilities, 50,000 sq ft or less, use "freons." Currently, the most prevalent "freon" is R-507, which is used for both high and low temperature applications, but R-448 (GWP: 1273) and R-449 (GWP: 1397) are fast becoming popular as well.

The advantage of cascade ammonia/CO_2 is that is places the ammonia refrigerant only in the machinery room, while the CO_2 operates in the refrigerated spaces. Generally, "freon" systems will operate in the range of 2-4 kWh/cuft/year for freezer space. The cascade ammonia/CO_2 system easily achieves from 0.5 – 0.75 kWh/cuft/year. Traditionally, "freon" applications require multiple compressors, increasing maintenance costs as well as tending to lose upwards of 25% of their charge each year, compared to ammonia, which would normally be in the 5% range.
The United States lags behind in the development of the technology of cascade ammonia systems. While Europe is further developed, we are in the infancy stage of the learning curve and many industrial refrigeration contractors, and designers for that matter, lack the knowledge in their applications.

In the meantime, you're seeing a variety of large "freon" systems using such refrigerants as R-507, which is to be banned in the near future, and are obviously not as “green” as the natural refrigerants such as ammonia and ammonia/CO_2. There are companies such as M&M Refrigeration and Hillphoenix, who have developed the technology, and this technology would be expected to grow exponentially in the next few years as “green” and “sustainability” take priority.

This recent white paper published by Danfoss reinforces my thoughts.

TECHNICAL ASPECTS

To make a technical comparison between refrigerants you would consider such attributes as latent heat of vaporization and operating pressures in the refrigerating cycle. If you compare the latent heat of vaporization for ammonia to R-507, the latent heat of the R-507 is 86.2 compared to ammonia at 602 BTU/lb, which basically says you have to circulate seven times as much R-507 to provide the same refrigerating effect. Ammonia has been ideal as a refrigerant because its pressure at -25° (the temperature you need for operating freezers at -10°), is around 2 psig of pressure. This makes it suitable for piping systems in that air would not enter the piping system.

While R-507 has a slightly higher operating pressure, around 12 psig at -25°F., it has a significantly higher discharge pressure – in the order of 228 psig – compared to ammonia’s operating pressure of 185 psig at the same 96° ambient air condition. CO_2 has the added advantage in operating at lower temperatures, i.e., for blast freezers, and still maintain a positive pressure. The piping systems normally used for ammonia are also satisfactory in strength for operating with CO_2. CO_2, being a higher density molecule, has good heat transfer coefficients, minimal pressure loss characteristics, and very low viscosity.

From a GWP perspective, CO_2 is rated 1 and ammonia less than 1, while “freon” (R-507) would be 3900. The relative cost factor based on R-12 for CO_2 would be a 0.1, ammonia 0.2, and “freons” well into the 3-5 range.