Ice Machine Refrigerants: A Path to Sustainable Alternatives

Sustainability is a significant factor in the design and development of refrigeration systems. Since the inception of refrigerants, manufacturers have been continuously adapting solutions in order to meet operational safety standards, client demands and environmental concerns.

However, until concerns about global warming arose, chlorofluorocarbons (CFC), such as those found in the R-12 and R-502 systems, were frequently used for refrigerants. CFCs are an organic compound consisting of carbon, chlorine and fluorine, and a derivative of methane and ethane.

In the late 1980s, substances containing chlorine were flagged for having ozone-depleting potential (ODP). Concerns about these substances led to the "Montreal Protocol on Substances That Deplete the Ozone Layer Treaty," an international treaty designed to protect the ozone layer by phasing out production of substances deemed harmful to the ozone layer. This treaty led to the eventual discontinuation of CFCs as refrigerants.

Additionally, hydro chlorofluorocarbons (HCFC) and hydro fluorocarbons (HFC) have a significantly lower ODP level than CFC. However, common HFC refrigerants such as R-404A and R-134a blends are known to have high global warming potential (GWP). Substances with high GWP are thought to contribute to global warming.

Current Regulatory and Market Environment

Manufacturers around the globe are exploring refrigerant options with low GWP. For instance, Europe is currently mandating a phase-out for R-134a refrigerants in automobiles due to its high GWP. In response, most European auto manufacturers have replaced R-134a with HFO-1234yf, a new refrigerant just entering the market with a very low GWP and zero ODP. In stationary applications, some European manufacturers have switched to alternative refrigerants with low GWP, such as the R-744 carbon dioxide (CO_2)-based refrigerant systems. The USA is not considering regulations at this time.

Current Alternatives

The two chief refrigerant alternatives to HFCS and HCFCs are CO_2 systems and propane systems.

A common CO_2-based solution, R-744, has both a low ODP and GWP. The solution is inexpensive and highly abundant. However, CO_2-based refrigerants operate in what is referred to as a "transcritical" state, which makes them 10 to 15 percent less efficient than conventional blends such as the R-404A and R-134a. Moreover, CO_2 operates at extremely high pressures, which requires components in the system to be stronger to contain the additional pressure.

R-404A operates between 300 and 400 pounds per square inch (psi) on the high side and 30 psi on the low side. Conversely, R-744 operates as high as 1800 psi on the high side and 400 psi on the low side. The CO_2-based systems' compressors must work harder due to the extremely high pressures. In addition, CO_2 systems currently have very limited application to remote low-side systems, which tie into rack refrigeration systems commonly used in supermarkets, unlike common HFC and HCFC systems currently in use today.

Propane-based systems are very common alternatives. Like CO_2, propane-based refrigerants are abundant and have a low ODP and a GWP. Unlike CO_2, propane-based systems operate at low pressures. However, propane is highly flammable and requires special safety components and operations for manufacturers. The flammability of propane-based systems is a serious concern in a factory environment and requires several safety regulations for operators to follow.

Propane systems are leading alternatives in Europe. Many European manufacturers have replaced HFC refrigerants, such as the R-134a systems, with R-290 propane systems in small refrigerators. The R-290 refrigerant has zero ODP and very low GWP as well as a good compatibility with system components. However, due to the flammability of the system, a limited amount of propane can be used in each unit. The maximum weight of the gas in any commercial application is 150 grams of charge (amount of refrigerants permitted in a refrigeration system). Given 150 grams of

charge, ice machines can produce about 400 pounds of ice in a day, which is suitable for most European applications. However, many U.S. end users need higher capacities to meet their customers' demands for ice. For example, many large-scale U.S. establishments buy machines that produce 1,000 pounds or more ice per day.

Future of Sustainable Refrigerants

In the United States, manufacturers continue investigating the market potential of alternative refrigerant systems. Such investigation includes researching the technical and environmental feasibility for U.S. systems within the manufacturing process and safety guidelines. Research includes trade focus groups, online forums directed toward suppliers, distributers and customers.

As end users remain focused on the environmental impact of their operations, they are likely to increasingly look to manufacturers to provide alternative refrigerant solutions.