

## OUT WITH THE OLD & IN WITH THE NEW: FREON VS AMMONIA & GLYCOL REFRIGERATION SYSTEMS

Freon refrigeration plants are frequently used in red meat processing facilities of small to medium size (i.e. in facilities that have an annual production of less than 6,000 tonnes of hot standard carcass weight). Generally, they are comprised of various independent systems, each with their own cooling task. The refrigerants which typify such systems have significant environmental impacts including significant ozone depletion and global warming potentials. Therefore they are being phased out and becoming more expensive due to decreasing supply. However, there are alternatives that make use of natural refrigerants and/or more efficient technologies. These alternatives are outlined in this factsheet.

### OVERVIEW OF FREON SYSTEMS

#### Freons as Refrigerants:

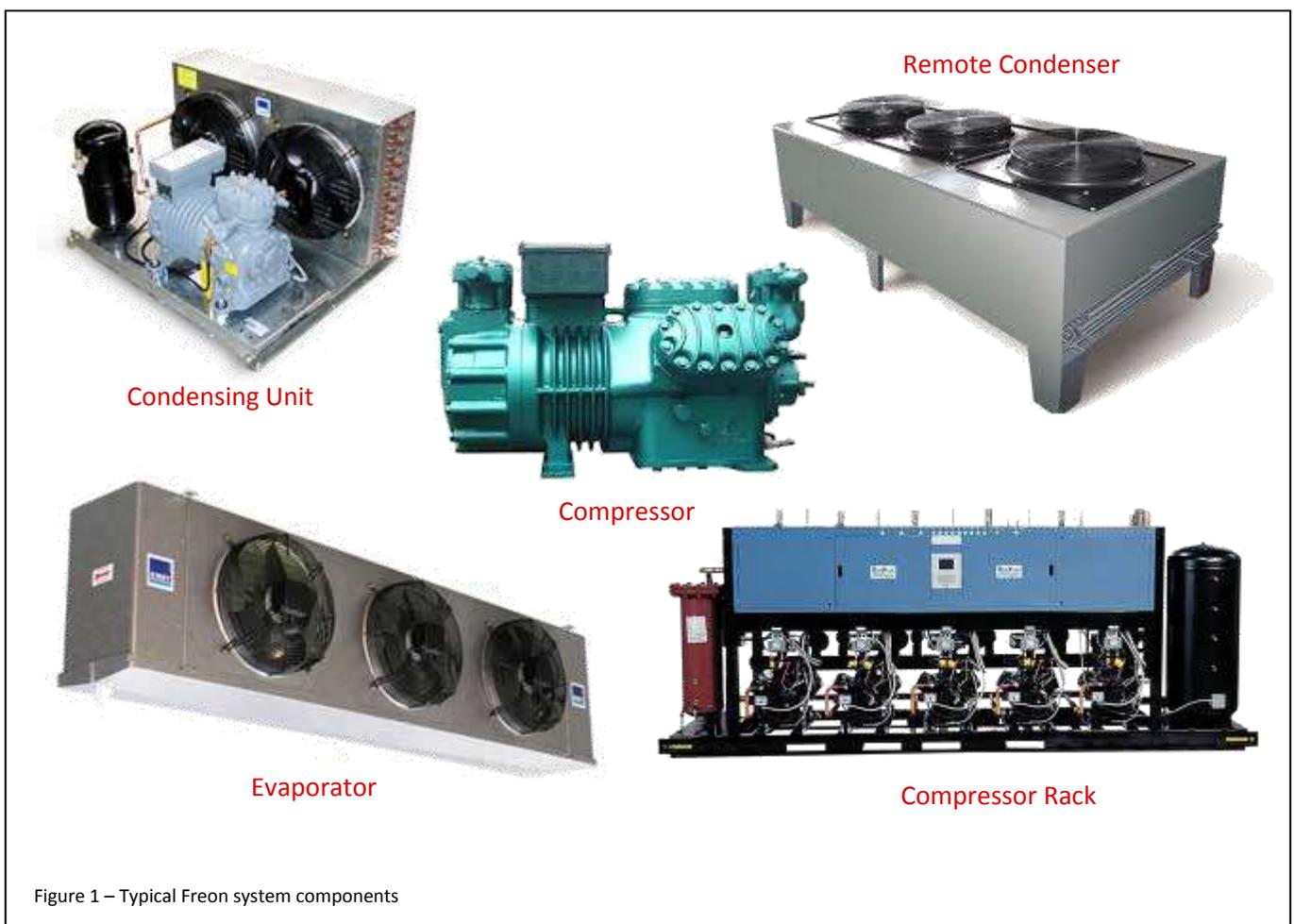
Freons refer to a family of refrigerants developed by the DuPont Company in 1928, which include both HCFCs and CFCs, the latter already phased. For convenience, the term Freon will be used more loosely in this sheet to refer to all synthetic refrigerants including HFCs. HCFCs (and CFCs) contain chlorine in their chemical makeup, causing them to be highly ozone depletive and for this reason are being phased out by the Montreal Protocol. HFC's do not contain chlorine or deplete the ozone layer, but are intense global warming gases. Some examples of the commonly used HFCs are given in the table below, in addition to their Global Warming Potentials. The significance of these values can be demonstrated using an example: If 1kg of R-404A were released into the atmosphere, this would have the equivalent global warming impact as releasing 3,260 kg of CO<sub>2</sub> into the atmosphere. This in turn is roughly equivalent to the CO<sub>2</sub> emissions produced by driving a car for 8 months.

	Refrigerant	Ozone Depletion Potential	Global Warming Potential *(GWP)
Synthetic Refrigerants	R-404A	0	3260
	R-410A	0	1725
	R-134A	0	1300
	R-507A	0	3300
	R-407C	0	1526
	R-22	0.05	1700
Natural Refrigerants	Carbon Dioxide (R-744)	0	1
	Ammonia (R-717)	0	0

Table 1 - GWP and ODP of commonly used refrigerants (International Panel on Climate Change AR2 1995 Report)

Due to the large environmental impact of Freons, legislative measures have been introduced globally to reduce their production and consumption. As a result, their availability is decreasing and prices of HCFC and HFC refrigerants are rising. Therefore refrigerant replacement or leakages have a significant environmental and economic impact.

Freon systems include typical components of compressors, compressor racks, remote condensers, condensing units and evaporators. While these systems are flexible in their configurations, the central components are generally the same, with a few such configurations being: Compressor/condenser built either together as a condensing unit or with remote condensers; several compressors in a compressor rack, etc. These are systems which are predominantly air-cooled (as opposed to being water-cooled).



### ENERGY CONSUMPTION & GHG EMISSIONS

The total emissions of a refrigeration system are determined by both the energy consumption of the plant and the total amount of refrigerant leaked into the environment. Lowering both of these factors will reduce a site's carbon footprint.

Freon systems such as direct expansion air-cooled R-404A systems which are commonly used in the meat industry, are inefficient when compared with alternative solutions such as water cooled flooded ammonia plants. Consequently, these systems can use 40-70%<sup>1</sup> more energy on an annual basis than water-cooled systems depending on condenser size and condition, ambient conditions and the application. Observations conducted on a significant number of Freon systems audited by Minus40 over the past 2-3 years across a range of industries,

<sup>1</sup> Typical range of values based on business case studies conducted by Minus40 since 2010.

have shown that these systems are often undersized or have mismatched components. On many sites, the systems are also poorly maintained (dirty or degraded evaporators or condensers, for example) and have control settings prioritized for reliability rather than energy efficiency. Additionally, on hot days, air-cooled condensers consume use significantly more energy. For example, at 35°C ambient with 40% relative humidity, an air-cooled system with typical condenser selection (15KTD) will operate at 50°C condensing temperature and consume 40-50% more compressor power than a water cooled system operating at 30°C condensing under the same ambient conditions. These factors combine together to cause the observed energy efficiency penalty with Freon systems.

Existing Freon refrigeration plants are typically difficult to upgrade, for numerous reasons including that they are made of the wrong material to be converted – Freon systems are made of copper, whilst ammonia systems need to be made of steel, and even carbon dioxide systems require a different type of copper piping to accommodate the properties of the different refrigerant. Additionally, it is not possible to convert a direct expansion system to a flooded plant and it is therefore difficult to make significant improvements to the energy efficiency of the plant. In some cases, complete equipment replacement is the only available option when Freon refrigeration plant reaches the end of its useful operating life.

### ENERGY EFFICIENT ALTERNATIVES

There are a number of alternative solutions available which can reduce energy costs, refrigerant leakage and maintenance costs. Two such options are outlined below.



Figure 2 – Fan Coil Unit

#### 1) Glycol refrigeration systems

This system makes use of glycol as a secondary refrigerant, where the primary refrigerant could be carbon dioxide, ammonia or a synthetic refrigerant. The glycol is cooled by a chiller and circulated to the space which requires cooling. If only medium cooling temperatures are required (such as carton/carcass/offal chillers, boning rooms and loading docks, where temperatures are typically -5 to 5°C) then cool air can be distributed using fan coil units. For low temperature

requirements (in spaces such as blast freezers and holding freezers, with temperatures from -30 to -20°C), dedicated low temperature CO<sub>2</sub> refrigeration units, known as CO<sub>2</sub> cascade units, which are connected to the main glycol system, will provide the necessary cooling.

Further options are available as to the type of chiller selected, as shown in Table 2.

Chiller type	Refrigerant Considerations	Energy Efficiency
Air-cooled Freon chiller	GWP is significant (see Table 1), leakage is insignificant	Slightly improved energy efficiency (5 – 15%)
Water-cooled ammonia chiller	Refrigerant is environmentally benign (GWP and ODP are 0), leakage is insignificant	Most energy efficient solution (20 – 40%)

Table 2 - Refrigerant and efficiency considerations for two chiller types.

#### Victorian Domestic Meat Processor:

Ryan's Wholesale Meats in Nathalia have an annual power consumption of 602 MWh and will be reducing this by 187 MWh whilst reducing maintenance costs by \$17,000/annum by upgrading their multiple Freon refrigeration systems to a central ammonia/glycol/CO<sub>2</sub> plant. The project is expected to save 226 tons of CO<sub>2</sub> equivalent GHG emissions per year.

## 2) Industrial ammonia refrigeration systems

An industrial ammonia plant is well-suited for implementation at larger sites, as it provides the most energy efficient solution (generally an increase of 20-40% efficiency). Ammonia refrigeration systems consist of two stages; a low stage for cooling spaces which require low (-20 to -30°C) temperatures and a high stage for cooling spaces which require medium (-5 to 5°C) temperatures. In addition to being highly energy efficient, the environmental advantage of implementing a plant with ammonia as its primary refrigerant is significant.

### **West Australian Chicken Processor:**

Mt Barker Chicken in Kendenup have an annual power consumption of 854 MWh and an LPG consumption of 898 GJ. Whilst nearly doubling production, the site energy consumption will increase by only 112MWh, the LPG consumption will reduce by 781GJ and maintenance costs will reduce by \$30,000/annum by upgrading their multiple Freon refrigeration systems to a central ammonia plant with heat recovery. The project is expected to save 487 tons of CO<sub>2</sub> equivalent GHG emissions per year.