Synthetic lubricants for tomorrow's refrigeration

ExxonMobil's solutions for the evolving refrigeration market

The importance of refrigeration to address the global food supply, health needs and the demands of the automotive industry has never been greater. Environmental considerations, supported by Montreal and Kyoto protocols, are driving change in refrigerant technologies, which subsequently has an impact on lubricant selection. ExxonMobil's Gilles Delafargue, Field Engineering Support Advisor, Europe, Africa & Middle East, looks into how synthetic lubricants respond to the changes and trends in today's refrigeration and help improve energy efficiency of refrigeration systems.

Evolution of the market

The Montreal Protocol (1989) addressed the phase-out of substances with high Ozone Depleting Potential (ODP) and has impacted ChloroFluoroCarbons (CFCs) refrigerants (now forbidden) and HydroChloroFluoroCarbons (HCFCs) – now in cancellation phase. The Kyoto Protocol (1997) established commitments for the reduction of greenhouse gases. It is likely to impact some ozone-friendly HydroFluoroCarbons (HFCs) refrigerants as some of them have high Global Warming Potential (GWP), and drive the use of HydroFluoroOlefins (HFOs). Together, these protocols indirectly promoted the re-birth of ammonia (0 ODP/0 GWP) and carbon dioxide CO_2 (low ODP/GWP) as refrigerant options.

The environmental legislation has created a growing trend towards natural refrigerants, such as ammonia, CO_2 and, to some extent, Hydrocarbons (HCs). HCs are likely to stay in domestic appliances, but advocates of HCs are continuing to promote their use in larger equipment, with commercial ice machines as well as reach-in/walk-in freezers and coolers possibly next in line[i]. HFCs still have an important presence, however their replacement with Low ODP/Low GWP HFOs is expected to grow. Both CO_2 and HFO-1234yf are being promoted in Europe for car air conditioning systems[ii]. In 2012, one of the world's biggest drinks companies announced that it will have completed phasing out the use of HFCs in new equipment by 2015[iii]. We have also started to see HFC-free supermarkets[iv].

Miscibility and viscosity for proper lubrication

Many of today's industrial refrigeration systems are compression-type systems, where cooling is generated based on the evaporation of a refrigerant fluid such as HFC, HFO, HC, ammonia or CO_2. The nature of the refrigerant fluid, compressor type and evaporator temperature determine both lubricant technology and viscosity selection. Accordingly, miscibility and solubility of the refrigerant fluid/lubricant mixture are key parameters to consider.

The lubricant's miscibility with the refrigerant at the evaporator temperature is crucial in miscible applications (systems not equipped with oil separators). The refrigerant fluid/lubricant blend must not separate after expansion in the evaporator to travel through to the compressor. If they separate due to inappropriate miscibility, fluid is likely to get trapped in the evaporator and seriously affect the efficiency of the refrigeration unit or the smooth running of the compressor.

At compressor level, both high pressure and temperature will cause a decrease in oil viscosity (linked to the solubility of the refrigerant in the lubricant), which would affect wear protection if viscosity at application was not high enough. The effects of the viscosity decrease can be mitigated by selection of the appropriate lubricant technology and viscosity. ExxonMobil provides a full set of miscibility curves and VPT (Viscosity/Pressure/Temperature) curves to ensure that the lubricant selected matches miscibility and viscosity requirements for the application. Customers also benefit from technical assistance via a team of field experts or via the ExxonMobil Technical Helpdesk.

Wide range of "cool" products

ExxonMobil has been closely following the changes in legislation and endeavoured to respond to the environmental requirements with high-performance

products for ammonia, HFO and CO_2 applications. Mobil EAL (Environmental Awareness Lubricants) Arctic series synthetic lubricants are designed specifically for refrigeration compressors and systems using HFC refrigerants. They are formulated from proprietary synthesized Polyol Esters (POEs) to provide outstanding lubricity, wear protection, chemical and thermal stability. Mobil EAL Arctic lubricants are adequately miscible with HFC refrigerants and have well-defined viscosity/temperature/pressure relationships with a wide range of HFCs.

Large refrigerant systems using ammonia (non- or low-miscible with HCs) as a refrigerant are equipped with oil separators so it is desirable to use a lubricant that is quite immiscible with the refrigerant fluid, and has low vapour pressure to avoid or minimise oil carry over in circuit. Mobil Gargoyle Arctic SHC 200 series, PolyAlphaOlefins (PAO) – based lubricants, are recommended for the lubrication of refrigeration compressors operating at very high temperatures, and for systems with very low evaporator temperatures. Their solubility and miscibility with commonly used refrigerants is low, resulting in higher film thicknesses in the presence of refrigerants under pressure which can reduce shaft seal leakage. With their naturally high shear stable viscosity indexes and low temperature fluidity they are able to perform efficiently in severe service conditions with ammonia as the refrigerant. Mobil Gargoyle Arctic SHC 200 is also suitable for CO_2 non- or low-miscible applications. In addition, the Mobil Gargoyle Arctic SHC 200 Series is NSF H-1 registered and is consequently suitable for incidental food contact.

Improving efficiency

Many compression refrigeration units today are using ammonia as a refrigerant fluid. The main lubricant technologies for ammonia applications are:

- **Mineral Naphthenic (MN)** and **Mineral Paraffinic (MP)** lubricants, refined from naphthenic and paraffinic crude oils;
- **PolyAlphaOlefin (PAO)**-based and **Blended PAO/AB** (Alkyl Benzene) synthetic oils.

The extensive set of tests carried out at ExxonMobil Research & Engineering centre (EMRE) in 2011 showed PAO as the potentially best technology for ammonia versus MN and MP (significant room for plant efficiency improvement, best low temperature characteristics, lowest oil carry over, excellent viscosity control at high temperature, best degassing characteristics). Mobil Gargoyle Arctic SHC™ 200 series lubricants – wax-free PAO lubricants for non-miscible applications – provide outstanding lubrication for compressors in industrial, commercial, and heat pump refrigeration systems, and have been particularly successful in systems using ammonia. Furthermore, the viscosity at low temperatures of ExxonMobil's PAO-based lubricants, significantly lower than standard Mineral Naphthenic or Mineral Paraffinic lubricants, makes it possible to improve plant efficiency by minimising insulating oil layer affecting thermal exchanges and, consequently, energy efficiency, when the lubricant is trapped at evaporator level*[v].

They benefit from excellent thermal, oxidative and chemical stability, which means potentially longer oil life and reduced maintenance costs, increased drain intervals, longer filter life and reduced shaft-seal leakage compared to standard mineral oils. Mobil Gargoyle Arctic SHC 226E has helped save a major brewery in Poland up to $140,000 in three years. Following a switch from a mineral lubricant, the oil drain intervals have extended by six times (from twice a year to every three years) resulting in reduced drain and separator costs as well as waste oil, reduced deposit formation and lower compressor maintenance costs.

Future for cold

Alternative technologies such as "Magnetic cold" have started to appear on the market and move towards the mainstream. Highly energy-efficient magnetic cold provides cooling by using the temperature change from adding and subtracting a magnetic field, without the need for refrigerants or expensive compressors. Recently two European firms have announced plans for commercial and domestic launches of products based on magnetic refrigeration within the next two years[vi], and some specialists say that magnetic refrigeration can cover 80 per cent of the vapour compressor market today[vii]. However the classic compression units, together with the evolution towards Low ODP/Low GWP refrigerant fluids, are expected to stay for a while in the market.

ExxonMobil's full range of products covers the needs of the evolving market, and its offer has been particularly strong for applications using ammonia.

Conclusion

It takes suitable maintenance to operate an industrial refrigeration system. Interruption of service or reduced system capacity can result in significant loss of production or products in storage. With the growing trend towards natural refrigerants (ammonia, CO_2 and HCs) or the gradual replacement of HFCs with Low ODP/Low GWP HFOs, the availability of high-performance lubricants to meet environmental requirements has never been more significant. ExxonMobil has endeavoured to respond to these demands and trends with a wide range of globally available products and continues to develop its portfolio to meet the challenges of tomorrow, while providing guidelines and expert technical assistance to customers.

Mobil's tools and services for the refrigeration industry

In addition to the wide selection of high-quality lubricants, customers can benefit from Exxon Mobil's tools and services for the refrigeration industry, such as expert advice, training, miscibility and VPT curves and a product selection tool.
Visit www.mobilindustrial.com to find out more.

About Mobil Industrial Lubricants

The team behind Mobil Industrial Lubricants delivers advanced products to major industrial equipment manufacturers to protect their customers' engines and machinery, helping to enable peak performance while improving energy efficiency. This dedicated work force focuses on delivering a reliable supply of high-quality lubricants through its strong distribution network while also providing technical application expertise to customers around the world.

**Compared to standard Mineral Naphthenic or Mineral Paraffinic lubricants*

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i 'Refrigeration trends towards natural refrigerants', P. Powell, July 2013, http://www.achrnews.com/articles/120384-refrigeration-trends-toward-natural-refrigerants
ii The Ebb and Flow of CO_2 and HFO-1234yf in Stationary and Transit Applications, Peter Powell, April 2013, http://www.achrnews.com/articles/123070-the-ebb-and-flow-of-co2-and-hfo-1234yf-in-stationary-and-transit-applications
iii 'Coca-Cola Co. said it will begin phasing out the use of HFCs in new equipment and complete that process by 2015' http://www.achrnews.com/articles/120384-refrigeration-trends-toward-natural-refrigerants
iv 'Awaiting the Natural Refrigerant Revolution', P. Powell, April 2013, http://www.achrnews.com/blogs/17-opinions/post/122990-awaiting-the-natural-refrigerant-revolution
v Based on 'Oil, just for lubrication!', Titus M.C. Bartholomeus, Senior Development Engineer, Grasso Products b.v. www.grasso-global.com
vi Commercial & domestic magnetic refrigeration launches imminent', Andrew Gaved, Refrigeration and Air Conditioning Magazine, June 2013, http://www.racplus.com/news/commercial-and-domestic-magnetic-refrigeration-launches-imminent/8649939.article
vii Cooltech research and development director Tim Lorkin cited in the article referenced above, http://www.racplus.com/news/commercial-and-domestic-magnetic-refrigeration-launches-imminent/8649939.article