Refrigeration Oils in industrial applications and 2010 legislation change : switch from HCFCs (HydroChloro FluoroCarbons) to HFCs and Ammonia

Many of today's industrial refrigeration systems are of compression type and use a range of refrigerant fluids to generate cooling via the compression/expansion cycle. The following fluids are the most popular in refrigeration industry:

- HCFCs (HydroChloroFluoroCarbons: R-22 /R-401 / R-414…)
- HFCs (HydroFluoroCarbons: R-134a / R-404a / R-507,…)
- HCs (HydroCarbons: R-600a-Isobutane / R-290- Propane,…)
- Ammonia (R-717)
- CO_2 (R-744)

Each refrigerant fluid requires a specific lubricant technology and viscosity grade according to the application.

The Montreal Protocol (signed 1989) defined new rules to protect the ozone layer. Refrigerant fluids were classified according to their ODP (Ozone Depletion Potential). In turn, production of CFCs was forbidden from 31 December 1994, and the use and production of HCFCs were progressively restricted with complete elimination expected by 2020. Therefore HFCs, having acceptable ODP, were developed to meet with Montreal Protocol new requirements.

The Kyoto Protocol (signed 1997) defined rules to fight against warming process, and refrigerant fluids are now classified according to their GWP (Global Warming Potential). It also impacts some HFCs with high GWP, like R-134a.

New international decisions on HCFCs / R-22

In September 2007, new international decisions, part of Montreal Protocol, claimed prohibition of HCFCs / R-22 in new plants by 1 st September 2010. Furthermore, in Europe it has been decided to end the use of new HCFC / R-22 for maintenance of existing plants by the same date. So, only recycled HCFCs / R-22 can be used for maintenance, but expected available quantity cannot cover the needs. So the change from HCFCs to new refrigerant fluids, compatible with both the Montreal and Kyoto protocols is compulsory and urgent. The main concern is R-22 with numerous switch over expected.

What solutions are there to meet the new legislation?

Today the possible solutions are :

- Switch to HFCs as substitutes of HCFCs : could represent a minimum hardware investment depending on the HFCs type. Potential limitations on the long term to expect, due to severity increase on GWP legislation.
- Switch to ammonia (R-717) : good solution for ODP- GWP, but needs detailed study / full revamp of the plant.
- Switch to CO_2 (R-744) : good solution for ODP- GWP, but needs detailed study / full revamp of the plant.
- Switch to HCs (Hydro Carbons) might be considered on specific cases, but unit size is limited by legislation, so generally dedicated for small units factory filled.

In summary, there is no easy answer as all refrigerant fluids have their pros and cons. Every solution will be a compromise as every application is specific. This technical topic covers the case of Switch to HFCs and ammonia as substitutes of HCFCs.

Switch to HFCs as substitutes of HCFCs

HFCs are generally a good solution, with some restrictions due to Kyoto's low GWP requirements. The change from HCFCs to specifically developed HFCs is possible providing specific switch over procedure is followed and generally a change of lubricant technology. However, in some cases, a loss of refrigeration efficiency may happen depending on the application. R-22 covers most of the volumes among HCFCs.

Switch over R-22 to HFCs

According to the application, evaporator temperature range, compressor type, etc…, the most popular HFCs to be used as R-22 substitutes are essentially:

- R-404a/R-507 for low temperature industrial cooling (freezing) with potential light hardware change-expansion valve.
- R-407c for air conditioning up to 400 kW with potential light hardware change -expansion valve.
- R-427a for direct expansion units, low and medium temperatures for industrial cooling, chillers, air conditioning applications. This substitution fluid generally does not need hardware change.
- R-422a for direct expansion units, low and medium temperatures. This substitution fluid generally does not need hardware change.
- R-422d for direct expansion units, chillers applications. This substitution fluid generally does not need hardware change.
- R-417a for direct expansion units, air conditioning applications. This substitution fluid generally does not need hardware change.

What lubricant to use?

Switch over to R-404a/R-407c/R-507

Change to POE-PolyOlEster type lubricants is required (i.e. MobilEAL Arctic series within ExxonMobil product line). Experience showed that residual oil should be less than 1% for "low" temperatures (freezing), and less than 3-4% for "high" temperatures (air conditioning), to ensure appropriate miscibility with new refrigerant fluid and proper running of refrigeration unit.

Switch over to R-417a/R-422a/R-422d/R-427a

Although, in some cases, refrigeration oil currently in use may be retained , ExxonMobil's preferred recommendation, based on experience, is to switch to POE PolyOlEster type lubricants (Mobil EAL Arctic series). This is to ensure / optimize oil return to the compressor and minimize efficiency losses at evaporator. Note that all abovementioned HFCs blends do contain a % of HCs (Hydrocarbons like R-600a-isobutane), improving miscibility.

However experience has showed that this cannot always guarantee full control of miscibility according to the application and existing lubricant in use.

Switch over procedure

Depending on the refrigerant fluid supplier, a specific switch over procedure is required, which aims to:

- Evaluate the current plant / monitor operating parameters.
- Drain and run the unit with fresh POE oil charge and R-22 for a short period of time.
- Drain and remove R-22.
- Re-fill with fresh POE oil charge (Mobil EAL Arctic) and fill the unit with substitute refrigerant fluid.
- Make all required adjustments.
- Evaluate the plant / monitor operating parameters following switch over.

More engineering support tools

ExxonMobil has developed specific tools to help ensure proper switch over from R-22 to most common substitutes refrigerant fluids.

1. **Miscibility curves**, to ensure that lubricant selected matches miscibility requirements according to application (to avoid oil trapped at evaporator) (Need to know evaporator temperature for use).

2. **VPT (Viscosity/Pressure/Temperature)** curves to ensure that lubricant selected matches viscosity requirements according to application. (Need to know temperature/pressure at compressor outlet for use).

3. **"MOBIL Refrigeration lubricant Selection Guide for Industrial Systems"** to help select proper lubricant type and viscosity.

Mobil EAL Arctic Series

Lubricants required are formulated from proprietary, fully synthetic polyolester (POE) base oils and a unique additive system to provide outstanding lubricity, wear protection, chemical and thermal stability and hydrolytic stability. They are miscible with HFC refrigerants and have well-defined viscosity/temperature/pressure relationships with widely used HFCs.

Mobil EAL Arctic Series has received approvals and endorsements from many major compressor and system builders worldwide. They are available in viscosity grades ranging from ISO VG 15 to ISO VG 220.

Switch to Ammonia (R-717)

Ammonia (R-717) is a perfect refrigerant fluid in terms of ODP/GWP (Ozone Depletion Potential/Global Warming Potential), but tied up with severe legislation in some European countries, due to potential toxicity, which may induce some confinement requirements according to application specificity and size. Ammonia is not compatible with copper alloys, and requires specific plant hardware / design making impossible its use for retrofit in existing HCFCs or HFCs plants. In turn this option generally requires complete revamping of the plant, so important investments.

However ammonia technology is already widely used and perfectly known, as it provides good performance and limited refrigerant costs, while no ODP/GWP impact.

ExxonMobil propose 2 high quality lubricants for ammonia applications:

Mobil Gargoyle Arctic SHC 226E PAO – PolyAlphaOlefin based product (used for new plants).

Mobil Gargoyle Arctic SHC NH 68
Blend PAO/AB AlkylBenzene (specially designed for lower temperatures, or when switching an existing plant from mineral oil, to avoid any issue with seals).

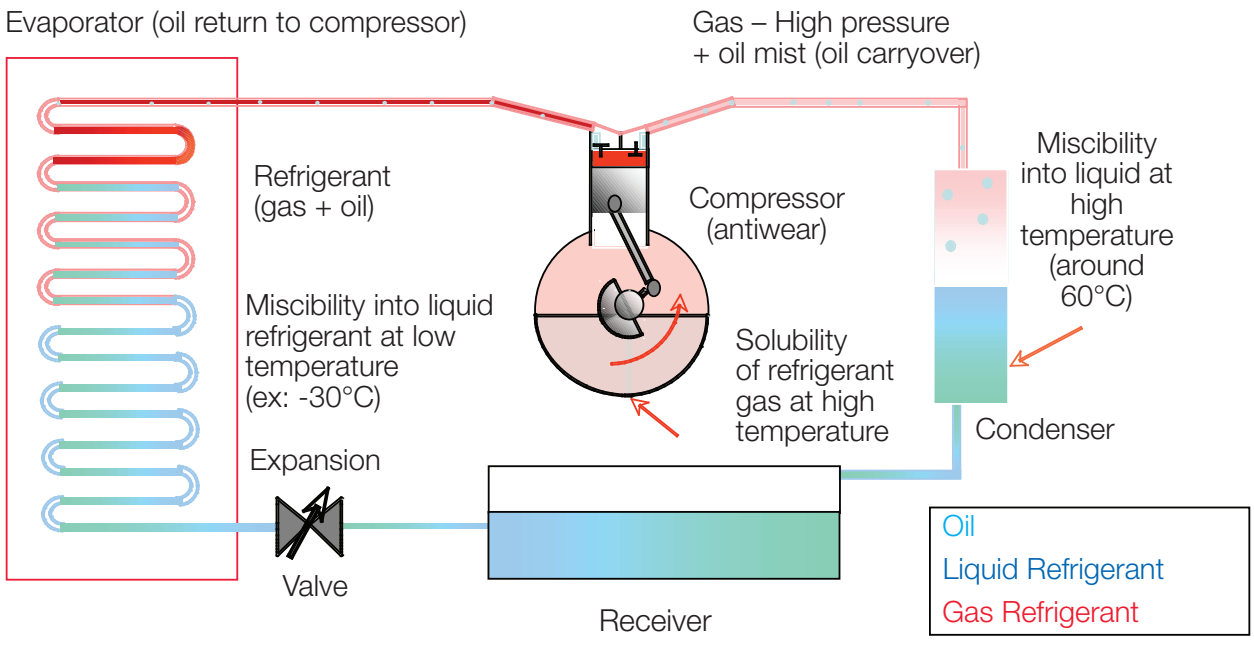
Both products are ISO VG 68 grades, and provide outstanding lubrication for compressors in industrial refrigeration systems using ammonia:

- High oil film thickness in the presence of refrigerant, offers improved antiwear protection for extended compressor life as well as better shaft sealing and reduced bearing fatigue, resulting in less unscheduled downtime.
- Outstanding viscometrics offer protection at high temperatures while a low pour point and the absence of wax enable operations at very low temperatures.
- Excellent thermal and oxidative stability, ensure potentially longer oil life, reduced drain intervals, and less maintenance.
- Excellent chemical stability and solvency from synthetic base oils offers reduced lacquer and deposit formation for longer filter life and reduced shaft-seal leakage. Also enable effective cleaning of plants when switching from mineral lubricants on existing units.

Conclusion

New legislation on HCFCs is inducing technical changes, especially for R-22, for refrigeration systems which needs to be taken promptly under consideration by all users concerned. ExxonMobil products and expertise can help end users for a trouble free switch over to suitable refrigerant fluids and lubricants.

Basic Refrigeration Process (compressor application)



Mobil-branded Refrigeration Lubricant Selection Guide for Industrial Systems

High performance Mobil Industrial Lubricants for refrigeration applications are listed below, each one formulated to offer outstanding equipment protection and extended oil life. These charts are designed to help you determine which lubricant is most suitable for your system, based on the type of refrigerant fluid, evaporator temperature and compressor type. Please visit www.mobilindustrial.com for more information.

See other side for additional charts.

Mobil

This guide is for refrigeration lubricant selection for industrial systems with dry type evaporators (i.e., oil carryover into evaporator is less than 15%). To select a lubricant for other types of refrigeration systems, please contact the Technical Help Desk on TechDeskEurope@exxonmobil.com or visit www.mobilindustrial.com

TABLE 1: Refrigeration Lubricant Selector

REFRIGERANT FLUID			EVAPORATOR TEMPERATURE		COMPRESSOR TYPE								
					Piston			Screw			Centrifugal		
ASHRAE Name	Type	Transition or Substitute of	From (°C)	To (°C)									
R12	CFC		-40	+40	7			8	5				
R502	CFC		-50	-20	7	16		8	18				
R22	HCFC		-25	+10	7	16	2*	8	18		8		
R22	HCFC		-30	+10		16	2*		18		8		
R22	HCFC		-40	+10		16			18		8		
R22	HCFC		-50	+10		16			17		8		
R123	HCFC	R11	0	+20							8		
R124	HCFC	R114	0	+80	8			18					
R401a	HCFC	R12	-20	+10	7	16							
R402a	HCFC	R502	-50	-30	16								
R408a	HCFC	R502	-50	-30	16			18					
R409a	HCFC	R12	-20	+10	7	16							
R290	C_3H_8 (propane)		-30	+20	8			15			15		
R600/600a	Butane, Iso Butane		-30	+20	8			15			15		
R717	NH_3 (ammonia)		-30	+10	8	2*	6**	8	2*	6**	8		
R717	NH_3 (ammonia)		-50	+10		2*	6**		2*	6**	8		
R744	CO_2		-55	-10									
R23	HFC		-100	-40	9								
R134a	HFC	R12	-20	+10	10			14			12		
R134a	HFC	R12	-30	+10	9			13			12		
R404a	HFC	R502	-40	-30	10			14			12		
R404a	HFC	R502	-50	-30	9			13			12		
R407c	HFC	R22	0	+10	12			14					
R410a	HFC		-45	+10	9			13			12		
R410a	HFC		-25	+10	10			14			12		
R410b	HFC		-25	+10	10			14			12		
R417a (Isceon M059)	HFC	R22	-15	+15	12			14			12		
R422a (Isceon M079)	HFC	R22	-45	-5	9			13			12		
R422a (Isceon M079)	HFC	R22	-25	-5	10			14			12		
R422d (Isceon M029)	HFC	R22	-45	+10	9			13			12		
R422d (Isceon M029)	HFC	R22	-25	+10	10			14			12		
R427a (FX 100)	HFC	R22	-40	+10	9			13			12		
R427a (FX 100)	HFC	R22	-20	+10	11			14			12		
R507/507a	HFC		-40	0	9			13			12		
R507/507a	HFC		-20	0	11			14			12		

Some products may not be available locally.

HOW TO USE THIS REFRIGERATION LUBRICANT SELECTOR

1. Obtain/confirm the following information:
   a. **REFRIGERANT FLUID** in use (ASHRAE designation)
   b. Evaporator is of dry type (oil carryover less than 15%) and **EVAPORATOR TEMPERATURE** in °C
   c. **COMPRESSOR TYPE** and outlet temperature
2. To identify the suitable Mobil-branded lubricant(s) refer to the row that corresponds to the refrigerant fluid and the evaporator temperature.
3. If mineral and synthetic lubricants are both indicated, synthetic lubricants will in general offer a higher level of performance than mineral oils with respect to equipment protection, particularly at high and low operating temperatures, compressor efficiency, and oil life.
4. For information on builder approvals for Mobil-branded refrigeration lubricants, please refer to Table 2 on the back page.
5. For further clarification, please contact your local ExxonMobil lubricants representative or the Technical Help Desk.

NOTE:

a. For equipment under warranty, please refer to equipment builder recommendations.

b. In changing refrigeration oil technology or brands, ensure thorough flushing of the system to minimize contamination with the previous technology or brand.

Mobil Gargoyle Arctic SHC 200 Series

Supreme performance synthetic lubricants for refrigeration compressors and heat pumps

Features and Benefits

Superb low temperature capability provides excellent fluidity at low temperatures. Resistance to viscosity loss due to refrigerant absorption under pressure for excellent bearing-film thickness and shaft-sealing properties.

N°	Lubricant	Technology	ISO VG
1	Mobil Gargoyle Arctic SHC 224	PAO (Polyalphaolefin)	32
2 *	Mobil Gargoyle Arctic SHC 226 E	PAO (Polyalphaolefin)	68
3	Mobil Gargoyle Arctic SHC 228	PAO (Polyalphaolefin)	100
4	Mobil Gargoyle Arctic SHC 230	PAO (Polyalphaolefin)	220
5	Mobil Gargoyle Arctic SHC 234	PAO (Polyalphaolefin)	400 cSt at 40°C

Mobil Gargoyle Arctic SHC NH 68

Supreme performance synthetic lubricant for refrigeration compressors with ammonia refrigerant

Features and Benefits

Wax-free for excellent low temperature fluidity and evaporator efficiency. Outstanding thermal/oxidative and chemical stability for long oil life and extended drain intervals. Compatibility with seals previously used with mineral lubricant for limited risk of oil leakage.

N°	Lubricant	Technology	ISO VG
6 **	Mobil Gargoyle Arctic SHC NH 68	PAO/AB (Alkylbenzene)	68

Mobil Gargoyle Arctic 155 & 300

High performance naphthenic mineral oils for refrigeration compressors

Features and Benefits

Low pour point and good fluidity at very low temperatures. Good chemical stability. Suitable for both cylinder and bearing lubrication.

N°	Lubricant	Technology	ISO VG
7	Mobil Gargoyle Arctic Oil 155	MN (Mineral Naphthenic)	32
8	Mobil Gargoyle Arctic Oil 300	MN (Mineral Naphthenic)	68

Mobil EAL Arctic Series

High performance Polyol Ester (POE) for refrigeration compressors and systems

Features and Benefits

Specifically designed for use with ozone-friendly HFC refrigerant fluids. Formulated from synthesized Polyol Esters to provide outstanding lubricity and wear protection, as well as chemical and thermal stability.

N°	Lubricant	Technology	ISO VG
9	Mobil EAL Arctic 22 or 22CC***	POE (Polyol Ester)	22
10	Mobil EAL Arctic 32	POE (Polyol Ester)	32
11	Mobil EAL Arctic 46	POE (Polyol Ester)	46
12	Mobil EAL Arctic 68	POE (Polyol Ester)	68
13	Mobil EAL Arctic 100	POE (Polyol Ester)	100
14	Mobil EAL Arctic 220	POE (Polyol Ester)	220

Mobil Glygoyle 22

Synthetic Polyalkylene Glycol–based (PAG) lubricant suitable for specific refrigeration applications

Features and Benefits

Shear-stable with outstanding resistance to thermal degradation and the formation of sludge and deposits. Suitable for HC (hydrocarbon) or CO2 refrigerant fluid applications.

N°	Lubricant	Technology	ISO VG
15	Mobil Glygoyle 22	PG (Polyglycol)	150

Mobil Zerice S Series

Premium synthetic refrigeration compressor lubricants for ultralow temperature applications

Features and Benefits

Outstanding solubility with halocarbon refrigerants, helping avoid oil separation and congealing on the valve and heat-transfer surfaces of the refrigeration system. Very low pour and floc points prevent harmful wax precipitation blocking expansion valves.

N°	Lubricant	Technology	ISO VG
16	Mobil Zerice S 32	AB (Alkylbenzene)	32
17	Mobil Zerice S 68	AB (Alkylbenzene)	68
18	Mobil Zerice S 100	AB (Alkylbenzene)	100

* For new units ** For existing units *** For Emerson Copeland pistons compressors or where indicated **, use only 22CC

For more information on these and other Mobil industrial lubricants and services, please contact the Technical Helpdesk on TechDeskEurope@exxonmobil.com or visit our website at www.mobilindustrial.com