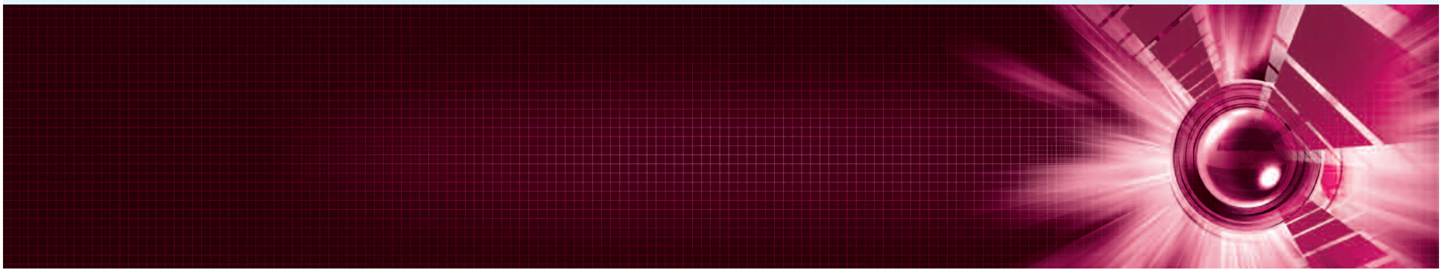


Lubricants for Air Conditioning:

How much do you really know?

PRIMALEC

PRIMALEC

Introduction

This Paper gives a brief outline of the technology behind refrigeration and A/C lubricants for both commercial and industrial refrigeration and air conditioning systems (AC&R) as well as mobile/vehicle air conditioning (MAC). It has been written with the technician in mind. Its aim is to clear some of the confusion which often exists about what lubricants to use in a given A/C system, to explain the difference between the different oil technologies, and the difference between a good oil and one traded on price alone.

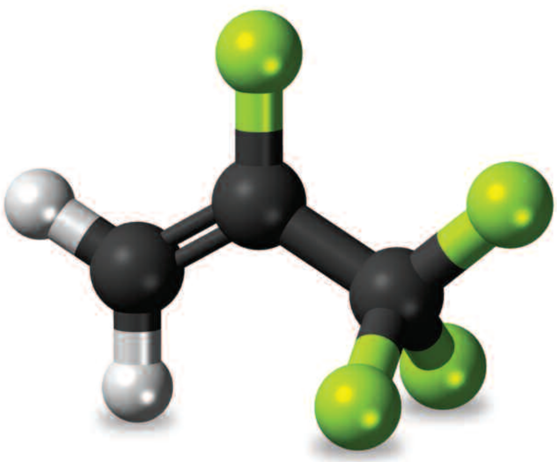
In the relatively recent past, lubrication was much simpler. Mineral oil did the trick for most lubrication jobs, and most lubricants were refined mineral oils with various additive packs tuned to the particular application. Today, engineering standards and technologies are more demanding by far, and they require more technically accomplished and demanding lubrication than straight mineral oils can deliver.

In the air conditioning and refrigeration space, mineral oils were the norm until the 1987 Montreal Protocol led to the eventual banning of traditional CFC and HCFC refrigerants. This was mainly because of their high - and in the case of CFCs very high - ozone depleting potential (ODP). They also had high Global Warming Potential (GWP). R12 refrigerant (CFC-12) with its ODP of 1.0, GWP of 10,500 and a life time of 100 years, was very harmful to the environment.

New refrigerants had to be developed which had significantly less damaging effects, and during the Nineties and Noughties HFC-134, or R134a, became the most widely used refrigerant for air conditioning applications, and the only one specified for automotive A/C.

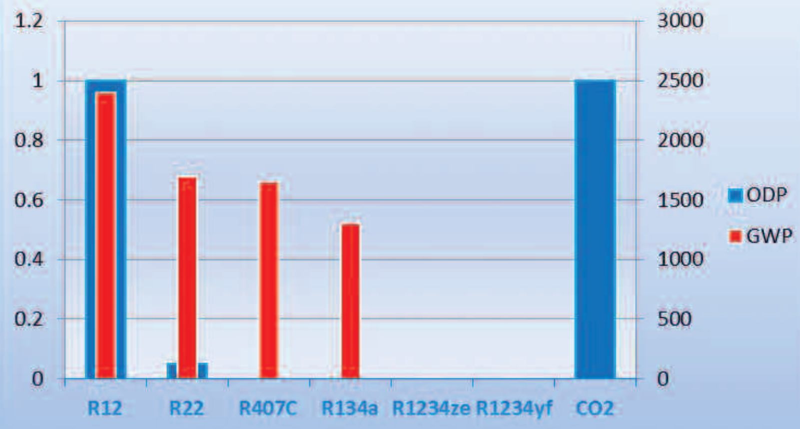
HFCs such as R134a do not mix nicely with mineral oils; they need specialised synthetic lubricants. However, it does not stop there. R134a has a ODP rating of 0, but its GWP number is still way too high at 1430. Hence the move towards zero or near zero GWP refrigerants such as CO2 and HFO-1234. CO2, operates under extremely high pressures with higher bearing loads, and R1234yf is very fussy about its lubricant choice. Enter the new era of high performing technical synthetic lubricants.

The Automotive industry was obliged to act early following EU Directive 2006/40/EC which banned refrigerants with a Global Warming Potential above 150 in newly type-approved vehicles from January 2011. R134a (GWP =1,430) can no longer be used in new models. After flirting with CO2, the Automotive industry settled on the mildly flammable HFO-1234yf (GWP=4) as its refrigerant of choice. A new class of refrigerant, this hydrogenated fluorinated olefin is a "near drop-in replacement" for R134a, which means there is no need for any major changes to components or assembly lines for the VMs. However, a complicated 5-stage production process means R1234yf is very expensive – many times the cost of R134a. Newly developed specialised double end-capped PAG oils, such as AircoLube HFO-PAG, are also much more expensive to produce than standard PAG oils used today. HFO-PAG can be used in R134a, but the old PAGs cannot be used in R1234yf.



The R1234yf molecule

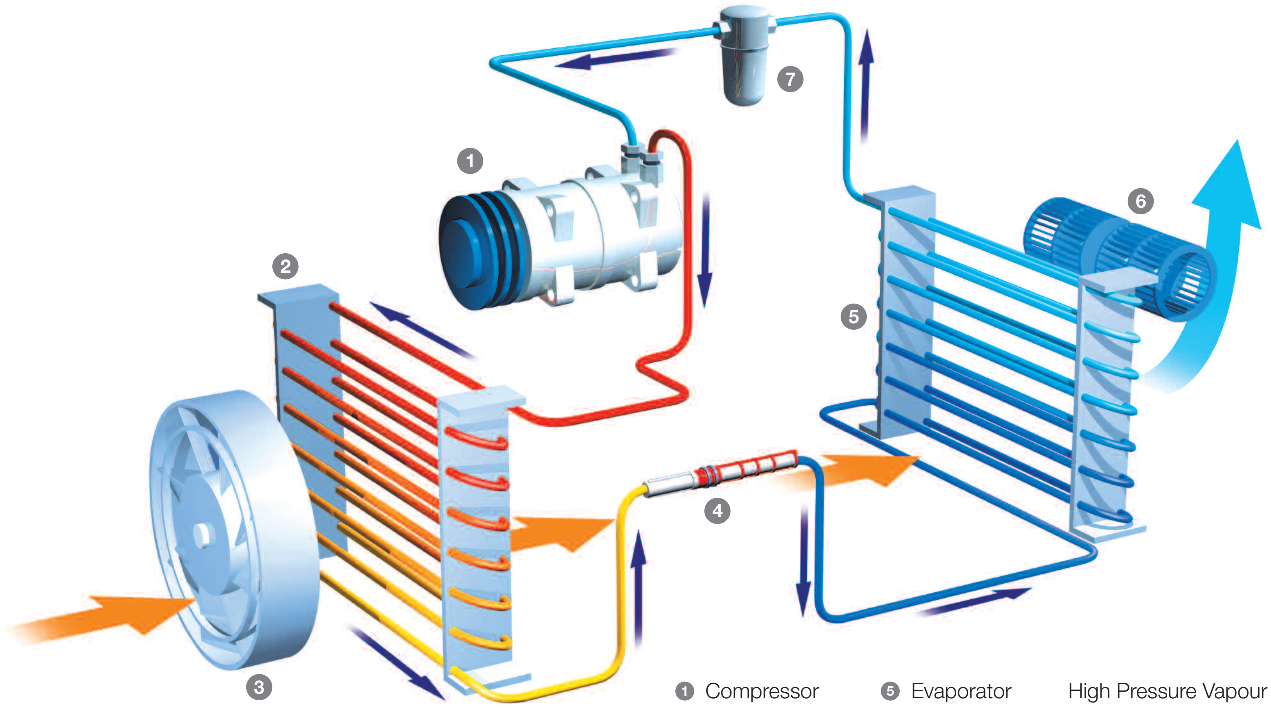
Environmental impact of common refrigerants



So what are refrigerant lubricants for?

The main job of AC&R lubricants is to lubricate the moving parts of the refrigerant compressor. Clearly the lubricant shares its home with the refrigerant, which means they must be mutually compatible and they must be willing and able to mix it with each other. Good compatibility and good miscibility.

In static systems the components and pipework can usually be fixed solidly and the joints brazed. Mobile systems are different because they are subjected to continual bumps and vibrations, so the mechanical joints and pipework need to retain some flexibility. Hence the o rings and flexible hoses found in MAC systems, which also need lubrication to keep them in good conditioning and reduce leakage through elastomer degradation. The diagram illustrates a typical MAC circuit, showing the main components.



1 Compressor
2 Condenser
3 Condenser Fan
4 Orifice Tube
5 Evaporator
6 Blower Fan
7 Accumulator

High Pressure Vapour
High Pressure Liquid
Low Pressure Vapour
Low Pressure Liquid

The most important characteristics of refrigeration oils are:

- Type (e.g. POE/PAG/AB/MO/PAO)
  see descriptions on the next page
- Viscosity
- Moisture content
- TAN
- Pour point

What are the different lubricant technologies?

Mineral oil (MO)

Mineral oil-based fluids still represent the majority of the wider market for lubricants in general, but that is changing. MOs have got about as far as they can get. Technological advances in engines, gearboxes, industrial equipment and machinery now also demand the benefits offered by the constantly improving performance capabilities of synthetic lubricants. In AC&R, synthetics are required for most of the newer environmentally friendly refrigerants. For the purpose of this Paper, the most important synthetic lubricant types are: polyalkylene glycols (PAG), polyol esters (POE), polyalfolefin (PAO), and Alkyl benzene (AB). I will take these in reverse order.

Alkylbenzene (AB) – the first synthetic oil to be used in AC&R

Alkylbenzene is an excellent lubricant choice for stationary refrigeration systems, including those with HCFC, HFC and NH3 (ammoinia) refrigerants. They are miscible with mineral oils (which they can replace) and all classes of synthetic refrigeration lubricants.

ABs usually have refrigerant miscibility advantages over mineral oils, maximising oil return to the compressor and minimising oil retention in the system's low temperature regions.

Alkybenzenes have excellent chemical stability, low pour points and floc points, and their superior thermal and oxidative stability offer major advantages over traditional mineral lubricants for ammonia applications at a better cost performance than other synthetics.

Polyalfaoleifin (PAO) - 'mineral synthetic oils'

PAOs are hydrocarbon polymers manufactured by the catalytic oligomerization of linear alpha olefins like alpha-decene. If you understood that mouthful, you are probably a chemist. They are considered high-performance lubricants and provide a high viscosity index and hydrolytic stability.

PAOs based oils are commonly used in passenger car motor oils as well as in numerous specific industrial applications. They are also used as lubricants in certain static refrigeration applications. PAO based oils are generally less expensive than other synthetic lubricants.

PAOs have very low hygroscopicity. This cuts the risk of introducing moisture into a system when oil is added. However, unlike PAG it does not absorb water which means that any water in the system remains free (see PAG oils below). PAO has been successfully used commercially in the mobile A/C aftermarket as a "universal" refrigerant oil in ISO 68 grade. However, no vehicle manufacturer has approved the use of PAO as an A/C lubricant.

Polyol ester (POE) – a fully synthetic lubricant

Polyol ester lubricants have become a primary technology for commercial and industrial HFC systems. They offer excellent miscibility with HFCs and other refrigerants, high inherent lubricity over a wide temperature range and good chemical stability with system components. However, care is required using POE with respect to water ingress, because of the potential formation of acidic species by reaction of POE with water.

POEs are manufactured by reacting alcohol and acids to form polyolesters and water, and the water is then separated out from the polyolesters. However, this reaction is reversible.

Therefore, although POE is less hygroscopic than PAG, in the presence of a significant amount of water, ester oil can undergo the natural reverse reaction and revert back to the acids and alcohols. (PAGs are not subject to that chemistry). In extreme cases, such acid formation could lead to capillary tube blockage, corrosion, and chemical degradation of the POE lubricant. However, this rarely happens in well maintained systems, and the starting moisture content of POEs should normally be just <50ppm.

POE has been widely and successfully used with electric compressors for over 20 years and its good di-electric properties make it the popular choice for MACs with electric compressors in hybrid cars and other vehicles with electric compressors. Correctly produced POE based lubricants are also compatible with HFO refrigerants such as R1234yf, R1234ze and the newly released R1234zd.

Most popular VG ISO grades are 22, 32 46, 68, 85, 100, 170.

Polyaklyene glocol (PAG) – a fully synthetic lubricant

PAGs were one of the first synthetic lubricants to be developed and commercialized. Towards the end of the CFC era at the end of the 1980s, polyalkylene glycol was identified by lubricant scientists and automotive companies as the best option for working with the then new R134a refrigerant in MAC systems. Conversely, the static AC&R industry went with polyol ester oils because of concerns over PAG's tendency to absorb moisture from the air.

PAGs were one of the first synthetic lubricants to be developed and commercialized. Towards the end of the CFC era at the end of the 1980s, polyalkylene glycol was identified by lubricant scientists and automotive companies as the best option for working with the then new R134a refrigerant in MAC systems. Conversely, the static AC&R industry went with polyol ester oils because of concerns over PAG's tendency to absorb moisture from the air.

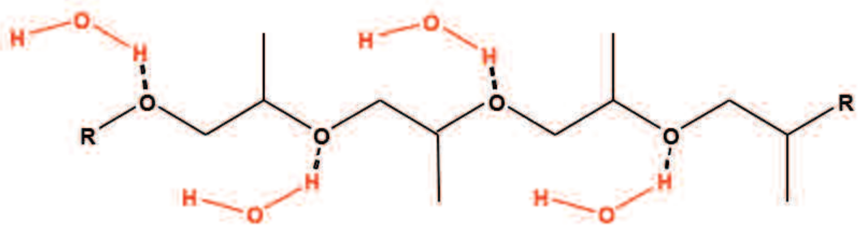
PAGs offer exceptionally high performance in HFCs like R134a, as they have excellent refrigerant miscibility and lubricity. Good quality PAGs tend to have better hydrodynamic and boundary lubrication properties than lubricants such as POE. A high kinematic viscosity index ensures maintained lubrication at high temperatures, and PAGs are chemically stable with system components, even at high temperatures. Energy efficiency benefits may also be apparent at system start up.

PAGs also have the ability to absorb water, but unlike POE, the water is hydrogen-bound to the PAG's ether linkages, and therefore does not exist freely within the system. This means that absorbed water is completely non-reactive with the PAG so there is no possibility of acidic species forming. Their hygropscopic character is often wrongly referred to as a disadvantage, but their ability safely to absorb system moisture can actually be seen as an advantage.

PAGs fall into 2 categories: single (or mono) end-capped (SEC), and double end-capped or di-capped (DEC). Mono end-capped PAGs are often referred to as standard or ordinary PAGs, whereas di-capped are referred to as OEM grade. This is because most compressor manufacturers and VMs exclusively specify di-capped PAGs.

Speciality PAGs are usually double end capped, and are needed for R1234yf, CO2 and for hybrid electric vehicles. They are specially (and more expensively) formulated from optimised base stocks to create the required miscibility, lubricity, extreme pressure tolerance, and di-electric properties respectively.

The commonly used ISO VG numbers for PAG are 46, 68, 100 and 150.



Water absorption in PAG: the water is bound into the PAG

What are the advantages of double capped PAGs?

A standard polyalkylene glycol generally consists of polymer chains with a terminating hydroxyl group at just one end of the molecule which is chemically inactive, whereas a "double capped" PAG has chemically inactive groups at both ends of the molecule.

The technical advantages of di-capped PAGs are generally considered to be:

- Better extreme performance and anti-wear properties, especially at higher pressures and temperatures
- Better miscibility with R134a
- Reduced water absorption
- Better chemical, hydrolytic and thermal stability

However, single end capped PAGs dominate the automotive aftermarket because:

- Price

It is worth bearing in mind that both DEC and SEC PAGs are much less hygroscopic than DOT 3 brake fluids. If handled with the same care as brake fluid, the hygroscopic nature of PAGs will not cause any problems provided the system is not left open to the air during service. Although both DEC and Mono PAGs are very water tolerant, excess water in the system will mar cooling performance. Both single and double capped PAGs have been used commercially in automotive A/C systems since 1992.

Di-capped PAGs are more expensive to buy because they are more expensive to make. But in most typical situations, the lubricity of the PAG is just as likely be influenced by the additive package, the quality of the materials from which the oil is synthesised, the individual additive package, and the quality of processing and packing. So, a di-capped PAG from one producer can be expected to perform better than a single capped PAG from the same producer. Most aftermarket service outside the premium main dealers is carried out using single end capped PAGs.

What is probably more important than DEC vs SEC is to avoid using very cheap oils. Synthesising oils is not a cheap process, and I have seen so-called PAG oil traded in India at street prices of less than $2 per litre; I would not put this in my car. In the past I have also seen a laboratory report on an oil described as PAG which had a significant mineral oil content. Choose your oil carefully.

I do however strongly recommend that you use premium speciality double end capped PAGs for:

- R1234yf systems on the newest vehicles, and this must be the specially developed HFO lubricant, as ordinary SEC & DEC PAGs would have major miscibility and compatibility issues and could damage the system.
- CO2 systems, which perform at extreme pressures and need very specialist highly additised PAG oils.
- Very hot and humid climates, where the AC system is working much harder.

Which oils to use for HFO R1234ze and R1234yf

These two hydrofluoroolefin (HFO) refrigerants come from more or less the same chemistry. R1234ze (1,3,3,3-Tetrafluoropropene) has achieved adoption in some static AC&R applications, including a number of supermarket installations, and will also be used as an R134a replacement blowing agent for foam and aerosol applications. Senior chemists at the two HFO refrigerant producers Du Pont and Honeywell confirmed to me some time ago that polyol ester lubricant technology is the recommended choice for R1234ze and R1234zd.

However, the automotive industry wanted a near drop in replacement for R134a and to stick with PAG oil technology. This called for slightly different chemistry in the form of R1234yf (2,3,3,3-Tetrafluoropropene), and more expensive chemical processing. Standard PAGs are not adequately compatible with R1234yf, so the oil also must undergo additional manufacturing processes with more complex additive packages tailored to the task.

A premium grade double end-capped PAG specially made for the R1234yf is required. The good news is that these specialist HFO PAGs are backward compatible, which means they can also be used with R134a.

Which oils to use for Hybrid electric cars

The issue with electric compressors is that the oil can contact live electrical parts, so the oil should be as non-conductive as possible. The industry is most comfortable with POE based oils. They have been successfully used for over 20 years to lubricate electric compressors in refrigerators.

A Hybrid safe PAG is available with a manufactured moisture content of <300ppm and comparable dielectric properties, but it meets market resistance because of entrenched perceptions. Lubricant quality – acid value, water content, residual catalyst content – is most important.

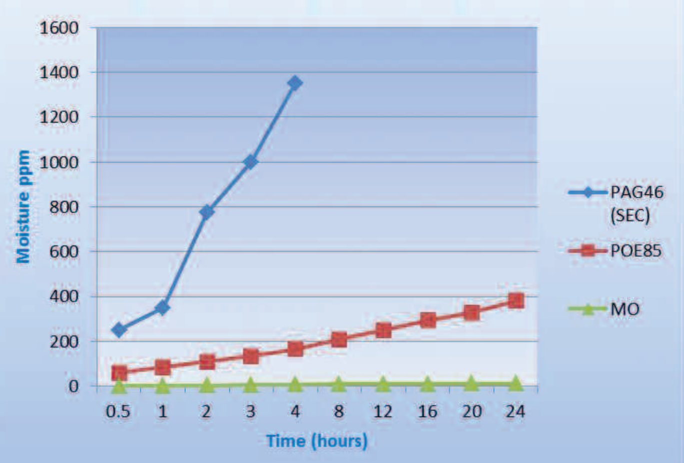
Which oils to use for CO2 systems

This natural refrigerant operates under very high discharge pressures – 120 bar or more - and requires a lubricant which keeps calm under pressure. Mineral oils and alkybenzenes are not recommended. POE and dicapped PAG based oils are commonly specified, as they have good miscibility with CO2 and good lubricating properties. However, under CO2 dilution POEs can suffer a dramatic reduction in lubricant viscosity. Extreme Pressure (EP) PAGs remain unaffected and do not show a decrease in viscosity under CO2 dilution, thereby retaining their good anti-wear properties at high pressures.

Hygroscopic characteristics of different oils

The graph shows typical moisture absorption into the three respective oils over time when left in an open container. Read the sections on PAGs and POE for more information. It illustrates the care with which PAGs and POEs should be treated. It does not show free water which may form in the open container of a mineral oil. See also the section on our Moisture Barrier Treated containers.

Typical hygroscopicity of PAG, POE, MO lubricants



The increasing importance of using the right quality and the right quantity of lubricant and refrigerant in vehicle air conditioners.

The gram (or margin) strategy is how VMs are trimming weight from new vehicles gram by gram, component by component, in order to improve energy efficiency and cut CO2 emissions. The air conditioner cannot escape this process. Already, the present generation of cars is being equipped with smaller volumes of refrigerant and lubricant than in the past. The very high cost of R1234yf is another good reason to make less gas work harder.

Most new cars typically contain rather less than 500 grams of refrigerant and 120 grams or less of lubricant – less than half what is was 15 or 20 years ago. Some systems have as little as 75 grams of oil. We expect this trend to continue as the pressure to reduce vehicle weight intensifies.

In future, technicians will need to be more precise about both the quantity and quality of refrigerant and oil in the system, because too much oil reduces performance, and too little oil can lead to component damage. Equally, with less lubricant in the system, the quality and lubricity of the oil becomes more important to cooling performance.

Whenever possible, each time an air conditioner is serviced, all the refrigerant and all the oil should be completely removed. The correct amounts and proportions of refrigerant and lubricant (as recommended by the VM) can then be re-charged into the system. This can make a huge difference to cooling performance, as I have witnessed in the tropical climes of South East Asia.

PRIMALEC

Packaging and processing of lubricants

Received wisdom can be defined as “knowledge or information that people generally believe is true, although in fact it is often false”. Received wisdom holds that synthetic oils like PAGs and POEs should always be packaged in metal containers. The thinking behind this is that moisture cannot pass through metal, but like all rigid rules and standards, received wisdom can be a block to innovation when followed blindly.

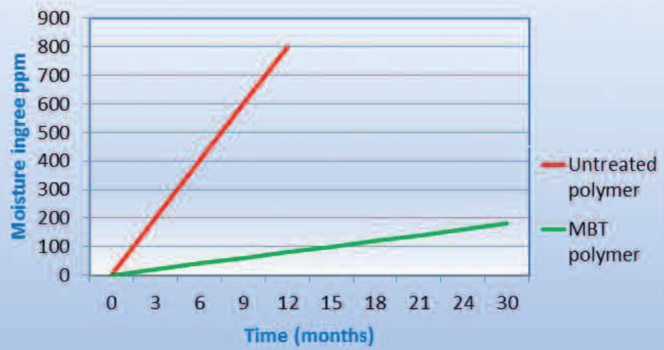
Now, there is nothing wrong with metal containers, apart from the fact that they are very easily dented during transport, are more expensive than polymer containers, and may also be liable to internal condensation after the first opening. There is also no guarantee that the oil was not compromised before being put in the metal container.

At Primalec, we used to receive regular complaints from customers that the metal cans and bottles had arrived dented at their destination. That is what led us to our new MBT polymer containers for all liquids in packs up to 5 litres. MBT stands for moisture barrier treated. This high-energy process increases the density of the container surfaces inside and out, reducing permeability, increasing chemical resistance and giving excellent surface barrier properties.

So we now package our AC&R lubricants (and our Glo-Leak tracer fluids) in these special MBT polymer containers, ranging in size from 30ml up to 5 litres. Before we fill them the pre-treated containers are purged with oxygen free nitrogen, then filled with the lubricant and sealed. These combined processes dramatically improve the shelf life, as illustrated in the graph, and they do not get dented in transit.

When all is said and done, the quality of the oil itself and the conditions under which the oils are filled are more important than whether the bottles are in metal or non-metallic containers.

Comparision of moisture ingress over time
Untreated bottles against mosture barrier treated



Hermetic dispensing containers
AC lubricants and UV leak test fluids

When you buy a hygroscopic oil in a container and use only part of the contents, the remaining space is filled with air. Unless you do this in impossibly dry atmospheric conditions, moisture will also enter the bottle. The oil will absorb that moisture, even though the cap is quickly re-fitted.

A unique and patented Concertina cartridge system allows part of the contents to be used without allowing air to enter the container, thanks to the collapsing bellows form and a one way valve built into the cartridge neck.

One version is for direct application under pressure using an injector tool, but larger cartridges are also available with special fittings for MAC service machines. These are designed to replace the oil and dye bottles supplied with the machine. Two big advantages of this system are

1. Oil (or Glo-Leak fluid) remains sealed in the hermetic container.
2. You can easily switch from a standard PAG46 oil to a Hybrid safe lubricant, just by swapping the cartridge over, with no fear of contamination.
3. When empty, the cartridge is disposed of, so there is no risk of the contamination that occurs with refillable bottles.

Premium additised lubricants and lubricant enhancers: What are they?

There are several products on the market which are sold as A/C Boosters or lubricant enhancers. I can only speak for the ones I have actually seen working in tests in Singapore, including ICE-32 and Primalec's own ExtraCool AC. The chemistry and functionality of these two products is very similar.

What are the claims?

- Faster cool down on hot days - up to 15% quicker
- Cabin air stays cooler, less humid - up to 15% cooler
- Use less energy to keep cool - faster refrigerant flow, more efficent heat exchange
- Longer compressor life - better lubricity, lower friction, less wear, longer life
- Reduced leakage - conditions hoses, seals and o-rings

How does ExtraCool work?

After a period of time, the internal surfaces of the pipework and heat exchangers in any AC system will accumulate oily, gummy deposits. This impedes heat exchange, and can also restrict the flow of refrigerant, which reduces its cooling capacity. The net result is that the AC works harder and uses more energy for less cooling.

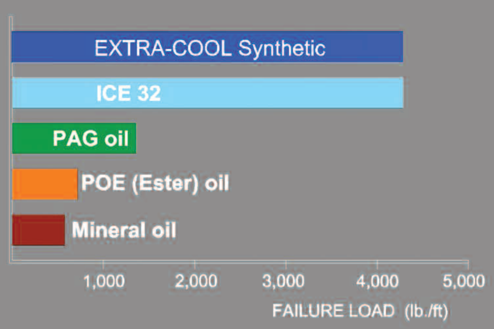
ExtraCool AC cleans this build up from all internal metal surfaces and creates a lasting elastrohydrodynamic barrier lubricant on the surfaces of all metal parts of the air conditioner, including the compressor. This stops any new build up on the surfaces, reduces heat caused by friction, gives a smoother surface for less drag, and speeds up refrigerant flow. It also suppresses foaming and creates a greater load bearing shield. This diagram compares failure load of standard oils and for the Extra Cool and ICE 32 using the standard Falex test.

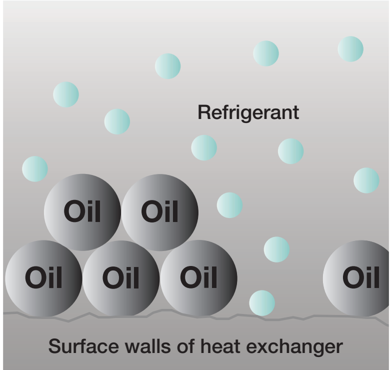
ExtraCool also improves heat transfer by minimising lubricant migration on the heat exchange surfaces of the evaporator and condenser. By eliminating the energy-robbing barriers caused by stagnant oil and carbon deposits, the system requires less energy and cools more efficiently. This means faster cooling down when the car starts on a hot day, and cooler vent temperatures while you drive.

We tested this product in the tropical heat of Singapore. The air vent temperature difference before and after injecting in the ExtraCool were impressive, even without any other service actions.

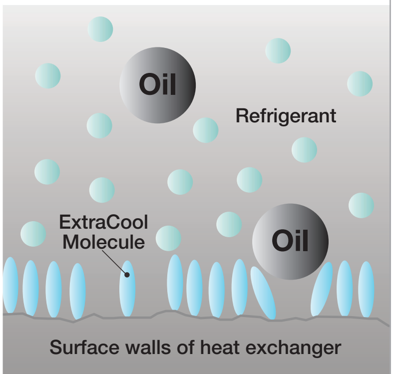
ExtraCool A/C is available as a concentrated additive or as a high performance lubricant, in both hermetic cartridges and in MBT bottles.

Falex lubricity analysis





Oil layers attach to heat exchanger surface which impedes heat transfer



Activated polar ExtraCool molecules displace oil molecules, facilitating better heat transfer

Primalec offers one of the most comprehensive ranges of compressor lubricants for air conditioning.

PRIMALEC

Automotive A/C lubricant application chart

Refrigerant types	Compressor types	Lubricant name	Lubricant basis	Specific applications and notes	ISO VG	Lubricant coding	Standard pack sizes
R134a	Belt driven	Airco-Lube PAGz	PAG - polyalkylene glycol, single end capped	Automotive A/C aftermarket refills and top ups. Use this for price sensitive applications.	46 100 150	AC2173 AC2174 AC2175	250ml, 1 litre
R134a	Belt driven	Airco Glo-Lube PAGz	PAG - polyalkylene glycol, pre-treated with Glo-Leak^{UV}	Use to top up a system previously treated with UV dye, or after a full flush.	46 100 150	AC2183G AC2184G AC2185G	250ml, 1 litre
R134a	Belt driven	Extra Cool HP-PAG	PAG - polyalkylene glycol with High Performance additives	A high performance premium lubricant for use in all Automotive R134a systems for better cooling and better lubrication.	46 100 150	AC53046 AC53100 AC53150	60, 250, 275ml
R134a	Electric	HYB-46	PAG - speciality double end capped, low moisture	Use on R134a charged vehicles with electric compressors.	46	AC52046	250ml
R134a	Electric	HYB-11	POE - polyol ester	Use on R134a charged vehicles with electric compressors.	68	AC2177	60, 250, 275ml
R1234yf R134a	Belt driven Electric	MRL-85	POE - polyol ester	This premium lubricant may be used as a "universal" oil in all mobile A/Cs, including R1234yf and electric compressors, where the specified oil ISO VG is up to 100.	85	AC54085	250ml, 1 litre
R1234yf R134a	Belt driven	HFO1234yf	PAG - speciality double end capped modified for R1234yf	This premium lubricant is specifically formulated for R1234yf, but is also excellent for R134a. Ordinary PAGs must not be used in R1234yf systems.	46 100	AC55046 AC55100	60, 250, 275ml
CO^2	-	EP-PAG Refrigeration lubricant for CO^2	-	Extreme Pressure PAG, specifically for use in CO^2 applications. The extreme pressure and anti-wear capabilities of this Speciality PAG are far superior to POE.	46 68 100	AC56046 AC56068 AC56100	250ml
R12→R134a	Belt driven	Airco-Lube Retro A/C	POE - polyol ester	Use this when retro-fitting or restoring pre-1993 vehicles from R12 to R134a.	100	AC2176	250ml
R134a	Belt driven	Airco-Lube PAO	PAO - polyaflaolefin	Sometimes used as a "universal" oil for Mobile AC. Not miscible with refrigerant, non-hygroscopic, and has no VM endorsements. Also available with Glo-Leak^{UV}.	68	AC2188 AC2188G	250ml, 1 litre
Any	Any	Airco-Lube VPO	MO - Mineral oil	Suitable for all vacuum pumps whose makers specify oils with these VGs.	68 100 46	AC2178 AC2179 AC2180	1 litre

Commercial & Industrial AC&R speciality lubricant application chart

Refrigerant types	Compatible lubricants	Compressor/ System types	Recommended Lubricant name	Lubricant technology	Specific applications and notes	ISO VG	Lubricant coding	Standard pack sizes
All **HFCs**	POE	Piston Screw Centrifugal	**POE** Refrigeration Lubricant	POE Polyol ester	Polyol ester is the primary technology for commercial and industrial HFC systems. They are recommended for all HFC refrigerants, including: R23, R134a, R404A, R407C, R410A, R410B, R417A, R422, R427, R507. However, despite good miscibility with CO^2, we advise not to use POE with CO^2 this can result in a dramatic reduction in viscosity, so we advise using our specially formulated EP-PAGs. All of our ester oils are manufactured by the world's leading producer to the highest specifications.	22 32 46 68 85 100 170 220	AC24022 AC54032 AC54046 AC54068 AC54085 AC54100 AC54170 AC54220	1, 5, 25, 200 litre
HCFCs and their interim replacements **HCs** Propane, Butane, Propylene	MO/AB MO/AB/PAG	Piston Screw Centrifugal	**Zerol AB** Refrigeration Lubricant	Alkyl benzene	This lubricant range is based on synthetic Alkyl benzene (AB) and has been developed for refrigeration, heat pumps and air conditioning compressors. Its miscibility with hydrofluorocarbon type refrigerants is excellent. They offer a very low floc point, good anti-foaming and good stability at high temperature provides optimum lubrication even under severe conditions.	150 250 350 500		1, 5, 25, 200 litre
R717 - NH_3 (Ammonia); R134a	MO/AB/PAG	Piston Screw Centrifugal	**PAG-R717** Refrigeration Lubricant for NH_3.	Polyalkylene glycol	PAG-R717 is a monolin itiatedco polymer of ethylene oxide and propylene oxide, manufactured to a molecular weight corresponding to a viscosity of 52cSt at 40°C. Its components are often used as lubricating oils for gears, hydraulics and compressors. PAG-R717 is also compliant for use in food applications.	52		1, 5, 25, 200 litre
CO^2	PAG/POE	Piston Screw Centrifugal	**EP-PAG** double end capped Refrigeration lubricant for CO^2	Polyalkylene glycol	These Extreme Pressure PAGs have been developed by world leading tribologists specifically for use in CO^2 applications. The extreme pressure and anti-wear properties of this PAG technology are generally superior to POE. Critically, EP-PAGs remain unaffected by the dramatic reduction in viscosity to which POEs may fall victim.	46 68 100	AC56046 AC56068 AC56100	1, 5, 25, 200 litre

Notes

Glossary

CFC	=	Chlorofluorocarbon, consisting of chlorine, fluorine, and carbon
HCFC	=	Hydrochlorofluorocarbon, consisting of hydrogen, chlorine, fluorine, and carbon;
HFC	=	Hydrofluorocarbon, consisting of hydrogen, fluorine, and carbon.
HFO	=	Hydrogenated fluorinated olefin, or hydrofluoroolefin
AB	=	Alkylbenzene
MO	=	Mineral oil
PAG	=	Polyalkylene glycol
PAO	=	Polyalfaolefin
POE	=	Polyol ester
ODP	=	Ozone-depleting potential - the ratio of the impact on ozone of a chemical compared to the impact of a similar mass of CFC-11 (trichlorofluoromethane). Thus, the ODP of CFC-11 is defined to be 1.0. Thus, a substance with an ODP of 2 is twice as harmful as CFC-11, and one with an ODP of 0.1 is one tenth as harmful as CFC-11. The lower the fraction of 1 the better.
ODS	=	Ozone-depleting Substance, a compound that contributes to stratospheric ozone depletion
GWP	=	Global warming potential - the ratio of the warming caused by a substance to the warming caused by a similar mass of carbon dioxide. Thus, the GWP of CO is defined to be 1.0
SEC	=	Single end capped PAG: just one end of the molecule which is chemically inactive
DEC	=	Double end capped PAG: both ends of the molecule are chemically inactive
MAC	=	Mobile Air Conditioner (Conditioning)
Lubricity	=	the measure of the reduction in friction and or wear of a lubricant

PRIMALEC

Nettlestead Green, Nr. Maidstone, Kent ME18 5HD, England.
Tel: +44 (0)1622 816955 Fax: +44 (0)1622 816110
customers@primalec.co.uk

www.primalec.com