Compressor Lubrication

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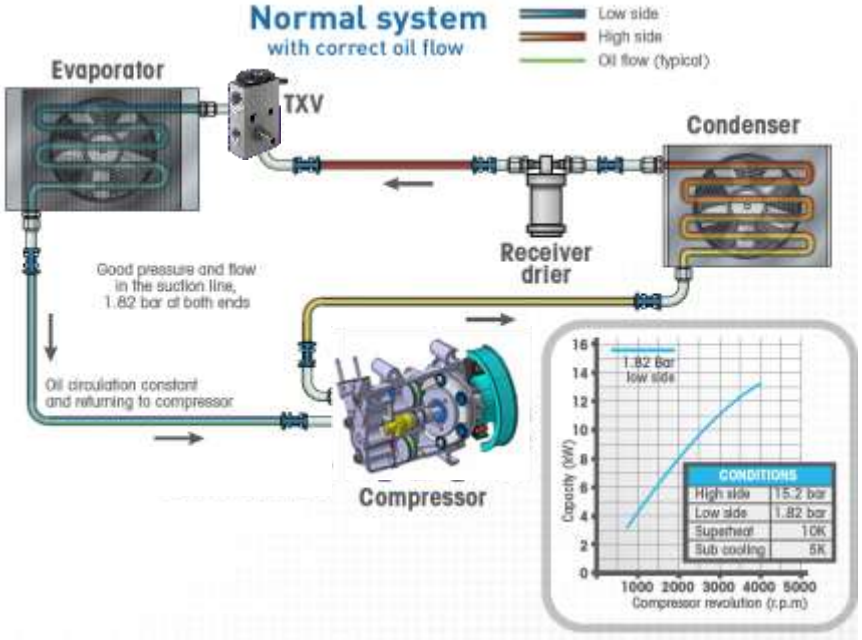
We find the three most common questions asked as a compressor manufacturer are:

1. Does the compressor come with oil?
2. How much oil do I use?
3. What oil do I use?

Contents:

1. The fundamentals of oil and how its used as a lubricant in compressors
2. Proper compressor oil & charge
3. System oil qty, OCR and oil addition
4. The detrimental effects of using contaminated oil
5. The fundamentals of system flushing & vacuum
6. R1234yf & SP-A2 oil

Air Conditioning Oil



- All mobile air conditioning systems have oil and refrigerant.
- Refrigerant is the vehicle by which oil circulates the A/C system.
- Oil is vital to lubricate the moving parts of the compressor and reducing friction
- Oil circulates within the system providing an essential film on the inside of the hoses that acts like a barrier reducing refrigerant leakage.

Air Conditioning Oil – Types

Synthetic oils such as glycols & esters have been used in Mobile Air Conditioning (MAC) applications for many years now without any problems. Below are the most common oils used in mobile AC.

Today we will concentrate on POE and PAG for mobile AC.

- Mineral oil (AN) – a by-product of crude oil distillation classified as Naphthenic and is mostly used in systems that are charged with R12
- Alkyl Benzene oil (AB) – common in R22 systems
- Poly Alpha Olefin (PAO) - a "mineral synthetic" with a chemical structure similar to mineral oil but formulated by so called monomers. Works good with R22 and Ammonia
- **Poly Alkylene Glycol (PAG) oil** – Basically one of the first oils developed for use in Hydrofluorocarbons (HFC) refrigerants as it mixes very well with R134A.
    - Note - PAG oil is (hygroscopic) - of a substance tending to absorb moisture from the air.
- **Polyol Ester (POE) oil** – is a type of synthetic oil used in compressors that is compatible with the refrigerants R134a, R410A and older R12 systems. It is often recommended as a replacement for systems using hydrofluorocarbons (HFCs).

Air Conditioning Oil

All mobile air conditioning systems have oil and refrigerant

Common HVAC system types oil and features

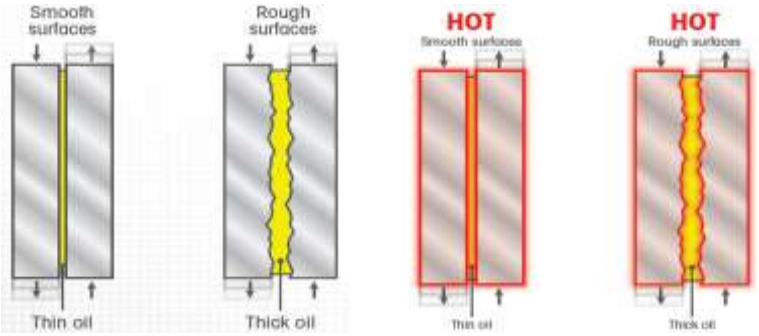
- Poly Alkylene Glycol (PAG)
- Polyol Ester (POE)

System type	Refrigerant	Oil type	Viscosity	Features
Automotive - passenger car	R134a	PAG	Mid range	High temp viscosity and stability
Automotive - passenger car	R1234yf	PAG (HD)	Mid range	Miscibility and stability with HFO refrigerant
Transport - bus	R134a	POE	High	Resiliance to moisture contamination
Transport - refrigeration	R134a	POE	Mid range	Miscibility at mid temp
Transport - refrigeration	R404a	POE	Low	Miscibility at low temp
Heavy vehicle - large hose	R134a	PAG/ POE	Low - mid range	Miscibility with refrigerant
Heavy vehicle - high temp	R134a	PAG/ POE	Mid-high range	Viscosity at high temp

Air Conditioning Oil

Oil is vital to lubricate the moving parts of the compressor and reducing friction

- Friction is the resistance that one surface or object encounters.
- Specialised air conditioning oils provide a lubricating film between surfaces ensuring no metal to metal contact occurs
- The type of surface will determine the type of oil that must be used. Rough surfaces are more effectively lubricated by thick oil.
- Other influences over whether an oil is providing the correct lubrication film also include temperature and force. An oil operating in extreme high temperatures will need different qualities to an oil required to do the same in sub-freezing conditions.



Air Conditioning Oil – Friction

If the lubrication layer deteriorates then the risk of the metal surfaces touching will result in friction.

- Compressor components will not survive prolonged metal to metal contact and at such point irreparable damage will occur to the compressor components resulting in a mechanical failure.

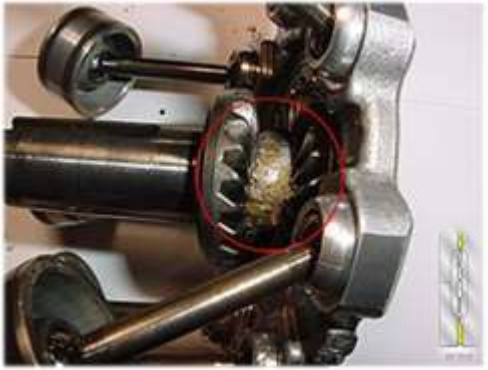
- Modern oil technology provides manufacturers the ability to formulate oils capable of working within multiple forces & temperatures.

- This is particularly evident in systems used in both air-conditioning and refrigeration systems operating under different system conditions.

Center Ball Seizure

Overheating from friction is most often caused by loss of the refrigerant charge.

- Under normal condition, cool suction side refrigerant/ oil returning from the evaporator provides cooling & lubrication for the compressor.
- Once the refrigerant charge is lost there is no refrigerant or oil return entering the compressor thus creating friction.
- Blockages in the system will also prevent cool refrigerant/ oil flow to the compressor causing friction.
- Results of an interrupted compression cycle equal a mechanical failure in a wobble plate compressor commonly referred to as "Center Ball Seizure"



Center Ball Seizure

Results of an interrupted compression cycle can equal a mechanical failure in a wobble plate compressor commonly referred to as "Center Ball Seizure"

What can interrupt the cycle?

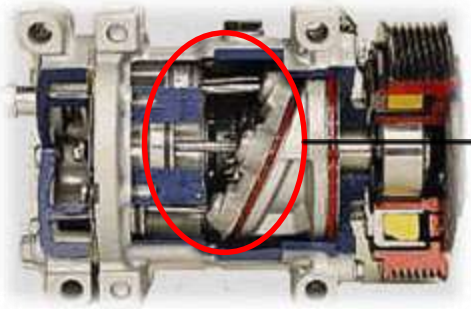
- TXV blockage or malfunction from contamination (moisture or debris)
- Thermostat failure.
- No air flow to the evaporator (blower fan motor failure or dirty and clogged)
- Lack of refrigerant and/ or oil due to a system leak. (Hoses or o-rings)
- Lack of return oil due to too long a circuit or system undercharge.
- Lack of refrigerant flow due to inadequate charge
- Blockage in system due to contamination in system.
- Liquid slugging due to improper system charging.
- Charging Liquid refrigerant into compressor (washes off oil film from around center ball).

Liquid Migration

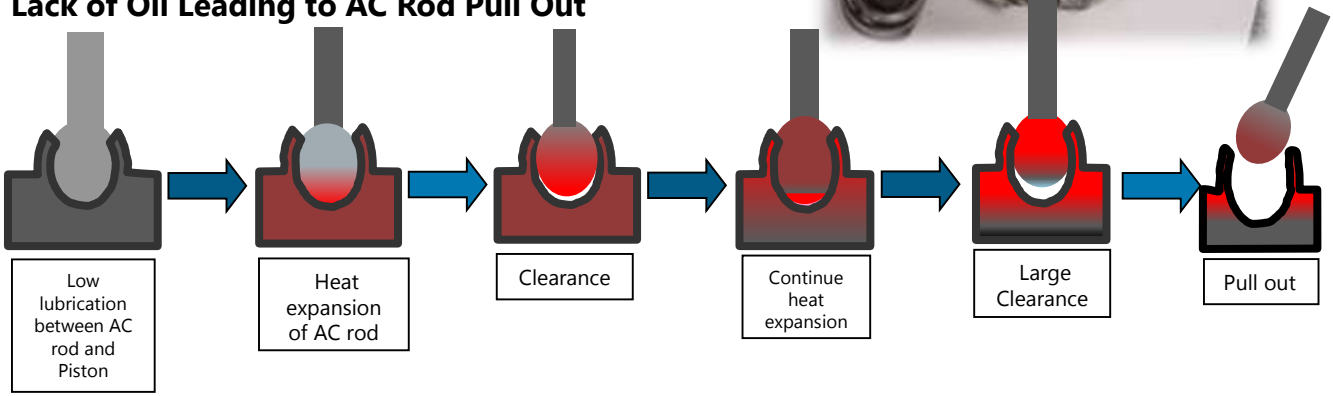
- When a compressor is shut down for an extended period, it's temperature will drop to around the ambient temperature. The compressor can become the coldest component in the system.
- Refrigerant in an air conditioning system will always; if given the opportunity, migrate to the coldest part of the system.
- The refrigerant vapor can condense back into a liquid, mix with the oil, and dilute the oil's lubrication properties.
- When the compressor is the coldest component, the liquid refrigerant will settle in the bottom of the compressor with the oil and the lubricating properties of the oil are greatly depleted.
- The level of the refrigerant/oil mixture is now higher than the normal oil level. When the compressor is started, the liquid will be agitated in the crank case.
- This agitation, combined with the sudden drop of pressure inside the compressor housing, will cause a sudden change of state of the refrigerant, from liquid to vapor. The result is that the oil will foam and be carried out of the compressor.

Liquid Migration

- The compressor will experience a loss of lubricant properties & washout of oil from the internals. A sudden reduction of the amount of oil in the compressor creates the potential for mechanical damage to the compressor due to liquid slugging as oil is discharged through the valves. A very high compressor discharge pressure will further add to the possibility of mechanical component failure.



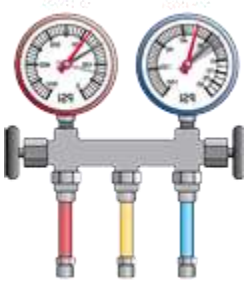
Lack of Oil Leading to AC Rod Pull Out



Liquid Migration

- While the accumulator and other methods can help prevent liquid migration, a proper system design and a well-balanced refrigerant and oil charge can help prevent this phenomenon.

- Other causes of liquid returning to the compressor
  - Evaporator problems
    - Faulty fan motor
    - Poor ventilation
  - Over charge
  - Faulty expansion valve


WHAT OIL DO I USE IN MY COMPRESSOR?

Choosing the Correct Oil

Choosing the correct oil is more complicated than just selecting an oil type. Making the right choice requires consideration of numerous factors, especially when designing a new system.

- **Type of refrigerant** – Oils mix differently at various temperatures with different refrigerants
- **Type and size of the vehicle** – influences the type of system
- **Size and length of hoses** – effects oil return and viscosity choice
- **Evaporator temps** - effects oil return and viscosity choice
- **Types and number of heat exchangers** – fin, tube or extrusion effect oil circulation
- **Type and control of expansion devises** – consistency of refrigerant flow is important for oil return
- **Ambient Conditions** – viscosity and miscibility of the oil must suit consistent and fluctuating temperatures
- **System Servicing** – inspection and service intervals effect moisture ingress to the system
- **Oil Separators** – guarantees oil return

Fortunately, most compressor manufacturers have specifically designed, tested and validated their compressor for a specific application, accounting for all the above factor and will likely dictate which oil gives their product the longest life and durability, specifying the sole use of it in their product.

Pour Point

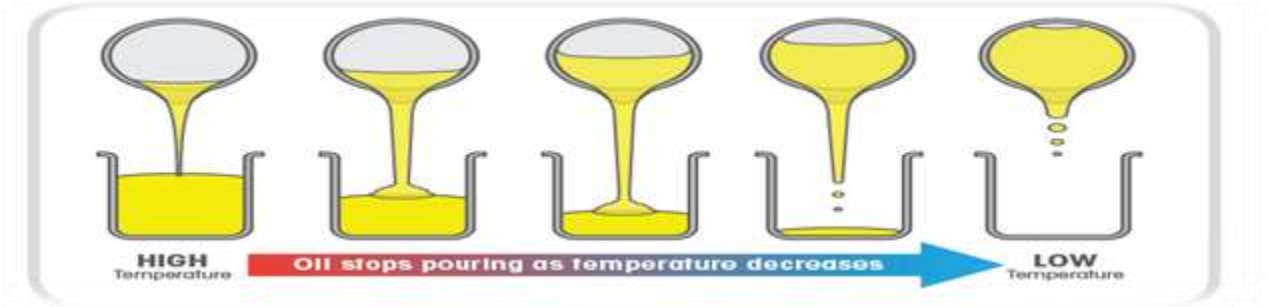
- There are three main factors we look at when deciding the best oil for a product
    1. **Pour Point**
    2. **Viscosity**
    3. **Miscibility**

- The **pour point** is the lowest temperature at which an oil still flows when it is cooled down under defined conditions and describes the way in which oil moves from one point to another.

- The standard for **pour point** testing are covered by standards, such as ASTM, SAE, DIN and ISO, and the methods used are all fundamentally based on cooling the oil at different temperatures.

- **Pour point** ratings usually follow the viscosity rating or index of the oil. A higher pour point temperature will mean a higher viscosity or thicker oil, and a lower pour point temperature will have a lower viscosity or thinner oil.

- In MACS usage, this feature is important to know as a certain amount of oil is always in circulation in the system, and it is critical for this oil to eventually return to the compressor and potentially continue to circulate.



Viscosity/ Miscibility

- **Viscosity** is the measure of a fluid's resistance to flow which is measured quite differently to pour point.
- **Dynamic viscosity (μ)** - also called absolute viscosity and it is a measure of a fluid's internal resistance to flow. It is measured by mechanical means using rotatory or centrifugal force to obtain the resistance and shear capability of the oil at a specific level of force and temperature
- **Kinematic viscosity (v)** - a measure of the resistive flow of a fluid under the weight of gravity, it is the ratio of the dynamic viscosity μ to the density of the fluid. It is measured without additional force applied by noting the time taken of a fluid sample to travel through an orifice in a capillary under the force of gravity only
- Oil manufacturers for refrigeration and air-conditioning systems will typically quote the **Kinematic viscosity** at two temperature points, 40°C (104°F) and 100°C (212°F) as prescribed by International standards (ISO and others) The 40°C number is generally used to identify the oil model

Miscibility

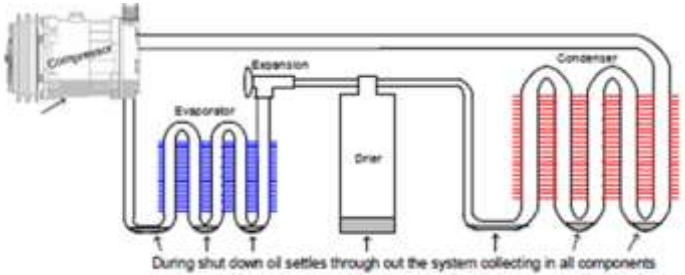
- **Miscibilit**y - miscibility is the mixing characteristic of the oil with the refrigerant while they are both circulating in a system. All systems are different and have varying qualities when it comes to the level of oil circulation ratio (OCR) requirements and results.

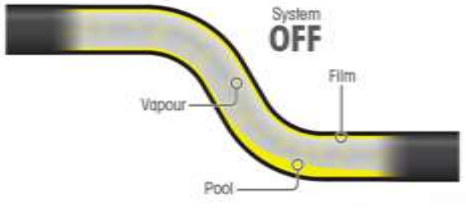
- Compressor lubrication occurs as the oil which circulates with the refrigerant passes through the compressor crankcase during operation. The Sanden SD series compressor achieves optimal durability and cooling performance when oil circulates through the system (OCR) is at a ratio of 3.3% to 8% oil to refrigerant.

- All systems have one basic requirement when it comes to miscibility- and that is to not have too much oil mixing with the refrigerant so that excessive oil is not leaving the compressor. The oil must have sufficient properties to stay in circulation and remain sufficiently 'miscible' with the refrigerant so that it does not park itself in the system components.

- *Why? - Excess oil can act as an insulator limiting heat transfer in the evaporator and condenser, while too little oil can negatively affect durability.*

- *Why? - Oil will collect in low pressure cool components (evaporator, accumulator and suction hose) of the refrigerant loop. For example a long suction hose which sags can collect several ounces thus reducing overall oil circulation ratio.*





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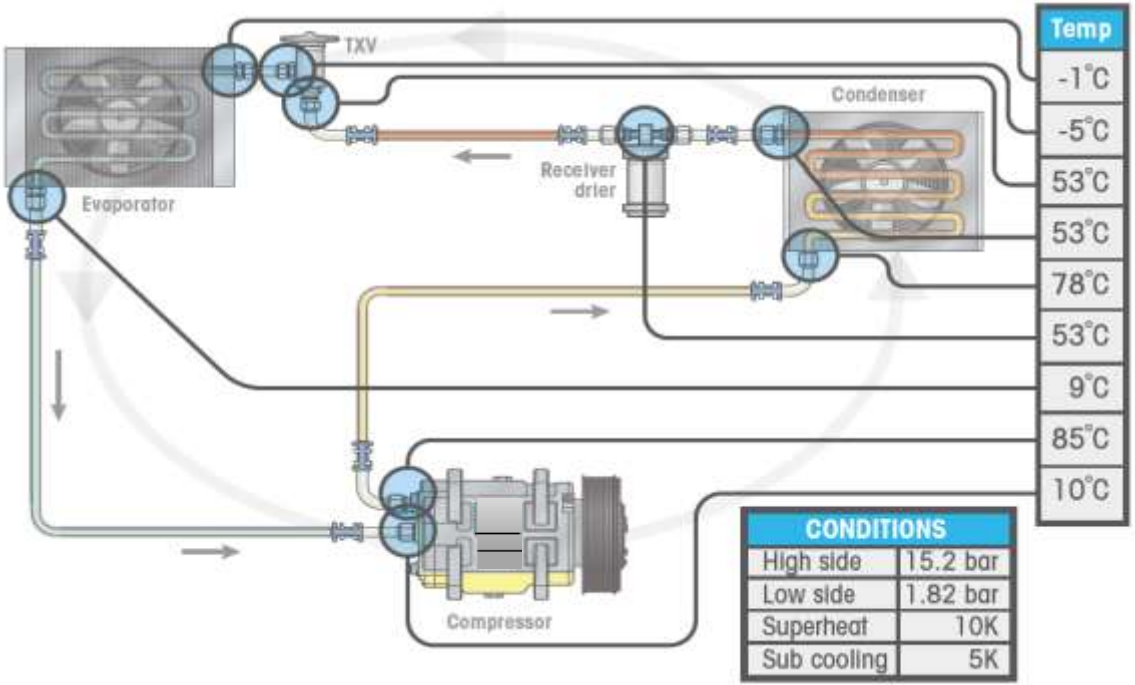
Air Conditioning Oil Flow

Why does this matter?

- Because oil in a mobile AC system is being pushed, pulled, constricted, cooled and heated at every turn in the system and the survival of the compressor is critical.



Air Conditioning Oil – MFG Usage

- The temperature range of the oil must allow for correct performance and lubrication within the system parameters. The table below provides a guideline for correct oil choice based on evaporator temperatures, which is critical to ensure oil return to the compressor.

COMP SERIES Sanden/ Unicla	REFRIGERANT	ORIGINAL OIL	Application	Low side saturation	Viscosity @ 40 °C	Viscosity @ 100 °C	Oil Separator
Sanden SD	R134a	SP-15	MAC	> 0°C	80.1	16.40	NO
Sanden PX	R134a	SP-10	MAC	> 0°C	47.73	10.42	NO
Sanden SDV	R134a	SP-10	MAC	> 0°C	47.73	10.42	NO
Sanden TR	R134a	SP-10	MAC	> 0°C	47.73	10.42	NO
Sanden SN	R134a	SP-10	MAC	> 0°C	47.73	10.42	NO
Sanden Electric Comp	R134a	SP-A2	MAC	> 0°C	42.66	9.51	NO
Sanden PX, SD, TR, SN	R1234yf	SP-A2	MAC	> 0°C	42.66	9.51	NO
Sanden Electric Comp	R1234yf	SP-A2	MAC	> 0°C	42.66	9.51	NO
Unicla F Series	R404a, R452a	Unicla Unidap 3 = POE32	Refrigeration	≥ -10°C	32.50	5.80	Required
Unicla F Series	R404a, R452a	Unicla Unidap 3 = POE32	Refrigeration	≥ -15°C	32.50	5.80	Required
Unicla F Series	R404a, R452a	Unicla Unidap 3 = POE32	Refrigeration	≥ -35°C	32.50	5.80	Required
Unicla All Models	R134a	Unicla Unidap 6 = POE68	MAC	> 0°C	65.50	9.30	Optional
Unicla All Models	R134a	Unicla Unidap 7 = PAG56	MAC	> 0°C	56.00	10.85	Optional
UWX with Extended Hose Length	R134a	Unicla Unidap 7 = PAG46	MAC	> 0°C	48.01	10.51	Optional

- **CAUTION**
- Never mix PAO with PAG as thickening will occur potentially clogging the TXV or Orifice as well as any other narrow channels severely restricting OCR.

End Capping

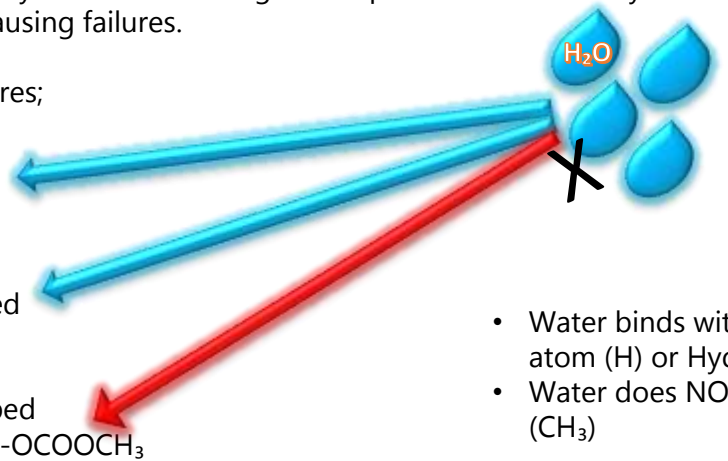
- Certain oils can be extremely hygroscopic and aggressively extract moisture from the atmosphere.
- Moisture in the oil turns to acid under heat and will damage the internal components of an A/C system.
- Certain oils can act as an aggressive solvent dislodging dust, dirt and small particles (swarf) from inside the A/C system which then get transported around the system and will damage the compressor causing failures.

Chemical Structures;

Non-end capped
HO-(PO)n-H

Single end capped
CH_3O-(PO)n-H

Double end capped
CH_3OCOO-(PO)n-$OCOOCH_3$

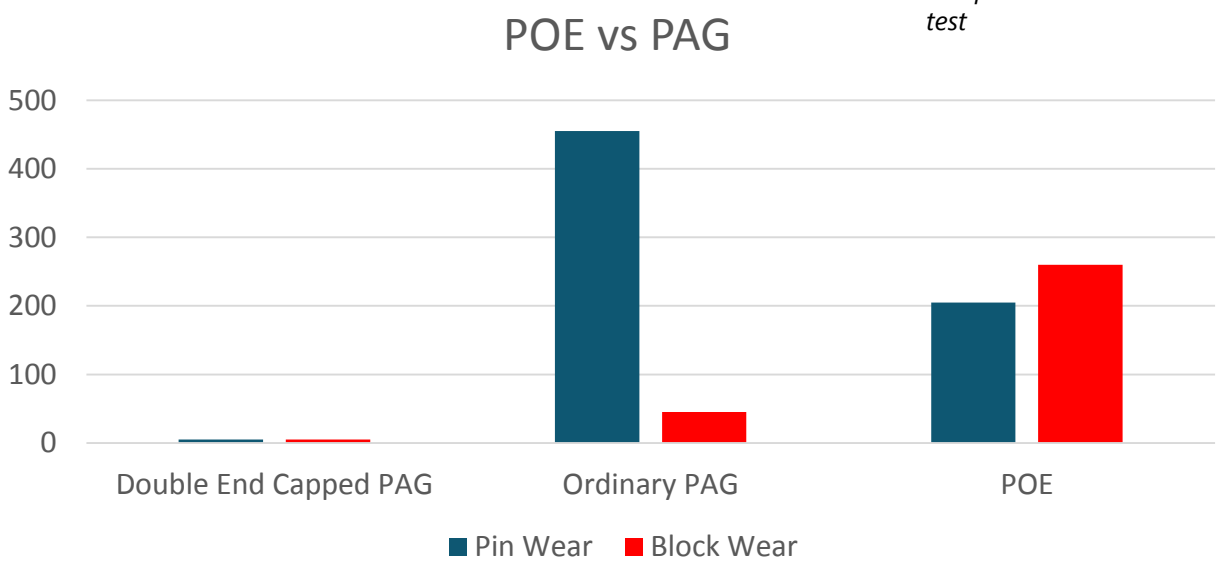


- Water binds with the uncapped Hydrogen atom (H) or Hydroxyl group (HO)
- Water does NOT bind to an Ether group (CH_3)

- Sanden uses a unique, patented, double “end-capped” formula of PAG that provides exceptional chemical stability to the oil. Ordinary PAG is still chemically active while “end-capped” PAG is chemically inactive or stable.

End Capping - POE vs PAG

Independent lab test NOT Sanden test



- The standard SAE test (Modified Falex Tests) was conducted using an aluminium pin rotating between two aluminium blocks. It has been modified to control specific parameters including temperature, pressure and atmosphere to simulate actual conditions within a compressor

Does my compressor have oil?

How much oil do I add?

Does it need more?

More is better – right?

It’s ok if we go ahead and add an extra ounce or two just to be safe?

Oil General

- As we have covered – the correct and genuine oil should be used in the A/C System as specified by the manufacturer.
- Oil is essential for effective lubrication of the compressor and preventing premature failures.
- Refrigerant is the vehicle by which the oil circulates the system and a correct charge of genuine refrigerant is imperative
- All Sanden compressors (expect those for use with R404a (SD5L/SD7L) are filled with an OEM level of oil on the production line and arrive to you filled with oil related to the original intended OEM application of the compressor.
- If the entire system is flushed, the Sanden factory amount should be sufficient.
- Most manufactures will identify the oil type and amount recommended for their product..
- Sanden PAG (SP10, SP15, SP-A2) are proprietary blends with a shelf life of five years

RECAP –Miscibility- Why it Matters!

- **Miscibilit**y - miscibility is the mixing characteristic of the oil with the refrigerant while they are both circulating in a system. All systems are different and have varying qualities when it comes to the level of oil circulation ratio (OCR) requirements and results.

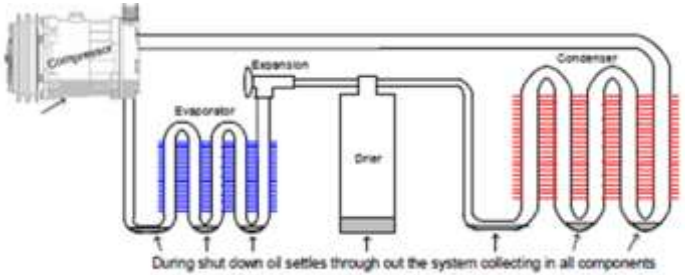
- The Sanden SD series compressor achieves optimal durability and cooling performance when oil circulates through the system (OCR) is at a ratio of 3.3% to 8% oil to refrigerant.

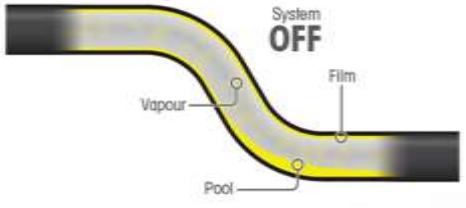
- We do not want too much oil mixing with the refrigerant causing excessive oil to leave the compressor.

- The oil must have sufficient properties to stay in circulation and remain sufficiently 'miscible' with the refrigerant so that it does not park itself in the system components.

- Excess oil can act as an insulator limiting heat transfer in the evaporator and condenser, while too little oil can negatively affect durability.

- Oil will collect in low pressure cool components (evaporator, accumulator and suction hose) of the refrigerant loop. For example a long suction hose which sags can collect several ounces thus reducing overall oil circulation ratio.





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SYSTEM OIL QTY

- Having an **adequate balance** of oil quantity to refrigerant level in the system is vital for proper performance.
- **Different systems** are able to operate with different system oil levels.
- Some systems may be capable of having **less oil**, which in theory promotes slightly better heat transfer in the system heat exchangers.
- **Other systems** may need more oil due to some design issue in the system circuit that compromises the oil return rate to the compressor.
- The system oil level must be sufficient to ensure the compressor maintains the correct oil level so that all components in the compressor receive adequate lubrication at all times.
- A safe and **recommended oil to refrigerant ratio** = ~20% ratio calculated by volume.
- For example a system with 1200 grams of R134a refrigerant should have ~240cc oil (1,200 x 20% = 240 cc). **Note OCR and SOQ are not the same**

Vehicle Type	Model Year	Compressor	OIL Type	Oil Volume CC	Refrigerant Type	Refrigerant Charge Grams	Oil to Refrigerant Ratio %
Volkswagen Jetta	2005-2010	Sanden PXE16	PAG SP10	110	R134a	550	20.00%
Volkswagen Arteon	2017 -	Sanden PX	PAG SP-A2	80	R1234yf	460	17.39%
Volkswagen Golf VII	2012-2016	Sanden PX E14	PAG SP10	80	R134a	460	17.39%
Volkswagen Golf VII	2016 -	Sanden PX E14	PAG SP-A2	80	R1234yf	460	17.39%
Case/IH 220/5230/5240/5250	ALL	Sanden SD7	PAG SP15	300	R134a	1750	17.14%
New Holland Tractor	ALL	Sanden SD7	PAG SP15	300	R134a	1500	20.00%
Volvo Class 8 HDT	Current	Sanden SD7	PAG SP15	300	R134a	1400	21.43%
Honda Accord	2003-2008	Sanden TR Scroll	PAG SP10	130	R134a	600	22.00%

Popular vehicles with refrigerant / oil quantity data, and System oil qty%.

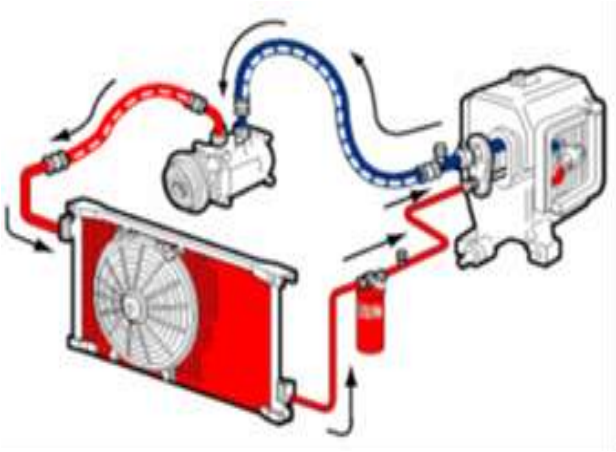
System Oil QTY

Oil Replacement Amount During Service

- When replacing a system component the goal is to restore to the original factory oil amount. This amount can be found on the compressor label.

- We can use the chart below as a guide for restoring oil quantities when replacing system components.

Component	Typical Oil Amount Large Truck		Typical Oil Amount Passenger Car	
	fl. oz.	cc	fl. oz.	cc
Major System Leak	3	88	1.5	44
Suction Line To Rear Evaporator				
Accumulator				
Condenser	2	60	1	30
Evaporator				
Receiver Drier	1	30	.5	15
Minor System Leak				
Suction Line To Front Evaporator				
Other Hoses or Hard Lines				
Compressor	Equal to amount drained from old compressor			



Note: When draining the old compressor roughly .5oz – 1oz will remain in the compressor as film coating all internal surfaces.

Contamination

Contamination

There are four primary causes of oil contamination and break down in a Mobile AC system.

1. **Acids**
2. **Moisture**
3. **Excessive Temperature**
4. **Foreign Particles**

ACIDS

- Acid formation is a significant cause of lubrication failure. Both organic and mineral acids are created depending on the refrigerant type and level of contamination and high temperature introduced to the system.

- Suction line leaks are particularly efficient at introducing air into the system, and the relative oxygen intake reacts with the refrigerant under high temperature to form acids.

- The acid attacks any surface or component possible in the system, with copper and alloy piping being particularly vulnerable causing corrosion and producing particulates of copper and alloy salts.

- Copper particulates plate onto the moving components and bearing surfaces, and form sludge in the oil channels of the crank shaft. The sludge restricts the flow of oil while the copper plating on the bearing surfaces decreases clearances, and operating temperatures rise.

- Once this cycle begins it is an ever-accelerating breakdown of the oil due to high temperature.

Moisture

Moisture Contamination occurs as a result of moisture being allowed to enter and remain in the A/C System. There are four primary identifiers of moisture contamination.

1. **Copper Coloring -** The presence of copper coloring generally occurs when there is a high moisture content in the A/C system.

2. **Rust -** Rust may occur on internal steel compressor components that are exposed to moisture for extended periods.

3. **Slugged Valves -** A Slugged valve is one that has been permanently deformed as a result of liquid slugging.

4. **Contaminated Oil** - Contaminated oil reflects a contaminated system.

This condition can be caused by the following:

- Insufficient Vacuum
- Inadequate filter drier use
- Vacuum leaks during the process
- Oil used contaminated by humidity
- Water penetration via hose leaks
- Additives containing high moisture content
- Poor handling procedures (storage, pouring, decanting, compressor left open)

Consequence of Moisture Contamination

- Disturbs the vacuum process.
- Saturates the compressor PAG oil with water and deteriorates the lubrication properties.
- Causes internal corrosion on steel components (E.g. Broken valve by fatigue due to corrosion)
- Causes blocked TXV (air bubbles remaining in the system if 3 mbar evacuation was not possible due to moisture)
- Creates higher system pressures by freezing in the expansion device and blocking refrigerant flow. This causes a blocked TXV due to ice formation around the needle resulting in mechanical failure.

Foreign Particles

Foreign materials such as dirt, metal, plastic and other solids, liquids and gasses can be introduced when careless practices are used to add lubricant to the compressor or when charging the system with refrigerant.

Recommended service practices;

- Always use pure oil in the compressor which is preferably taken from a sealed container
- Use clean rags, hand gloves and tools
- Use recommended grade of oil suitable to the application
- Use pure refrigerant from a known source (cylinder), supplier and manufacturer.
- Always change the receiver drier

Refrigerants are excellent cleaners and eventually carry contaminants back to the compressor oil. Therefore a properly maintained system with a new receiver drier is essential

Foreign Particles

High system temperatures occur in the discharge side and compressor which can be caused by:

Common types of contamination:

- Chips from broken reed valves
- Moisture ingress via system components and seals
- Particles from rubber lines
- Green slime from copper lines
- Silicone or rubber material from flexible hoses
- Particles from the casting process used for the compressor body, heads, and other cast alloy and iron components
- Desiccant from failed drier

Sludge is caused by chemical breakdown of the oil, most commonly due to operating temperatures which are higher than the oil rating, usually above 120°C.

Compressor Replacement – Key Points

It's critical for successful compressor replacement that the new compressor is installed in a clean system with a correct oil charge.

- Contamination from foreign material can be found by looking at the oil drained from either the compressor or the suction and discharge lines.

- Contamination can also be seen collecting in the orifice tube or expansion valve.

- Contamination remaining in the system will be pulled into the new compressor and lodge under the valves and in bearings causing quick failure of the new compressor.

- It's important to maintain the original OEM oil charge amount when replacing the compressor.

Oil Colour – Visual Evidence

✓	CLEAR OIL	New Oil Factory Filled
✓	LIGHT GREY OIL	Common after use
✓	LIGHT GREEN YELLOW OIL	Contains a leak detector additive/ UV tracer
✗	DARK SILVER/ GREY OIL	Indicates the presence of metal particles in the oil from compressor wear as a result of wrong oil/refrigerant circulation. The compressor must be replaced.
✗	ORANGE/ COPPER OIL	The oil has become contaminated by humidity creating acid which corrodes key components in the compressor leading to failure. Often due to ineffective vacuum, failure to change receiver and/or use of non approved oils.
✗	BLACK OIL	A/C system has overheated due to a condenser malfunction, blockage or airflow restriction through the condenser, defective pressure switch or lack of oil/refrigerant.

Flushing Key Points

Flushing

- Most Refrigerant recovery recycle machines contain a flushing circulation pump to purify refrigerant by removing solvent.

- A closed loop flushing machine in which the circulated flushing fluid is returned to a reservoir for filtering and continued circulation. Most of these machines provide a pulsing action to dislodge particles that are stuck in small passageways.

- A pressurized flush gun with a pulsating spray can also be used. To use this technique, block one end of a AC system component being flushed in order to build pressure inside the component, and then quickly release the blockage to pulse the flushing solvent out.

Acceptable Flushing Fluids

- Fluids designated for AC flushing should be used and may be either solvent or lubricant based. Fluids used to flush the system should meet SAE specification J2670 to ensure compatibility with refrigerant, oil and any materials used in the A/C system.

Components to Flush

- Flush hoses, hard lines and heat exchangers. If your flushing – replacement of compressor, orifice tube, receiver drier/ accumulator and possibly heat exchangers may be recommended.

- Safety
  1. **Do not use flammable fluids.**
  2. **Protect eyes with safety goggles.**
  3. **Wear chemical resistant gloves.**
  4. **Use approved fluids.**

Flushing Key Points

Why Suction Side Flushing Is Important

- When the off-cycle pressure equalizes in the backwards direction through damaged compressor valves, debris may be forced back up the suction hose. If it is not removed, this debris will travel into the replacement compressor and be circulated through out the AC system, causing subsequent failures.

Flushing Rear Evaporator Lines

- Debris is distributed throughout the entire AC system so it is important to flush the rear lines. After blowing out the flushing fluid and fumes a new thermal expansion valve should be mounted.

Importance Of Flushing Direction

- "Back flush", or flushing in the reverse direction to normal flow, is the most effective. The plate fin evaporators used on many front and rear evaporators have many small passages which are difficult to clean without a strong pulsating reverse flow.

How long do I flush?

- Closed loop procedure, flush until the flushing fluid leaving the AC components are clean. Manual pressurized gun method requires a minimum of three times, but more if exiting fluid is not clean

Drier Replacement

- Always replace the receiver drier or accumulator if (CCOT) system any time the system is opened.

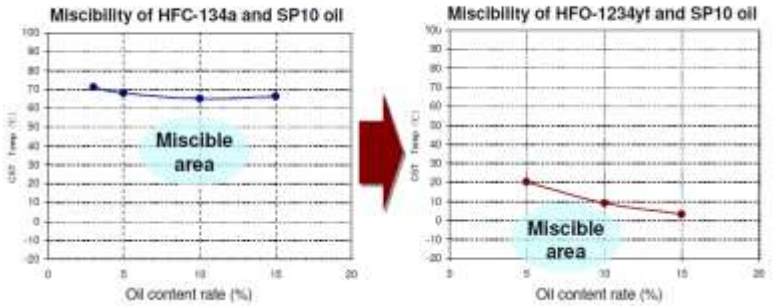
Vacuum – Key points

- **Evacuation** is the process of removing air and moisture from the refrigeration system before charging the system with refrigerant.
- Goal: to ensure that all moisture and non-condensable gases like air etc. are evacuated.
- Air or moisture remaining in the system before and during the refrigerant charge process will cause increased pressures during operation resulting in reduced or poor cooling and greatly reduce the compressor life.
- The common metric unit for vacuum measurement is the millibar, or mbar. equals 29.92 in. of mercury.
- A successful evacuation depends on a thorough prep of the system
  - Clean system
  - Clean oil
  - No leaks
  - A good vacuum pump with clean oil
  - Time of vacuum

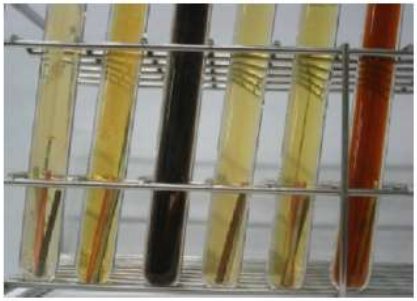
R1234yf & SP-A2 OIL

New Refrigerant – R1234yf

- For Passenger car compressors and most universal type compressors no internal compressor changes are necessary for the change of oil for R1234yf.
- Sanden test results show the level of oil circulation and oil remaining in the compressor are similar to the levels of compressors using R134a.
- There is no necessity of changing the quantity of oil when the refrigerant is changed from the R134a to the R1234yf.
- Most compressors used in passenger car applications with R1234yf gas have an integrated oil sump and so less oil is charged to the compressor on the production line (typically 75cc total charge)
- There does seem to be a negative 3-10% impact on the cooling capacity of the new R1234yf gas.
- Sanden SP-10/ 15 oil cannot be used with R1234yf due to the relatively low level of miscibility of SP10/15 with HFO-1234yf resulting in stability issues. Hence introducing SP-A2 for R1234yf



Using SP-10 with R1234yf

Test (336hrs)	HFC-134a/SP10			HFO-1234yf/SP-10					
Photograph									
	Low moisture			Low moisture			Moisture 5000ppm		
Temperature[℃]	175	185	200	175	185	200	175	185	200
ASTM color	OK	OK	OK	NG	NG	NG	NG	NG	NG
Acid value	OK	OK	OK	NG	NG	NG	NG	NG	NG
Deposition	No	No	No	Yes	Yes	Yes	No	No	Yes

<Test condition>
- Temperature : 175℃, 185℃, (200℃ :Reference)
- Test duration : 336h
- Metallic catalyst : Fe, Al, Cu
- Moisture : Natural moisture (adjunction is reference)
- Inclusion rate (refrigerant / oil) : 2ml / 2ml
- Refrigerant : HFC-134a and HFO-1234yf

<Criteria of evaluation>
- 175℃ & 185℃ (200℃ : Reference)
- ASTM color & Total acid number

Stability of SP-10/SP-15 in long term use with R1234yf is not acceptable

Using SP-A2 with R1234yf

Ref	HFO-1234yf			
OIL	SP-A1		SP-A2	
Photograph				
Moisture	<200ppm	2000ppm	<200ppm	2000ppm
Temp.[℃]	175	175	175	175
ASTM	OK	OK	OK	OK
TAN [mgKOH/g]	OK	OK	OK	OK
Deposition	No	No	No	No

Long stability of SP-A2 oil is tested and result is acceptable and satisfies Sanden parameters

Using SP-A2 with R1234yf

Item	SP-10 (PAG1) For HFC-134a	SP-A2 For HFO-1234yf
Kinematic viscosity (40℃) [mm²/s] in accordance with DIN 51562-1 or ASTM D 445	44.25	42.14
Kinematic viscosity (100℃) [mm²/s] in accordance with DIN 51562-1 or ASTM D 445	9.89	9.42
Viscosity index pursuant to DIN ISO 2909	219	216
Acid number [mgKOH/g] TAN pursuant to DIN EN 12634	0.07	0.01>
Density [g/cm³] pursuant to DIN EN ISO 12185 at +15℃	1.0052	0.9882
Colour/ Appearance optionally pursuant to ASTM D 1500/ASTM D 6045/ DIN ISO 2049	L0.5	L0.5
Pour point [℃] pursuant to DIN ISO 3016	-40>	-40>

- SP-A2 oil is very similar to the current SP-10/SP-15 oil used with R134a

Using SP-A2 with R1234yf

PXE16 testing result (HFO-1234yf and SP-A2)

Acceptable condition of internal parts and comparable to SP-10 after testing with SP-A2 and R1234yf

R1234yf Impact –Compressor

- The new Sanden PAG oils (SP-A2) for R1234yf can be also used with R134a.
- The current Sanden SP10/ 15 oil cannot be used for R1234yf because the lack of long-term stability of the current oil.
- A Sanden compressor for R134a should not be installed in a system using R1234yf.
- We do not recommend to use R1234yf refrigerant in an R134a system due to the probability of remaining oil for R134a.
- Our coming products will be compatible with both R134a and R1234yf with the same level of quality and reliability.
- SAE standard J639 requires new label identifiers

Thank You