OIL IN REFRIGERATION SYSTEMS

INTRODUCTION

Until the phaseout of CFC refrigerants, mineral oils were the primary oils used in refrigeration systems. However, mineral oils are not suitable for use with the new refrigerants. The main reason for this incompatibility is the insufficient lubricity (lubricating ability) and miscibility(mixing ability) of mineral oils.

Much work has been done to find acceptable lubricants to use with the new refrigerants. Synthetic oils such as alkylbenzene and polyolester appear to meet the requirements.

As research into new refrigerants continues, so will the search for acceptable lubricants. Synthetic lubricants themselves are not new. They have been used for many years in various industries. As with other oils, lubricants are blended specifically for use in refrigeration systems. Until the phaseout of CFC refrigerants, such oils were considered too expensive for general use compared with mineral oil.

Oil producers and compressor manufacturers go to great lengths and expense to develop and test new lubricants. There are tests for viscosity, floc point, pour point, flash point, etc. The service engineer does not need to know the details of these oil qualities, but should understand the terms and why they are important. Remember, also, that you should use only the lubricant recommended by the compressor manufacturer.

PROPERTIES OF LUBRICATING OILS

Lubrication is the separation of moving parts by a film of oil. The closer the parts are to each other—that is, the tighter the fit—the more emphasis there must be on the role of lubrication. It is safe to say that all high-quality oils lubricate satisfactorily. Then what is so special about oil for refrigeration compressors? How does it differ from other oils? There is, in fact, a big difference. It is described by the following characteristics or properties:

- viscosity
- floc test
- dielectric strength
- neutralization number
- flash point
- fire point.

VISCOSITY

Viscosity means how thick or thin an oil is at a given temperature, and how readily it flows at that temperature. The oil becomes more "fluid" (it flows more easily) as the temperature increases, and more "viscous" (thick) at low temperatures. A standard of 100°F has been set as the temperature at which most oil viscosities are measured.

The importance of viscosity lies in the selection of a range that provides proper lubrication under all conditions. It must also allow for the diluting effect of the refrigerant. Refineries can supply viscosity ranges to meet any specification. When in doubt about proper oil viscosity, consult the manufacturer's recommendations.

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FLOC TEST

All mineral oils contain paraffin wax, some more than others. Even those that are called "wax-free" contain very small amounts of wax. The floc test determines the measurable temperature at which wax separates from an oil. The small amounts of wax in "wax-free" oils will settle out in a mass(flocculate)only when oil/refrigerant mixtures are at very low temperatures.

In general, the solubility of a material (its ability to be dissolved in a solvent) decreases as the temperature of the solvent decreases. In the same way, as the temperature of an oil/refrigerant mixture is lowered, the solubility of the paraffin wax decreases. If there is more wax present in an oil/refrigerant mixture than can remain in solution at a given temperature, precipitation will take place.

DIELECTRIC STRENGTH

Dielectric strength is a measure of the resistance of an oil to an electric current. It is expressed in thousands of volts (kilovolts, or kV) of electricity required to jump a gap of 0.1 in. between two poles immersed in the oil. Recommended dielectric strength is a minimum of 25 kV.

NEUTRALIZATION NUMBER

Neutrality is a difficult thing to visualize. Chemically, it is something that is neither alkaline nor acidic. The concept of neutrality may take on more meaning if you think of it in terms of drinking water. Household ammonia is alkaline, and vinegar is acidic. By contrast, ordinary drinking water is neutral. Nearly all lubricating oils contain materials of varied and uncertain chemical composition, which react with alkali. These substances are known as organic acids. They should not be confused with corrosive mineral acids,which are never found in properly refined oils. Mineral acids, if present, are detected by the neutralization number test. A low neutralization number indicates the absence of corrosive mineral acids.

FLASH POINT AND FIRE POINT

If you heat an oil in an open container and pass a small gas flame over the surface of the oil, at some point there will be a flash of fire on the surface as the oil vapor burns. The temperature at which this occurs is called the flash point. If you heat the oil further, it will reach a point at which it can be ignited and will continue to burn. This temperature is called the fire point.

SOLUBILITY

Oil in a refrigeration system must do more than simply meet the normal requirements of lubrication. It must be able to mix with the refrigerant and travel through the system. Therefore, you must consider the solubility relationships between refrigerants and oils. Refrigerants fall into three groups:

- Those that mix in all proportions with oil in the range of temperature operation. These include R-12, R-113, ethane, propane, isobutane, and the other hydrocarbons.
- Those that separate into two phases in the operating range, depending on temperature, pressure, and type base stock (chemical category) of the oil. These include R-21, R-22, R-114, and R-115.
- Those that are insoluble in oil in the operating temperature range. These include R-13, R-14, ammonia, and carbon dioxide.

Of the refrigerants listed in the last two groups, only ammonia and carbon dioxide are lighter than oil. They float on top when the oil/refrigerant mixture separates into two phases.

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Of the refrigerants that undergo phase separation during operation, only R-13 and R-22 have caused problems. These problems can be avoided through proper design. Several important factors help to keep oil from accumulating in the evaporator, which causes "oil logging." The factors include the following:

- proper evaporator design
- proper capacity balance with the compressor
- correct refrigerant line sizing
- avoidance of improper traps
- installation of properly designed traps.

High-side oil separators may help in some installations, especially low-temperature ones. Such separators are not 100% efficient, but they can keep the compressor from passing excessive amounts of oil to the evaporator.

R-13 OIL PROBLEMS

Pour point difficulties are encountered with R-13 when capillary tubes and expansion valves are used as flow control devices. (The pour point of an oil is the temperature at which it ceases to flow, because of high viscosity.)Field reports on R-13 indicate that there is less trouble with expansion valves. A low-viscosity oil (80 to 90 Saybolt Seconds Universal, or SSU) with a very low pour point may be the solution. R-13 is used as a replacement for ethane, often found in the low stage of low-temperature cascade systems.

R-22 OIL PROBLEMS

R-22 is more widely used than R-13. An oil in which R-22 is readily soluble has been the object of intensive research by manufacturers of condensing units. Solubility varies somewhat with the type base stock of the oil used. In low-temperature operations, many problems are caused by the oil being held up in the evaporator. The first indication in many cases has been the extensive damage to compressors caused by inadequate lubrication. The inadequate lubrication, in turn, is caused by insufficient oil return.

WHY DO PROBLEMS EXIST?

Oil is used in refrigeration systems to lubricate compressor bearings and other moving parts. The properties of the oil selected must be suitable for this purpose. In an automotive engine, motor oil stays in the crankcase where it belongs. If refrigerant oil did the same thing—that is, if it remained in the compressor crankcase—it would eliminate many oil-related problems in refrigeration systems.

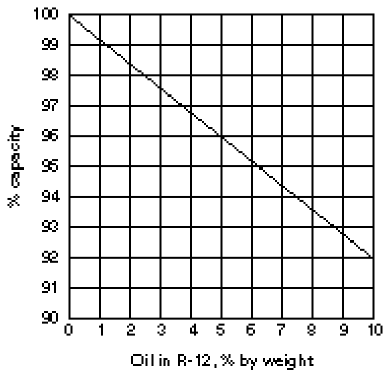

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FIGURE 1. LOSS OF CAPACITY WHEN OIL IS PRESENT IN R-12

However, in a refrigeration system, oil is carried through the compressor by the refrigerant. It circulates with the refrigerant throughout the system. A small amount of oil in circulation is not harmful. In fact, it may be of some benefit in lubricating valves, etc. Large amounts of oil, however, create problems. Consider the following four areas of concern.

First, oil circulating with the refrigerant is not in the compressor crankcase where it should be. This can be a major problem. A shortage of oil may develop in the crankcase. As a result, bearings and other parts may not be properly lubricated. Adding more oil after start-up to compensate is not a solution, because the amount of oil circulating with the refrigerant is not consistent throughout the system. Excess oil may accumulate in the evaporator and then return to the compressor in a slug. This could overfill the crankcase and possibly damage the compressor.

Second, excessive amounts of oil in an evaporator decrease the capacity of a system. Figure 1 shows the typical result in an R-12 system. Heat transfer through the coil wall decreases. The coil area is less if part of the space is occupied by oil. Both of these factors produce a larger temperature difference (TD) between load and evaporating refrigerant. Increased TD in the evaporator indicates a decrease in capacity. Capacity is further reduced to the extent that the vapor pressure of a refrigerant/oil solution is less than that of a refrigerant alone. If suction pressure controls the compressor, it stops running at a higher temperature when vapor pressure is reduced. If evaporating temperature controls the compressor, then it runs longer to maintain a given temperature when vapor pressure is reduced.

Third, oil in the refrigerant may cause restrictions in expansion valves or capillaries, and thus reduce refrigerant flow. Improvements in oil quality have greatly reduced this problem, but restrictions may still occur in unusual circumstances.

Finally, circulating oil may break down at hot spots in the system and cause varnishing and valve sticking. It may react with the refrigerant at high temperatures and form acids.

AMOUNT OF OIL CIRCULATED

In the field, it is hard to find out how much oil is circulating with the refrigerant. It helps to know the complete history of the equipment. On larger equipment, you can observe the oil level in the crankcase. However, if oil has been added, the crankcase level may not indicate the correct oil charge.

A loss of capacity might indicate excess oil in the evaporator. For example,a system operating with low capacity might return to normal after a brief shutdown, or after hot-gas defrosting. Oil in the evaporator might be blown out when the coil is warmer than normal. If this occurs, the result is a gradual loss in capacity until the coil warms up again.

OIL IN THE EVAPORATOR

Many oil-related problems are caused by oil collecting in the evaporator. You need to understand the properties of refrigerant/oil mixtures in this part of the system.

FACTORS AFFECTING OIL IN THE EVAPORATOR

When there is oil in the evaporator, three factors determine whether or not it stays there:

- the viscosity or fluidity of the oil
- the velocity of the refrigerant gas
- the geometry of the piping.

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Oil itself is quite fluid and has a relatively low viscosity at ordinary temperatures. At lower temperatures, the oil becomes more viscous. It becomes more difficult to pour or flow. At very low temperatures, it becomes solid. Whether refrigerant vapor can push oil out of the evaporator depends on how fluid or viscous the oil is. Remember that refrigerant itself has very low viscosity. Solutions of oil and refrigerant have a viscosity between that of the oil and that of the refrigerant. As more refrigerant dissolves in the oil, the solution becomes less viscous.

CHANGING CONDITIONS IN THE EVAPORATOR

Figure 2 shows some changes that take place in an evaporator. The diagrams are intended to illustrate conditions, not quantitative changes. The beginning of the evaporator coil is filled with liquid refrigerant. It contains a small amount of oil. It moves along the evaporator and evaporates, leaving oil behind. When liquid refrigerant evaporates, the temperature rises. When the temperature goes up, some of the refrigerant dissolved in the oil is forced out.

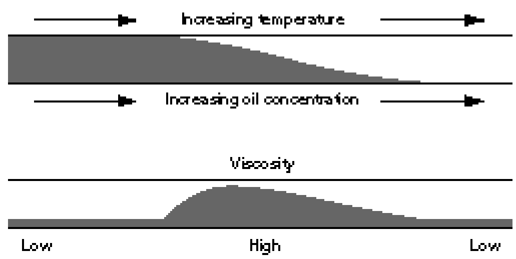

FIGURE 2. CHANGING CONDITIONS IN THE EVAPORATOR AND SUCTION LINE

The bottom diagram shows changes in viscosity at different points in the evaporator. At the inlet, the viscosity of a liquid refrigerant containing a small amount of oil is very low. When superheating begins, refrigerant evaporates from the oil. Viscosity begins to increase quite rapidly. At some point along the line, it reaches a maximum value. Then, viscosity slowly decreases as temperature rises. The location of this area of maximum viscosity is important. It is here that the velocity of refrigerant vapor must be able to push oil through the tube. It must push it to a place where higher temperatures make it more fluid.

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MEASUREMENTS OF VISCOSITY

The viscosities of solutions of a naphthionic base oil and various refrigerants have been measured under conditions similar to those found in an evaporator. Figure 3 shows the results with R-12, R-22, and R-502.

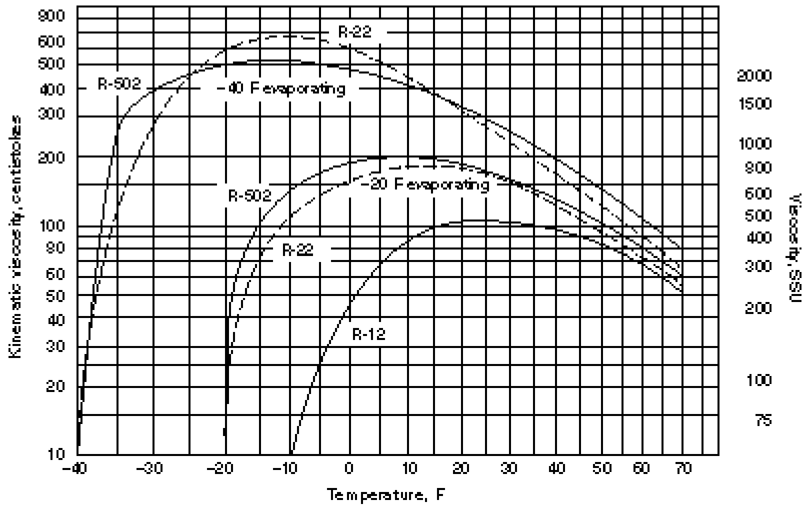

FIGURE 3. VISCOSITY CHANGES IN R-12, R-22, AND R-502

The viscosity of mixtures containing a large amount of refrigerant is very low. When the refrigerant has evaporated, the viscosity of the oil left behind rises rapidly. However, if the temperature continues to increase after the refrigerant has escaped from the oil, the oil will become more "fluid" (its viscosity will decrease). The curves in Figure 3 represent changes in viscosity when pressure remains constant. Such would be the case in the evaporator and suction line. Note that the point where viscosity is highest is never the coldest location. There is always enough refrigerant dissolved in oil at lower temperatures to affect viscosity. Also, viscosity is lower at higher pressures because more refrigerant is dissolved in the oil.

The effect of R-22 and R-502 on the viscosity of oil solutions is about equal. Solutions with R-12 have lower viscosities.

The curves in Figure 3 show quantitatively the viscosity changes represented in Figure 2. When liquid refrigerant is present, viscosity stays low, even at low temperatures. As soon as temperature rises (when superheating begins), viscosity goes up rapidly. For example, when evaporation is at −40°F, the oil viscosity has increased greatly by the time the gas temperature reaches −35°F. The point of highest viscosity is at a gas temperature of about −10°F for both R-22 and R-502. This corresponds to a superheat of 30°F.

You might assume that oil is most difficult to move in the coldest part of the evaporator, but these viscosity measurements show that this is not so. Refrigerant gas is more soluble in oil at low temperatures than at high temperatures at the same pressure—or, in other words, near saturation conditions. In many systems, the point of highest viscosity may be outside the evaporator. In this case, it would help to raise the suction-line temperature quickly. If a liquid-vapor heat exchanger is used, locate it close to the evaporator to keep superheat low.

SOLUBILITY OF REFRIGERANTS IN OIL

The viscosity of refrigerant/oil solutions relates to the solubility of the refrigerant in the oil. Relative solubilities of R-12, R-22,and R-502 are shown in Figure 4. Data are for the same evaporating

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temperature, but pressures are different. They correspond to the vapor pressure of the refrigerant at each temperature. Note that the solubility of R-22 is slightly higher than that of R-502 at −40°F. However, their solubilities are about the same when oil temperature rises. The solubility of R-12 in oil is far greater than in other refrigerants at low temperatures, and still higher when the oil is warm. This difference in solubility explains the lower viscosity found in R-12/ oil solutions and the better oil return usually found in R-12 systems.

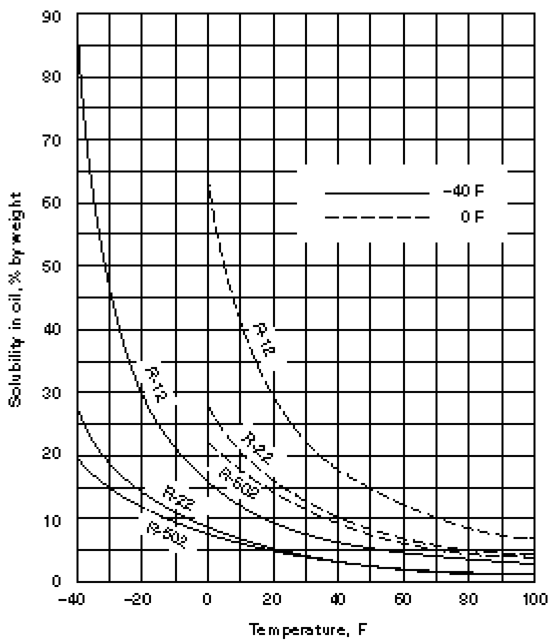

FIGURE 4. SOLUBILITY OF REFRIGERANTS IN OIL AT CONSTANT PRESSURE

It was noted earlier that some refrigerant/oil solutions separate into two liquid phases at low temperatures. Figure 5 shows examples of this for R-22 and R-502. Regarding oil return, the formation of two liquid phases is not important in a dry-type evaporator. The principal factor is the viscosity of the oil. And the viscosity of the oil, in turn, depends on the amount of refrigerant dissolved. With R-502, two liquid phases form at a far higher temperature than R-22. However, viscosities of their oil solutions are about the same. At −40°F, the oil phase contains about 20% R-502, or about 27% R-22, as shown in Figure 4.

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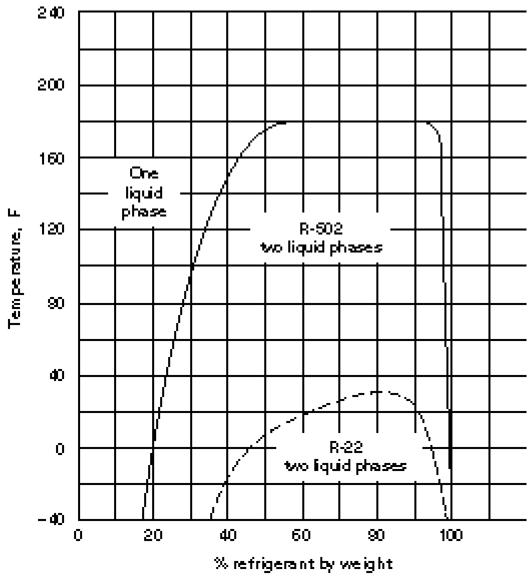

FIGURE 5. LIQUID PHASES OF R-22 AND R-502

In each case, enough refrigerant is dissolved in the oil to cause low viscosity.

In flooded evaporators, it is important whether or not two liquid phases form. If they do, the oil return must be handled differently than if the oil is completely miscible at low temperatures.

REDUCING THE AMOUNT OF OIL CIRCULATED

As noted earlier, the compressor may not be properly lubricated if too much oil circulates with the refrigerant. There may be a drop in capacity, as well as other problems. Knowledge of refrigerant/oil relationships at higher temperatures will help you find methods of keeping oil in the crankcase where it belongs.

PREVENTING REFRIGERANT BUILDUP IN THE CRANKCASE

Lubricating oil tends to dissolve appreciable amounts of refrigerants at temperatures found in the compressor crankcase. But the amounts vary for different refrigerants. For example, assume that you are looking at the differences in solubility of R-12, R-22, and R-502. At 85°F and 60 psig, a typical oil dissolves about 35% of R-12, 11% of R-22, and 7.5% of R-502 by weight. When a cold compressor % by weight is started, pressure drops rapidly and the temperature of the oil rises. As a result, the solubility of the refrigerant is sharply decreased. There will be a rush of gas out of the oil over a very short period of time. The drop in crankcase pressure causes oil foaming.

When this occurs, an excessive amount of oil may be carried with the refrigerant through and beyond the compressor. There is a good way to prevent refrigerant buildup in the crankcase—just be sure that the oil temperature is kept above that of the liquid refrigerant elsewhere in the system.

CRANKCASE HEATERS

A small electric heater immersed in the crankcase oil is often used to maintain adequate oil temperatures. The amount of refrigerant dissolved in crankcase oil depends on the temperature of the oil and the temperature of pure refrigerant elsewhere in the system. The temperature of liquid refrigerant determines its vapor pressure. Figure 6 shows these relationships and gives some examples.

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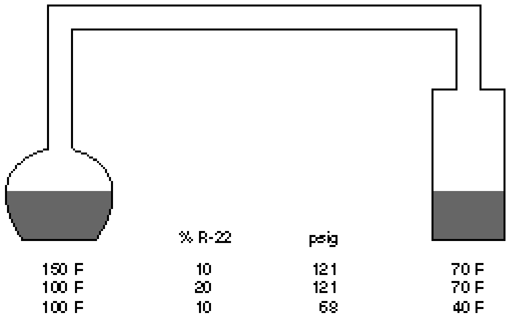

FIGURE 6. SOLUBILITY OF R-22 IN OIL

Example:

For example, if liquid R-22 is at 70°F and the pressure in the crankcase is the same as the vapor pressure of the refrigerant, the oil will contain 10% R-22 when the temperature is 150°F. Under the same conditions, the solubility of R-22 will be 20% when the oil temperature is 100°F. When liquid R-22 is 40°F with a vapor pressure of 68 psig, the solubility of the refrigerant will be 10% in oil at 100°F.

SOLUBILITY UNDER OPERATING

The ideal situation would be to maintain the temperature of the oil, when a system is shut down, so that the concentration of refrigerant is no greater than it is when the system is operating. Table 1 gives examples of oil/refrigerant relationships under operating conditions for R-12, R-22, and R-502. You can see that, in general, the concentration of refrigerant in oil is quite low. For a given refrigerant, the solubility decreases as the oil temperature increases. Solubility also is less at lower evaporating temperatures for the same oil temperature. Ideally, as noted above, it would be desirable to keep the refrigerant concentration in oil at these low levels while the system is idle.

Table 1. Solubility Of Refrigerants In Oil Under Operating Conditions, % By Weight

	Evaporating temperature					
	40°F			0°F		
Oil temperature, °F	R-12	R-22	R-502	R-12	R-22	R-502
100	15.0	9.7	8.2	6.1	3.9	3.7
150	7.6	5.4	4.4	3.3	2.3	2.1
200	4.6	3.5	3.8	2.0	1.5	1.8

In practice, it is not necessary to maintain these limits exactly. A small increase in refrigerant solubility will probably not lead to an excessive amount of oil carryover at start-up.

OIL TEMPERATURES

Oil at a certain temperature maintains refrigerant concentration at a given level when the supply of liquid refrigerant is at different temperatures. Figure 7 shows these temperatures for R-12. Figures 8 and 9 on the next page are for R-22 and R-502. The temperatures shown are those at which pure refrigerant, and oil with some dissolved refrigerant, have the same pressure.

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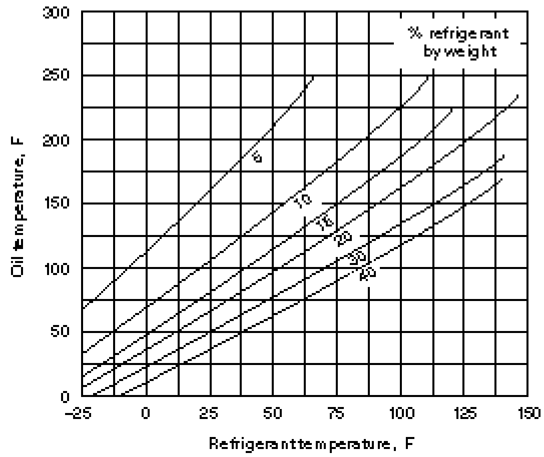

FIGURE 7. SOLUBILITY OF R-12 IN OIL

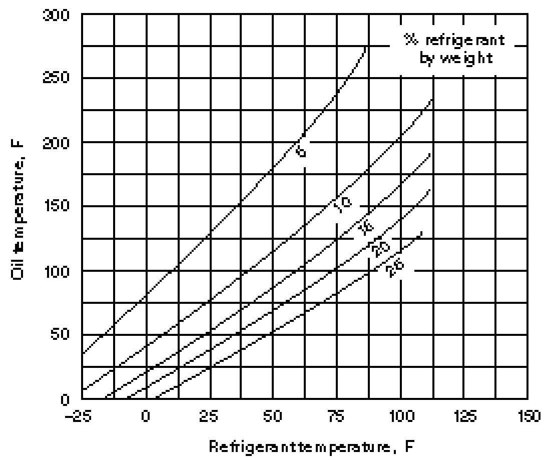

FIGURE 8. SOLUBILITY OF R-22 IN OIL

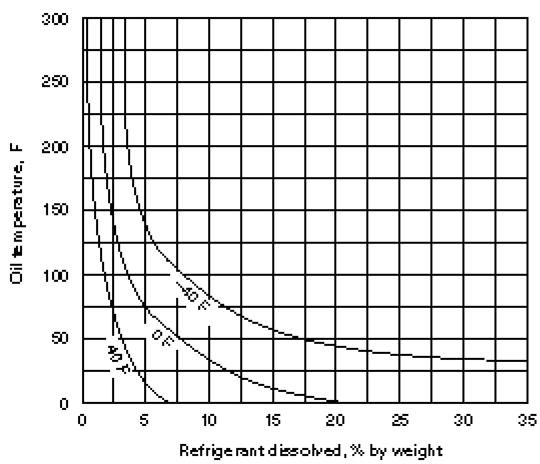

FIGURE 9. SOLUBILITY OF R-502 IN OIL AT DIFFERENT EVAPORATING TEMPERATURES

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Look at Figure 7 as an example. Assume that the evaporating temperature is 20°F and the oil temperature is 150°F while the system is operating. R-12 in the oil would be 5% by weight. To limit R-12 in the oil to 10% when the system has warmed up to 75°F, the oil must be kept at 185°F. If the oil temperature were held at 150°F, there would be, at most, 15% of R-12 in the oil. If not heated, the oil could reach the refrigerant temperature. Then, there would be as much as 50% of R-12 in the oil.

Oil temperature is usually higher than the condensing temperature while the system is running. The amount of refrigerant in the oil is low. When the compressor is idle, the oil cools down. Refrigerant concentration begins to increase. If the ambient temperature around the compressor is lower than elsewhere in the system, refrigerant rapidly transfers into the crankcase. In this situation, a crankcase heater is useful.

Refrigerant moves into the compressor even though the oil temperature is higher than that of the liquid refrigerant. However, it moves at a fairly slow rate. The rate depends on the following factors:

- temperature difference
- surface area of oil
- system layout.

Even here, a crankcase heater is useful in many cases. It is especially desirable if equipment is idle for a day or more at a time.

LOW-WATTAGE HEATERS

Oil temperatures of 200°F are seldom needed. In most cases, 140 to 150°F or less is adequate for R-12. Temperatures can be lower for R-22 and R-502 than for R-12 because of differences in solubility. It is better to use a low-wattage unit with an ON/OFF control. A continuous heater that holds oil at about 40°F above ambient temperature has been shown to increase operating temperatures by 1 or 2°F.

Crankcase heaters are usually part of the original compressor equipment. The manufacturer has determined the most effective size and location.

PUMP-DOWN CYCLE

In some cases, sealing off the compressor and evaporator from the rest of the system with a liquid-line solenoid valve keeps refrigerant from dissolving in oil. The evaporator and crankcase then can be pumped down before the compressor stops running. Very little refrigerant remains in the part of the system containing oil. The concentration of refrigerant dissolved in oil when the system is idle would be about the same or lower as when it runs. This is a direct, positive way to prevent refrigerant buildup in the crankcase during OFF cycles.

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REDUCING OIL FOAMING AND ENTRAINMENT

Assume that refrigerant concentration in the oil does increase greatly during OFF cycles. If this is the case, what can you do to reduce entrainment of oil by the refrigerant when the compressor starts? The following paragraphs will discuss four areas of consideration:

- compressor check valve
- antifoam agents
- mechanical construction
- oil separators.

COMPRESSOR CHECK VALVES

Some compressors have a check valve in the compressor crankcase. It is designed to close when the crankcase pressure is higher than the pressure in the suction line leading to the compressor cylinder. However, there is a small bleed line around or through the valve. It allows crankcase pressure to reduce gradually while the compressor is running. This avoids the sudden rush of refrigerant out of the oil. The amount of oil circulating with the refrigerant is greatly reduced.

ANTIFOAM AGENTS

Antifoam agents have been successful in many chemical processes and applications. They also have been used to reduce foaming in compressor crankcases.

MECHANICAL CONSTRUCTION

Compressor design and the mechanical condition of the equipment also affect oil entrainment. Internal baffling and arrangements to admit the refrigerant to the cylinder may be important. The condition of pistons and piston rings also has a bearing on the problem.

OIL SEPARATORS

Oil separators can effectively remove oil from refrigerant vapors. The oil removed usually collects at the bottom of the separator. From there, it is returned periodically to the crankcase. The relationships of solubility, pressure, and temperature between oil and refrigerant in the crankcase also apply here. Too much refrigerant can dissolve in oil and present a real problem when oil gets to the crankcase. The separator should be warm enough to keep oil at a higher temperature than the refrigerant in the condenser. For this reason, the oil separator should be close to the compressor. It might be good to insulate or heat the lower part of the separator.

SYNTHETIC LUBRICANTS

As noted previously, CFC refrigerants are completely miscible, or mixable, with mineral oils over the range of expected operating conditions. Mineral oil is not miscible with the new refrigerants. In fact, some studies show mineral oil separating in both the condenser and evaporator. This impedes flow and reduces efficiency. In some cases, lack of oil return to the compressor could cause premature compressor failure.

*Consult manufacturer for specific recommendations

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POLYOLESTER OILS

Refrigerant and compressor manufacturers have identified polyolester oils suitable for use with HFC replacement refrigerants. These oils are miscible with HFC refrigerants. They also are miscible with CFC and HCFC refrigerants. Polyolester oils may be used with any of these refrigerants. When you change the system oil, consult the compressor manufacturer about the proper polyolester oil to use. Table 2 and Table 3 are good examples of what is available.

TABLE 2. Typical data from a compressor manufacturer

CFC refrigerant	Source	Similar to	Application	ODP	HGWP	Glide	Components	Lubricant*	Comments
R-12	Many	—	LM	1.000	3.1	0F	12	MO or POE	Phaseout by 1996
R-502	Many	—	LM	0.330	3.75	<1.0F	22, 115	MO or POE	Phaseout by 1996

TABLE 2. Typical data from a compressor manufacturer

HCFC refrigerant	Source	Similar to	Appliation	ODP	HGWP	Glide	Components	Lubricant*	Comments
R-22	Many	—	LMH	0.055	0.34	0°F	22	MO or POE	Phaseout by 2020
R-401A	DuPont/Allied	R-12	MH	0.03	0.22	9.3°F	22, 152a, 124		Same as MP39
R-401B	DuPont/Allied	R-12	LM	0.035	0.24	8.8°F	22, 152a, 124	AB, MO[1]	Same as MP66
R-409A	ElfAtochem	R-12	LM	0.05	0.3	12.0°F	22, 124, 142b	POE, MO[2]	Same as FX56
								POE	
R-402A	DuPont	R-502	LM	0.02	0.63	2.8°F	125, 290, 22		Same as Suva® HP80
R-402B	DuPont	R-502	LM	0.03	0.49	2.9°F	125, 290, 22		Same as Suva® HP81
R-408A	ElfAtochem	R-502	LM	0.026	0.73	1.0°F	22, 125, 143a		Same as FX10

TABLE 2. Typical data from a compressor manufacturer

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HFC refrigerant	Source	Similar to	Application	ODP	HGWP	Glide	Components	Lubricant*	Comments
R-134a	Many	R-12	MH	0	0.28	0°F	Single	POE	OK above – 10°F evap.
R-407A	ICI	R-502	LM	0	0.49	8.7°F	32, 125, 134a	POE	Same as KLEA-60
R-407B	ICI	R-502	LM	0	0.7	5.3°F	32, 125, 134a	POE	Same as KLEA-61
R-507	Allied	R-502	LM	0	0.98	<1.0°F	125, 143a	POE	Same as Genetron® AZ-50
R-404A	Many	R-502	LM	0	0.94	<1.0°F	125, 143a, 134a	POE	Same as Suva® HP62, Forane® FX70
R-407C	DuPont/ ICI	R-22	MH	0	0.37	8.0°F	32, 125, 134a	POE	Similar pressure to R-22 (AC9000/KLEA 66)
R-410A	Allied	R-22	MH	0	0.44	<1.0°F	32, 125	POE	Higher pressure than R-22 (AZ-20)
Suva® 9100	DuPont	R-22	MH	0	0.49	<1.0°F	32, 125	POE	Higher pressure than R-22

*Lubricants:	MO = mineral oil (3GS or equivalent	AB	=	alkylbenzene (Zerol 200 TD)
	[1]AB (50+ %) + MO	POE	=	Mobil EAL™ Arctic 22CC
	[2]POE (50+ %) + MO		=	ICI EMKARATE™ RL 32CF

OIL IN REFRIGERATION SYSTEMS

TABLE 3. Accepted refrigerants/lubricants published by a compressor manufacturer

			Application		Lubricant choices			
	Refrigerants	**Source**	**Retrofit**	**New**	**Preferred**	**Alternate 1**	**Alternate 2**	**Comments**
Ozone-depleting	CFC R-12	Many	LM	LM	MO	AB, MO		Phaseout by 1996
	CFC R-502	Many	LM	LM	MO	AB, MO	POE	Phaseout by 1996
	HCFC R-22	Many	LMH	LMH	MO	AB, MO	POE	Phaseout by 2020
Interims	HCFC R-401A	DuPont/Allied	MH	N/A	AB, MO	POE, MO	POE	Service only Suva ® MP39
	HCFC R-401B	DuPont/Allied	LM	N/A	AB, MO	POE, MO	POE	Service only Suva ® MP66
	HCFC R-402A	DuPont	LM	N/A	AB, MO	POE, MO	POE	Service only Suva ® HP80
	HCFC R-408A	Atochem	LM	N/A	AB, MO	POE, MO	POE	Service only FX10
Non-ozone-depleting	HFC R-134a	Many	MH	MH	POE			Suva ® HP62,
	HFC R-404A	Many	LM	LM	POE			Forane ® FX70
	HFC R-507	Allied	LM	LM	POE			Genetron ® AZ50

MO = mineral oil (3GS or equivalent)

AB = alkylbenzene (Zerol 200 TD)

POE = Mobil EAL™ Arctic 22CC or ICI EMKARATE™ RL 32CF

POE, MO = minimum 50% POE

AB, MO = minimum 50% alkylbenzene (Shell 22-12)

NOTE:

Shell 2212 is a 70/30 mixture of AB and MO Zerol 200 TD is 100% AB

Polyolester oils, unlike mineral or alkylbenzene oils, are very hygroscopic. This means that they absorb moisture quickly. These oils come in metal containers to keep them as dry as possible. Exposure to the atmosphere must be kept to a minimum. Polyolester oils will typically saturate at 1,000 ppm moisture when exposed to the atmosphere. Compare this with about 100 ppm for mineral oils. Oils with a high moisture level can create problems in a refrigeration system.

OIL IN REFRIGERATION SYSTEMS

ALKYLBENZENE OILS

Alkylbenzene oils are similar to mineral oils, but are more miscible with CFC and HCFC refrigerants. They are often recommended for systems using HCFC refrigerants. This particularly applies in low-temperature applications, where oil miscibility is more of an issue.

Alkylbenzene oils are also preferred with some of the HCFC replacement refrigerants. In using these oils to convert to an HCFC refrigerant, you may not have to remove all the mineral oil from the system. Mixing an alkylbenzene oil with mineral oil is generally not a problem. Consult the compressor manufacturer for more information.

REMOVING OIL FROM A SYSTE

Normally, you remove oil from a system by draining it from the compressor crankcase. You then replace the mineral oil (or alkylbenzene oil) removed with the appropriate polyolester oil. But remember that the system oil charge is not located entirely in the compressor. A small amount of residual oil remains in the system. The usual procedure is to keep changing the oil until the level of mineral or alkylbenzene oil is less than 5% of the total oil charge. This level often can be reached by changing the oil three times. Consult the compressor manufacturer for up-to-date information. Get into the habit of changing the filter-drier with each oil change. It is a good idea to change the filter-drier anytime the system has been opened.

There are devices that measure the percentage of mineral oil in a system. One is a refractometer. It measures the refractive index of the oil. If you know the refractive index of the polyolester oil and the mineral or alkylbenzene oil, you can figure the oil mixture ratio.

You must drain the oil from systems that use oil separators, oil reservoirs, oil level controls, and accumulators. In systems with reclaim condenser coils, run the system in both normal and reclaim modes. This ensures that oil is removed from both the normal and reclaim coils.

Removing oil from systems with hermetic compressors can be difficult. There is usually no simple means for draining the system oil. For these systems, refrigerant conversion is often done only when the compressor must be replaced.

RETROFITS

The type of system determines which new refrigerant to choose for a retrofit. This, in turn, determines which lubricant to use, and how critical the effect of residual mineral oil is. Table 4 shows that one oil change is enough for R-401A and R-401B retrofits with alkylbenzene as the new lubricant. A retrofit with R-134A and polyolester lubricant requires a minimum of three oil changes (flushes).

OIL IN REFRIGERATION SYSTEMS

Table 4 Quick Reference To Replacements For R-12 And R-502 With Suva® Refrigerants

R-12 replacements	Applications*	Retrofit notes
Suva MP39 (R-401A)	Commercial retrofits above −10°F (−23°C) evaporator	One oil change required Use alkylbenzene lubricant Better capacity than R-12
Suva MP66 (R-401B)	Commercial retrofits below −10°F (−23°C) evaporator Some truck/trailer retrofits	One oil change required Use alkyl benzene lubricant
Suva 134a (R-134a)	All new equipment Retrofits above 20°F (−7°C) evaporator	Minimum of three oil changes required Use polyolester lubricant Lower capacity than R-12 below 20°F (−7°C) evaporator
R-502 replacements	**Applications***	**Retrofit notes**
Suva HP80 (R-402A)	All commercial retrofits	One oil change required Use alkylbenzene lubricant Better capacity than R-502
Suva HP81 (R-402B)	Retrofits of ice machines and other self-contained equipment New ice machines	One oil change required Use alkylbenzene lubricant Better efficiency than R-502
Suva HP62 (R-404a)	All new equipment All commercial retrofits	Minimum of three oil changes required Use polyolester lubricant Lower discharge temperature than R-502

There are several test instruments available today that can help you determine the level of residual mineral oil remaining in a system after flushing. One such instrument, called a Retrocheck® test kit, is a go/no-go test that can be used when converting to HFC refrigerants.

HANDLING

All refrigerant oils absorb moisture when they are exposed to the atmosphere. However, synthetic oils are very hygroscopic-they absorb many more times the amount of moisture than mineral oils do-and as a result you must exercise special care when changing a system or transferring such lubricants from one container to another. Do not store polyolesters in plastic containers. Polyolesters can actually absorb moisture through the walls of a plastic container. Always follow the manufacturer's instructions.