



NEWS

Danfoss Commercial Compressors

R22 retrofit

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Introduction

Many of us have experienced the phase-out of R12 and R502 in the nineties. And now the same is happening with R22. Starting from 1st January 2010, the use of virgin R22 refrigerant is no longer allowed in the European Union.

The use of R22 in new installations in Europe already stopped in 2000. Manufacturers of air conditioning equipment mainly made the choice for R407C because of its better performance at high ambient temperature. Manufacturers of refrigeration systems mainly switched to R404A or R507 which are better suitable at low and medium temperature without showing significant glide.

Many older systems however, still contain R22; either as a pure refrigerant or as a component of blends for earlier R12 or R502 retrofits. For servicing of these installations after 1st January 2010, the use of virgin R22 is no longer allowed. It's not recommended to rely on recycled R22 for which availability is likely to be lower than the demands.

Below list shows several R22 alternatives proposed by refrigerant manufacturers. Some of these alternatives are already in use for a while and the industry has built up experience with these. Others are relatively new but could be valid candidates as well.

Trade name	ASHRAE number	Components [%]									Retrofit or drop-in for
		HFCs				Hydrocarbons					
		R32	R125	R134a	R143a	R218	R290	R600	R600a	R601a	
R-404A	404A		44	4	52						R22
R-507	507		50		50						
AC9000	407C	23	25	52							
Forane 427A	427A	15	25	50	10						
Isceon 59	417A		46.6	50				3.4			
RS-44	424A		50.5	47				1	0.9	0.6	
Icor XAC1	422B		55	42					3		
RS-45	434A		63.2	16	18				2.8		
Isceon MO29	422D		65.1	31.5					3.4		
RS-52	428A		77.5		20		0.6		1.9		
Icor XLT1	422C		82	15					3		R402, R403, R408A
Isceon MO79	422A		85.1	11.5					3.4		
RS-24	426A		5.1	93				1.3	0.6		FX56, R409A, R12
R-413A	413A		88			9		3			

Note: The listed blends containing hydrocarbons are generally promoted as 'drop-in' solutions. However the hydrocarbon component allows only for partial miscibility with mineral oil. For some applications this will not be enough and correc-

tive actions to reach satisfactory running conditions may require the use of POE oil. Because POE oil is fully miscible with the listed blends, Danfoss strongly recommends the use of POE oil at any retrofit to one of the listed blends.

Decision criteria before starting

When a retrofit or drop-in is planned for a system with R22 and mineral oil, the following criteria shall be considered;

1. First of all, make a thorough analysis of the installation and the costs of a retrofit. Take into account the age of the installation and its main components. Estimate how long the installation could still run and which components may require soon replacement. This can strongly influence the choice for the best retrofit process.
2. Take into account that the retrofit will lead to reduced cooling capacity. This is partly due to the thermodynamic properties of the refrigerant. Further the large glide of some blends can reduce the heat exchanger capacity up to 7 %. Partial miscibility of the blend with the oil can affect the heat exchanger capacity with another 5 %. The decrease in cooling capacity can have different consequences:
 - In some cases, such as cold rooms, it can easily be compensated by increased running time.
 - Some other applications, such as beer coolers and ice makers, require instantaneous capacity. These applications usually don't allow for significant capacity loss.
 - Finally there are applications, such as bottle coolers and milk tanks, which are designed to comply with performance specifications. A retrofit may cause these systems to work out of their specifications.

3. The new refrigerant and oil may affect the system in some ways:
 - The combination of POE oil with HFC refrigerant has a great cleaning effect on old circuits used with mineral oil and HCFC. Carbon deposits can be washed away quickly and block filters or pollute the oil. It may be necessary to replace the filter and/or the oil a short while after the retrofit.
 - POE oil with HFC refrigerant requires a low residual moisture level of 100 ppm. Procedures, components and tools must be of high quality to obtain this level.
 - Some gaskets can be sensitive to POE oil and HFC and need to be replaced to avoid leakage.
4. The 'standard rules' don't apply to some specific applications:
 - A drop-in solution may never be applied to installations with a receiver. Due to reduced miscibility of HFC with mineral oil, a part of the oil can accumulate on top of the refrigerant in the receiver, starving the sump.
 - Installations with flooded heat exchangers, such as tube-&-shell require refrigerants with negligible glide such as R404A or R507. Blends with a large glide shall not be applied.

Retrofit and drop-in scenarios

Danfoss has evaluated different scenarios for retrofit and drop-in, which are listed in below tables. 4 procedures are considered:

1. Drop-in: The HCFC refrigerant is replaced by an alternative refrigerant without any additional change other than labelling the new refrigerant name and quantity.
2. Light retrofit: The oil and filter drier are replaced

3. Standard retrofit: As a light retrofit but with a second oil change
4. Heavy retrofit: The circuit is flushed and the expansion device is changed. Oil and filter drier are changed. In this case it's often the best option to replace the compressor as well.

Air conditioning applications with R22 and mineral oil

Application	Expansion device	New refrigerant	Procedure	Capacity loss	Comments
All	Capillary	R417A	Drop-in	25%	No change on capillary
		R417A	Light retrofit	20%	
		R427A	Standard retrofit	10%	
		R407C	Heavy retrofit	5%	
Windows PTAC Single split	Thermostatic expansion valve (TXV)	R417A	Drop-in	25%	Application without receiver
		R422D	Drop-in	15%	Adjust the TXV
		R422D	Light retrofit	10%	
		R427A	Light retrofit	10%	
		R407C	Heavy retrofit	5%	
Different from above	Thermostatic expansion valve (TXV)	R422D	Light retrofit	10%	Adjust the TXV
		R427A	Standard retrofit	10%	
		R407C	Heavy retrofit	5%	

Refrigeration applications with R22 and mineral oil

Application	Expansion device	New refrigerant	Procedure	Capacity loss	Comments
All	Capillary	R417A	Drop-in	25%	No change on capillary
		R417A	Light retrofit	20%	
		R427A	Standard retrofit	15%	
		R404A	Heavy retrofit	5%	Capillary - 20 %
Packaged unit	Thermostatic expansion valve (TXV)	R417A	Drop-in	25%	Application without receiver
		R422D	Drop-in	20%	Adjust the TXV
		R422D	Light retrofit	15%	
		R427A	Light retrofit	10%	
		R422A*	Heavy retrofit	5%	Replace the TXV
		R404A	Heavy retrofit	5%	
Different from above	Thermostatic expansion valve (TXV)	R422D	Light retrofit	15%	Adjust the TXV
		R427A	Standard retrofit	10%	Replace the TXV
		R422A*	Heavy retrofit	5%	
		R40AA	Heavy retrofit	3%	

* R422A provide high performance for commercial refrigerated warehouses and ice makers

Some blends listed in the first table were not evaluated. Their application and capacity loss could be estimated according their composition compared to the evaluated blends. For example; R422B is in between R422D and R417A.

R404A, R507 & R422A will lead to higher superheat (10K) with no possibility to adjust the setting.

R407C, R427A & R417A will lead to lower superheat with possibility to adjust the setting.

Effect on expansion device: The thermostatic expansion valve in the system is designed to work with R22. When applied with one of the blends this will lead to following consequences:

R422D will lead to lower superheat with possibility to adjust the setting. 20% more capacity is needed from the TXV.

Retrofit process

The step-by-step retrofit process has been described in many publications and can be considered as known practice. Only a few points need to be highlighted:

Remaining mineral oil quantity :

System cleanliness is the essential parameter in a retrofit process and is of much higher importance than the exact quantity of remaining mineral oil. Although some publications recommend a remaining mineral oil quantity of less than 2 %, common sense and experience indicate that the system performance and reliability is not immediately compromised at higher levels of mineral oil remaining. In fact, the amount of remaining mineral oil can often serve as a global indication for system cleanliness.

Component replacements:

- Gaskets: Replace gaskets to new ones to avoid leaks (for example O-rings used on solenoid valves),
- Filter drier: Apply a molecular sieve filter drier to obtain less than 100 ppm moisture,

- Sight glass: Apply a sight glass dedicated to HFC refrigerants,
- Safety valves: Replace safety valves when required for new maximum working pressures,

Adjustments :

- Control devices: New pressure and temperature settings,
- Safety devices: New pressure and temperature settings,
- Expansion valve: Adjust superheat setting (use the Saturated Suction Temperature at dew point).

New components on large circuits

- Oil separator
- Suction line filter

In case an R22 compressor with mineral oil should break down before the phase-out date, it's strongly recommended to replace it by an equivalent compressor for HFCs charged with POE oil. Perform a heavy retrofit on the system and charge with R404A, R507 or R407C as marked on the nameplate.

Conclusion

Apart from a few cases allowing a drop-in solution, virtually all R22 retrofit procedures require the use of POE oil. Potential system contaminants that were not an issue with mineral oil could become an issue due to the cleansing properties inherent to POE oils. And these contaminants could end up compromising the performance or reliability of TXV, filter drier, and compressor. Also moisture level and leakage risks must be consid-

ered. One shall never economize on the retrofit process. Perform a heavy retrofit whenever possible and always apply the recommended component replacements and adjustments.

Note: The above scenarios and conclusion focus on systems with mineral oil with an oil change to POE. Most of this will be valid as well for alkylbenzene oil instead of mineral and PVE oil instead of POE.