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# **DIFFERENTIAL SOLUBILISATION OF HFC BLENDS IN POE OILS AND INFLUENCE ON SYSTEMS PERFORMANCE**

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## **ABSTRACT**

HFC blends are now accepted worldwide by the refrigeration and A/C market to replace CFCs and HCFCs. They are mostly composed by two or three refrigerants, each of them having a different behaviour with lubricants in terms of solubility.

Consequently, a test procedure has been developed to determine the solubility curves for refrigerant and oil mixtures as well as the differential solubilisation of blend components in lubricants. It is important to evaluate their behaviour since differential solubility may lead to a composition shift in the system.

This paper intends to show that there is no impact of composition shift on systems performance with R-22 substitutes.

## **I - INTRODUCTION**

In most countries, CFCs (ChloroFluoroCarbons) are now banned and HCFCs (HydroChloroFluoro Carbons) that helped their phase out will be soon subject to restrictions. For example, in Sweden R-22 is already forbidden in new equipment and this will also occur in Germany and some other countries in 2000.

To face their phase out, HFCs (HydroFluoroCarbons) have been developed. As these refrigerants are not fully compatible/miscible with standard mineral and Alkylbenzene oils, Polyolester (POE) lubricant are now available to be used in refrigerating and air conditioning systems.

Each component of a refrigerant blend has a different behaviour with the oil and therefore differential solubilisation of the refrigerant blend into the oil may occur.

This paper intends to describe this phenomenon with R-22 substitutes (R-410A and R-407C) and the potential impact on systems' performance.

## II - SOLUBILITY

### 2.1. Experimental procedure

The solubility in oil of a refrigerant is determined by plotting the pressure of the blends in front of the weight percent of fluid in oil.

In the case of a totally miscible blend, a single phase exists and consequently the pressure will decrease steadily when adding the oil.

On the contrary, with partially or non miscible blend, the pressure decrease corresponds to the fluid solubilisation in oil : the pressure remains constant until the fluid started to solubilize into the oil as shown on Figure 1.

### 2.2. Solubility of pure components

R-407C is a blend of R-32, R-125, R-134a at 23, 25,52 weight % and R-410A is composed by R-32, R-125 at 50/50 %. Therefore solubility of two different POE oils with R-32, R-125 and R-134a alone was measured. POE 1 is fully miscible with HFCs whereas POE 2 is only partially miscible. The results are plotted in Figure 2 and Figure 3. It can be observed that each single component has a different behaviour with the same lubricant. In both cases, R-32 is less soluble than R-134a which is less soluble than R-125.

During the procedure, the pressure is taken when it reaches a constant value after stopping the agitation. Time to reach the equilibrium was strongly depending on the refrigerant. The equilibrium pressure was reached much quickly with R-32 than with R-125 for example which means that even if the solubility of R-125 is higher compared to R-32 the speed of solubilisation is lower.

Due to these two opposite phenomena, the global behaviour of refrigerant blend is not predictable and therefore we investigated it.

### 2.3. Solubility of blends

#### 2.3.1. R-410A

R-410A was first studied to check the different behaviour of R-32 and R-125, in presence of POE 2.

### ***a) Evolution of the vapour phase***

During the experiment the vapour phase was sampled and analysed to check its composition.

It can be pointed out as shown in Figure 4 that R-32 is continuously decreasing when adding oil to the cell. In parallel the R-125 content increases this means that even if R-125 has a better solubility in comparison to R-32, the solubilisation is too slow and R-32 saturates the oil before R-125 has the possibility to get in.

### ***b) Evolution of the liquid phase***

On the same figure we plotted the composition evolution of R-410A in the liquid phase.

POE 2 is partially miscible that is to say that miscibility is obtained after adding a certain amount of lubricant in the refrigerant/lubricant mixture.

On Figure 5 where the decrease of pressure vs weight % of refrigerant in the mixture is reported, the miscibility point is obtained when the pressure is quickly decreasing. This happens at about 40 weight %. At this point the liquid phase that is sampled contains 40 % of refrigerant and of 60 % lubricant. The refrigerant content is vaporised and analysed and there is a significant increase in R-32 content due to the solubilisation of R-32 from the vapour phase in the oil. Before this point (higher content of R-410A in the mixture) R-32 and R-125 content in the refrigerant keep the same composition which tends to mean that there is no or low solubilisation from the liquid phase.

### **2.3.2. R-407C**

R-407C was then studied to identify the impact of adding a third component i.e. R-134a.

### ***a) Evolution of the vapour phase***

In this case the content of R-32 is also decreasing as R-125 stays constant and R-134a is increasing. This means that, as before, R-32 has the quickest solubilisation into the oil followed by R-125 and R-134a.

### ***b) Evolution of the liquid phase***

As it was expected from the vapour phase evolution, the content of R-125 stays constant during the experiment as after reaching the miscibility mixture, around 40 % of refrigerant in the oil refrigerant mixture, R-32 content increases and R-134a decreases following the same explanation as the binary refrigerant R-410A.

### III - REFRIGERANTS PERFORMANCES

The previous study showed that the oil has an impact on the composition of the refrigerant in the vapour phase.

The maximum variations for R-410A and R-407C with POE 2 are shown in the following table.

	R-32	R-125	R-134a
R-410A	-0,81 %	+0,81 %	-
R-407C	-1,81 %	-0,05 %	+1,86 %

The ASHRAE composition tolerances from the ASHRAE standard ANSI/ASHRAE 34-1992 are the following :

R-407C : R-32/125/134a ( $\pm 2/\pm 2/\pm 2$ )

R-410A : R-32/125 (+0,5 ; - 1,5/- 0,5 ; + 1,5)

Therefore the composition change that may occur in the system are within the tolerance.

It must also be pointed out that these composition changes are reached at the equilibrium at 20°C. In a system the location where the oil and the refrigerant are in contact, with a high percentage of oil, is the compressor but usually the temperature of the oil would be higher than 20°C allowing less refrigerant to solubilise. Therefore the composition changes described in the previous table are critical.

As these are low, it won't have any impact on systems' performance.

### IV - CONCLUSION

This study showed the effect of differential solubilisation of the refrigerant in the oil on the composition of two R-22 alternatives : R-410A and R-407C.

Even if there is a composition shift, it remains in the tolerances of the refrigerant composition and therefore won't affect the systems' performance.

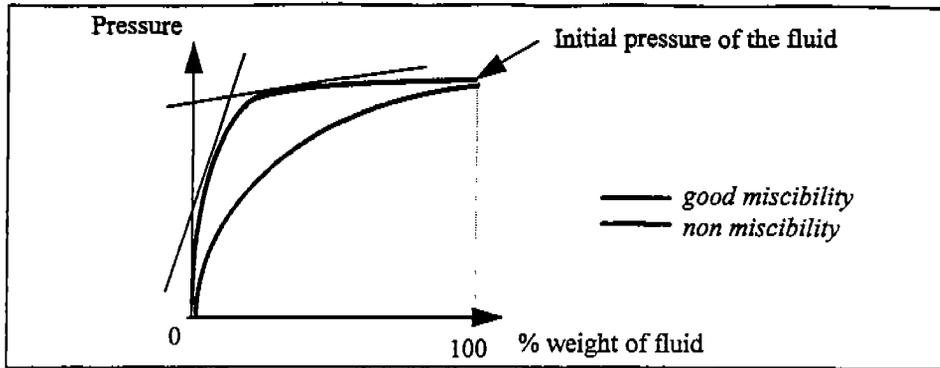


Figure 1 : Pressure evolution of the oil/fluid blend

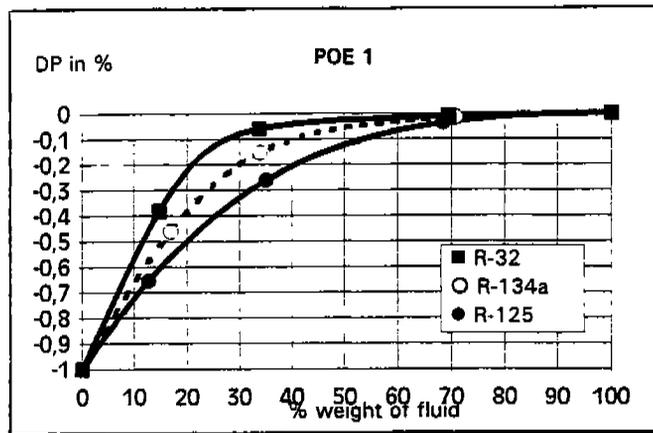


Figure 2 : Comparative miscibility of single components with POE 1 oil

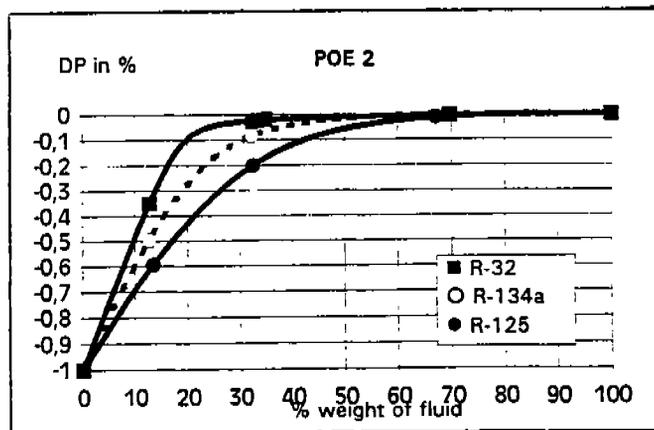


Figure 3 : Comparative miscibility of single components with POE 2 oil

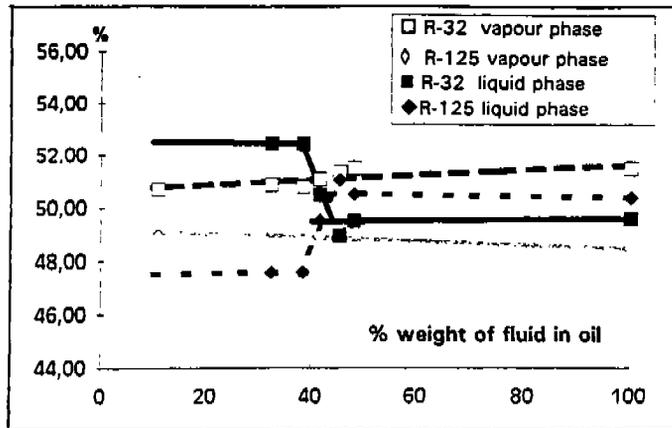


Figure 4 : Composition evolution of R-410A in the vapour and liquid phase in presence of POE 2

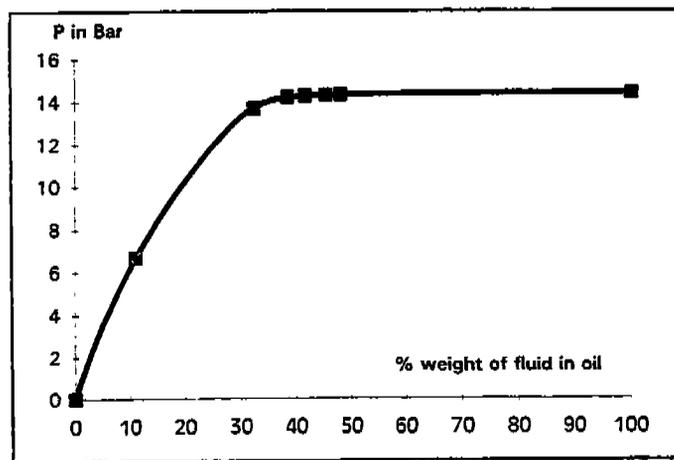


Figure 5 : Pressure evolution of R-410A in presence of POE 2