

MORE ABOUT

The replacement of CFCs in refrigeration and air conditioning is already effective on the field. The regulation on ozone depleting substances will also lead to the replacement of HCFCs including R-22. Moreover, more severe restrictions on the use of HCFCs for new installations already apply in the European Union (regulation # 2037/2000).

Arkema is now offering a complete range of HFC type substitutes with no effect on the ozone layer. Among them, FORANE[®] 407C has been chosen to replace R-22 in air-conditioning applications, from low to mid-power ranges.

FORANE[®] 407C possesses thermodynamic properties which match quite well those of R-22. It can be used with either reciprocating or rotating compressors, in association with a polyolester type of lubricant, like other HFCs. The level of performance achieved with FORANE[®] 407C is very close that of R-22.

CHARACTERISTICS

FORANE[®] 407C is a ternary blend of pure HFC molecules.

Rigorous specifications are warranted by Arkema (composition, water content, etc.). Furthermore, the product is non-toxic and non-flammable, according to the most severe safety standards, as defined in the USA by Underwriters Laboratories (UL) and ASHRAE.

REFERENCES

FORANE[®] 407C has already been chosen to replace R-22 by major equipment manufacturers across the world and especially in Europe. It is being used in all type of comfort air-conditioning equipment (split-systems, packaged A/C, or water chillers).

Properties	Units	R-22	FORANE [®] 407C
Components	-	HCFC-22	HFC-32, 125, 134a
Composition	% weight	-	23/25/52
Molecular weight	g/mol	86.5	86.2
Bubble temperature (at 1,013 bar a)	°C	-40.7	-43.4
Temperature glide (at 1,013 bar a)	K	0	7.2
Saturated liquid density (25°C)	kg/dm ³	1.194	1.139
Saturated vapour density (at 1,013 bar a)	kg/m ³	4.70	4.56
Critical temperature	°C	96	86.2
Critical pressure	bar	49.8	46.2
Critical density	kg/m ³	0.525	0.511
Latent heat of vaporisation (at 1,013 bar a)	kJ/kg	233.7	249.9
Specific heat at 25°C • liquid • vapour (at 1,013 bar a)	kJ/(kg.K) kJ/(kg.K)	1.26 0.662	1.6 0.83
Flammability limits in air		none	none
ODP		0.055	0

FORANE[®] 407C

When to replace R-22?

Montreal Protocol calls for a progressive reduction of the quantities of HCFCs being introduced on the market with a schedule depending on the countries. For existing installations, R-22 remains available for service purposes for several years even in Europe where the strictest regulations apply.

For new installations, usage restrictions exist in Europe according to regulation EU 2037/2000 depending on the equipment type. As a consequence, the choice of using FORANE[®] 407C has been made by several major OEMs.

What does R-407C mean?

This number has been given by the American standard, ASHRAE 34, and it defines precisely the

nature and composition of the blend (see front page), as well as the manufacturing specifications.

What are the application fields for FORANE[®] 407C?

FORANE[®] 407C is formulated to replace R-22 in comfort air-conditioning, from 1 to several hundreds of kW cooling capacity, as well as in heat pumps.

FORANE[®] 407C should not be used in refrigeration, because of the cooling power drop relative to R-22 (and to R-502) when moving toward medium and low temperature applications.

Are there other replacements of R-22 in refrigeration and A/C?

Since 1994-1995, in low and medium temperature refrigeration applications, R-22 (and R-502) has been successfully replaced by FORANE[®] 404A (FX 70) or by FORANE[®] 507 with specific technical benefits.

In air-conditioning, FORANE[®] 134a is of course primarily a substitute of R-12 (mobile A/C, turbo-compressors...), but it also serves as a R-22

alternative for equipment with relatively large refrigerating power (from one hundred kW). Furthermore, high pressure refrigerants, such as FORANE[®] 410A will play a role alongside FORANE[®] 407C, most probably for small equipment (residential type). However, some high-pressure components required by R-410A are not fully available yet.

What are the main advantages of FORANE[®] 407C?

The vapour pressure curve and the volumetric enthalpy of FORANE[®] 407C are very similar to those of R-22. This is a great advantage because it means that FORANE[®] 407C can be used in many instances with equipment originally designed for R-22.

Furthermore, it is possible to benefit from the glide of FORANE[®] 407C to increase systems energy efficiency, for example by using counter-flow design for the heat exchangers (see also page 4). This is being done through the so-called "soft-optimisation" of different types of systems (split-systems, water-chillers...).

QUESTIONS AND ANSWERS

Can FORANE® 407C be used as a R-22 retrofit refrigerant?

A retrofit from R-22 to FORANE® 407C is possible in many cases in terms of material compatibility -with some modifications- but one has to change the original mineral or alkylbenzene oil to a

polyolester type, through oil flushes, just like when changing from R-502 to FORANE® 404A, or from R-12 to FORANE® 134a.

Are there usage limitations associated with FORANE® 407C?

R-407C should not be used with flooded type evaporators, because of its zeotropic character. For

performance reasons, it is also preferable to use inside-tube or plate condensers.

How should FORANE® 407C be charged into the installation?

The optimum weight of R-407C to be filled is approx. 5% lower than with R-22, for an equivalent type of equipment.

Like all blends, FORANE® 407C must be charged from the liquid phase.

Is it possible to top up the fluid charge during servicing?

YES.

Because the leakage rate of all air-conditioning equipment is very moderate (a few % per annum), there is no significant risk of composition change for the product inside the installation.

A noticeable composition change will only occur if there is a large accidental leak, where both vapour

and liquid refrigerant are present at the same time. One may then observe a drop in pressure and refrigeration power due to refrigerant loss. Should this be the case, it will be necessary to empty the installation and make a complete refill.

Is FORANE® 407C a long term refrigerant?

YES.

This fluid is not subject to any regulation. Furthermore, it is the refrigerant which currently satisfies the technical requirements of equipment manufacturers (reliability and performance) for a large range of comfort A/C systems (1 to over 100

kW...). This is necessary to comply for instance with the European regulations, which already forbid the use of R-22 in most new installations.

SATURATION TABLE

PRESSURE (bar a)	TEMPERATURE (°C)	
	Saturated vapour	Saturated liquid
2	-21.3	-27.9
2.4	-16.9	-23.3
2.8	-13.3	-19.3
3.2	-9.6	-15.7
3.4	-8.0	-14.1
3.6	-6.5	-12.5
3.7	-5.7	-11.7
3.8	-5.0	-11.0
3.9	-4.3	-10.2
4	-3.6	-9.5
4.1	-2.9	-8.8
4.2	-2.2	-8.1
4.3	-1.6	-7.4
4.4	-0.9	-6.8
4.6	0.3	-5.5
4.8	1.6	-4.2
5	2.8	-3.0
5.2	3.9	-1.8
5.4	5.0	-0.7
5.6	6.1	0.5
5.8	7.2	1.5
6	8.2	2.6
6.4	10.2	4.6
6.8	12.1	6.6
7.2	13.9	8.4
7.6	15.7	10.2
8	17.4	11.9
9	21.3	15.9
10	24.9	19.5
11	28.3	22.9
12	31.4	26.1
13	34.3	29.1
14	37.1	31.9
15	39.7	34.5
16	42.2	37.1
17	44.5	39.5
18	46.8	41.8
19	48.9	44.0
20	51.0	46.2
21	53.0	48.2
22	54.9	50.2
23	56.7	52.1
24	58.5	54.0
25	60.2	55.8
26	61.8	57.9

PERFORMANCE COMPARISON

This performance comparison corresponds to a thermodynamic model, calculated using FORANE[®] software available free of charge on FORANE[®] pages (www.forane.com) of our web site.

Standard cycle:

5°C/40°C, suction 18 °C, sub cooling 5 K.

%/R-22	FORANE [®] 407C
Refrigerating capacity	101 %
Energy efficiency (COP)	98 %

IMPROVING PERFORMANCE WITH FORANE[®] 407C

The real, practical level of performance observed with FORANE[®] 407C when compared to R-22 depends on the type of equipment being considered.

The partial or total counter-flow configuration will allow, by taking the temperature glide effect into account, a reduction in the mean temperature difference between the refrigerant and the outside (air or water). This causes an important increase in systems' efficiency. This is most notably illustrated in the case of compact water-chillers fitted with brazed plate heat exchangers.

Furthermore, the possible use of an internal heat exchanger in the refrigeration circuit brings a much more significant increase of performance when looking at FORANE[®] 407C compared to R-22, because of the higher liquid specific heat capacity of R-407C.

Moreover, considering the constant improvements in technologies, there is no doubt that new FORANE[®] 407C equipments will soon outperform older R-22 types.

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Arkema - 4/8, cours Michelet - 92800 Puteaux (France) - Tél. : (33) 1 49 00 76 50 - Fax : (33) 1 49 00 53 12

www.Arkema.com