

## Replacements for R404A

Days are counting until the first requirements of the revised F-Gas Regulation will come into the legal force from 1 January 2015. Therefore, there is no surprise that many in refrigeration industry are interested in how the Regulation affects each of them and what they can do in order to comply with the Regulation's requirements.

The topic of high attention in the recent days is the effect of the Regulation on installations that use refrigerant with very high GWP values of 2500 and greater. According to the requirements of the Regulation, from 1 January 2020 stationary refrigeration equipment that contain high GWP refrigerant with GWP of 2500 or more, with some exceptions, is prohibited from placing on the European market [1]. Moreover, the use of such fluorinated greenhouse gases to service or maintain refrigeration equipment with a charge size of 40 tonnes of CO<sub>2</sub> equivalent or more, shall be prohibited from the same date [1].

Thus, the greatest impact of the Regulation in the coming future will be on users of R404A, which is the popular refrigerant for supermarket refrigeration systems. Equipment manufacturers and users are therefore looking for the alternative refrigerants to replace R404A in new and existing equipment.

### Short-term alternatives.

Refrigerants R407A and R407F are known replacements to R404A. They are both blends of R134a, R125 and R32 in different composition (R407A – 40/40/20 and R407F – 40/30/30 of R134a, R125 and R32 respectively).

R407A has been known to industry for years and used as a retrofit solution for many existing R404A systems. It is compatible with the same oils, elastomers and plastics as R404A that makes transition from R404A relatively easy. Still, R407A is not a “drop-in” replacement to R404A and several aspects of R407A use should be taken in account, as for instance its increased compressor discharge temperature and increased temperature glide.

R407F is another replacement to R404A, which brings significant GWP reduction along with the improved capacity and energy efficiency. Compared to R407A it has increased share of R32 in favor of decreased amount of R134a. With otherwise similar to R407A behavior, R407F has greater compressor discharge temperature that makes it necessary to confirm the acceptance of R407F with a compressor manufacturer (see Table 1 for some of these refrigerants' property data). Some of them have already included R407F suitable compressors in their product range.

Table 1 – property data of R404A refrigerant and its alternatives [2][3]

	R404A	R407A	R407F
<b>Boiling point at 1 atm, °C</b>	-46.5	-45.5	-45.5
<b>Critical temperature, °C</b>	72.0	82.3	82.6
<b>Critical pressure, bar</b>	37.3	45.2	47.5
<b>GWP</b>	3922	2107	1824
<b>GWP as % of R404A</b>	100%	54%	46%
<b>Temperature glide, K</b>	~1	~4	~6

### Low GWP R404A alternatives.

For some time we used to think about low GWP refrigerants as the refrigerants with GWP value of 150 and lower. While it has been possible to replace R134a with R1234yf, for R404A the low GWP replacement has not been found. Among the number of potential refrigerants, the lower GWP values are in the range of 200-500. These are mildly flammable refrigerant blends of R32 with R1234yf (Table 2). Unlike R404A, these refrigerants are flammable and therefore their use will require new systems specially adopted for the use of flammable refrigerants.

Table 2 – R404A alternatives with low GWP under 250 [4]

Refrigerant	R32/R1234yf [mass%]	Classification*	GWP(100)
ARM-30a	(29/71)	A2L	199
D2Y65	(35/65)	A2L	235
DR-7	(36/67)	A2L	246

\*estimated safety group rating

Due to the safety and cost reasons, the transition from R404A to its flammable alternatives will not happen fast, and therefore nonflammable R404A alternatives are of great interest nowadays. In addition to the above-mentioned R407 family of refrigerants, nonflammable R404A replacements have been found by blending HFCs with HFOs. Arkema, DuPont and Honeywell have been testing different compositions of HFCs (R32, R125 and R134a) with HFOs (R1234yf and R1234ze(E)) to get nonflammable R404A alternative refrigerants with GWP values in the range from about 1300 to 1600 [4].

### New refrigerants R448A and R449A

R448A and R449A are two of the tested blends that has been developed recently. R449A is non-flammable non-toxic blend of almost equal amounts of R32, R125, R1234yf and R134a (24.3/24.7/25.3/25.7 mass% respectively) with a GWP of 1397. It was developed by DuPont and now sold under the name Opteon XP40. R449A is non-flammable refrigerant that closely matches R404A performance and suitable for both retrofit and new systems [5]. Its boiling temperature is close to that of R404A, but critical temperature is somewhat higher (81.5 °C). The temperature glide is not negligible and is approximately 4 K [6].

Dupont has presented the test data obtained from a display case/condensing unit converted to R449A from R404A during low- and medium-temperature operation at two ambient conditions with only adjustments to thermal expansion valve (Table 3).

Table 3 – R449A test results data in relation to R404A data [6]

	Medium temperature		Low temperature	
	28	35	28	35
Ambient temperature, °C	28	35	28	35
Energy consumption	-8%	-12%	-3%	-4%
Relative mass flow	-16%	-17%	-19%	-21%
Suction pressure, kPa	+0	+35	-8	-12

<b>Discharge pressure, kPa</b>	-48	-35	-31	-37
<b>Discharge temperature, K</b>	+3	+2	+5	+5

According to the test results, presented by DuPont, R449A shows better performance, compared to R404A, at an expense of slightly increase of compressor discharge temperature. Relative mass flow is seen to be decreased as well, that could requires some attention to the piping when retrofitting of a refrigeration system.

R448A is composed with the similar components as R449A with an addition of a small amount of R1234ze(E). It is developed by Honeywell and is sold under the name Solstice N40. Both R448A and R449A have similar composition, temperature glide and expected to have similar system performance. R448A and R449 can be suitable for retrofitting R404A in existing systems.

As it seems for now, efficient lower GWP R404A alternative are already available. In the next Kyla+ we will continue this topic and focus specifically on R448A and R449A properties, available performance data, and their applicability as R404A retrofits.

Följ gärna våra publikationer och få vårt digitala nyhetsbrev. Anmäl dig genom att följa länken [bit.ly/kth\\_ett](http://bit.ly/kth_ett).

## References

- [1] European Parliament, "Regulation (EU) No 517/2014 of the European Parliament and of the Council on fluorinated greenhouse gases," *Off. J. Eur. Union*, no. L150, pp. 195–230, 2014.
- [2] DuPont, "DuPont™ SUVA 407A refrigerant." 2013.
- [3] Honeywell, "Honeywell Genetron Performax™ LT refrigerant." 2013.
- [4] W. Xudong and A. Karim, "AHRI low Global Warming Potential alternative refrigerants evaluation program (Low-GWP AREP) – summary of phase I testing results," in *15 th International Refrigeration and Air Conditioning Conference at Purdue*, 2014.
- [5] DuPont, "The Opteon family of lower GWP refrigerants," 2014. [Online]. Available: <http://goo.gl/78hs4E>.
- [6] DuPont, "Opteon XP40. Product information bulletin for stationary refrigeration." 2014.