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Guidelines for use of R-407H as a replacement for R-22 in commercial refrigeration.

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Introduction

R-407H has been designed around traditional chemistry to achieve high efficiency and a GWP of 1380 (IPCC AR5) to be used in new commercial refrigeration systems such as racks, remote condenser and standalone; and as a service refrigerant for replacing R-22 in R-404A/R-507A in existing refrigeration systems.

Daikin has produced this guide to focus on R-22 retrofits and help service technicians better understand the various technical and operational aspects of carrying out retrofit procedures with R-407H. Although the information can be helpful as a general guide, it should not be used as a substitute for the equipment manufacturer's specific recommendations. Also, retrofitting should be considered system specific. Since systems can differ in condition and configuration, retrofit actions applied to one system will not necessarily result in the same level of success in another system.

For this reason, we recommend contacting the equipment manufacturer for detailed information on retrofitting the specific model under consideration. Also, refer to the Safety Data Sheet (SDS) for safety information when you will use R-407H.

When should R-407H be used?

One should consider current system reliability, timing, energy efficiency changes, material and labor costs as just some of the criteria when evaluating a retrofit. This can be done through a cost estimate by the refrigeration contractor or engineer. Some items to take in to deep consideration would be current system emissions rates, availability and pricing of existing refrigerant gas currently and in the future, energy efficiency impacts of the retrofit, current system capacity and design, any additional equipment since first commissioning,

In some situations, newer installations or leak free systems would not benefit from a retrofit; and on the reverse side, a refrigerant retrofit combined with a deep system maintenance or improvements (e.g. condenser cleaning, replacement or addition of doors/air curtains to certain cases, controller and valve fine tuning, addition of electronic valves) can provide a double benefit while minimizing labor costs and down time.

With R-407H, Daikin Chemicals offers a refrigerant specifically developed to replace R-22. The main advantage of R-407H is the close match in working pressure, volume flow rate, and efficiency. Which results in a shorter conversion time because it is often not necessary to change major parts of the system such as distributors or valves. In addition, R-407H discharge temperatures are typically lower than R-22 reducing the need for liquid or vapor injection.

As R-407H has zeotropic fluid characteristics, it is incompatible to systems equipped with a flooded evaporator or in pump installations.

Specific behavior of R-407H in R-22 systems

R-407H is a mixture of R-125 / R-32 / R-134a. It has been specially developed to be a lower GWP and economically friendly alternative to R-22. In most cases, R-407H can be used without major component changes. However, a few points should be noted when using R-407H:

Range of application of R-407H

Replacement refrigerant for MT; Replacement refrigerant for the LT refrigeration systems equipped with liquid injection or other discharge temperature mitigation.

For details of the allowable compressor envelope range, please check with each compressor manufacturer.

Pressure Requirements (Also see: Wet vapor table)

R-407H has a normal boiling point (NBP) of -44°C and a slightly higher vapor pressure than R-22; when comparing bubble point pressure R-407H is 3psi higher at -40°F 42psi higher at 105°F. Generally, this is within design parameters of R-22 systems and as such it can be used in existing R-22 systems without problems. However, the pressure tolerance and design range of existing systems should be thoroughly tested when attempting any retrofit.

Temperature Glide (Also see: Wet vapor table)

The temperature glide of R-407H can be calculated from the tables and ranges from 7.9°F to 8.6°F at the evaporator for low temperatures to medium temperature set points. The system controller should be set for the evaporator midpoint of R-407H. Likewise, when adjusting manually superheat and sub cooling should also be calculated from the midpoint.

Expansion devices

Thermostatic Expansion Valves (TXV):
As discussed previously, R-407H has a slight higher saturation pressure than R-22, especially at higher temperatures. If the pressure drop can't be compensated by the adjustment of the TXV (closed) a replacement to a different TXV is necessary. If dedicated R-407H TXVs are not available we recommend the use TXV suitable for R-407C/A/F (e.g. Parker ENF/SF/HF series with VZ charge for LT and VC charge for MT)

Electronic Expansion Valves (EEV):
For the programming of the p-T curve within the control of the EEV please contact the manufacturer of the EEV. In case coefficients for the programming are needed, please contact our regional technical support team.

Suction Side Components

Some suction side components such as valves need to maintain a minimum pressure drop for proper system operation. R-407H has a lower vapor density when compared to R-22 and thus the volumetric flow rate required will be 14-16% higher at LT conditions and 9-12% higher at MT conditions. Typically, this increase is within the range of operation for existing R-22 valves, however if components need to be replaced due to age or performance limits we recommend R-407H type components. Alternatively, if R-407H components are not available we recommend R-407A type components for LT conditions and R-407C or R-407A type components for MT conditions.

Liquid separator and Distributors

The volume flow of R-407H is almost identical to R-22 at comparable capacities. Suction line liquid separators rely on a minimum volume flow to return the liquid (oil) to the compressor. If existing R-22 components are providing adequate performance no change is required. If existing components need to be replaced due to age we recommend R-407H type components. Alternatively, if R-407H components are not available we recommend R-22 or R-407F type components.

Oil management

R-407H is compatible with POE and PVE oils. POE oil is recommended due to availability. Check with the compressor manufacturer to determine which lubricant and viscosity grade is appropriate. It is absolutely necessary to check the oil return precisely after the conversion and during the running-in period.

R-407H is not compatible with Mineral Oil (MO) and will not provide appropriate oil return. All MO must be removed and replaced as part of the retrofit.

Moisture

In refrigeration systems moisture should generally be avoided, regardless of the refrigerant or refrigerating machine oil selected. High levels of humidity in the refrigeration cycle may lead to the formation of ice at the expansion valve, to corrosion of metal surfaces and damage to the motor coils. When present, moisture may also begin the chemical decomposition of the oil to acid further increasing damage to the system.

Humidity can be avoided by adequately evacuating the refrigerating system. As always after maintenance and repair work, the vacuum should be lower than 500 microns.

Filter dryers

R-407H is compatible with the common HFC filter driers used e.g. for R-134a and R-407A/C/F.

Compatibility with elastomers and plastics

R-407H has the same compatibility with elastomers and plastics as R-404A, R-507A or R-407A. But even suitable sealing materials existing in the system are subject to aging. Penetration by the old refrigerant can lead to embrittlement and swelling of the seals upon pressure reduction or change. This breakdown can lead to leaks and as such the replacement of all elastomers is highly recommended when performing a retrofit.

Table 1 and Table 2 list sealing materials compatible with R-407H.

	Neoprene	HNBR	NBR	EPDM
POE	+	O	+	+
MO	+	-	+	-

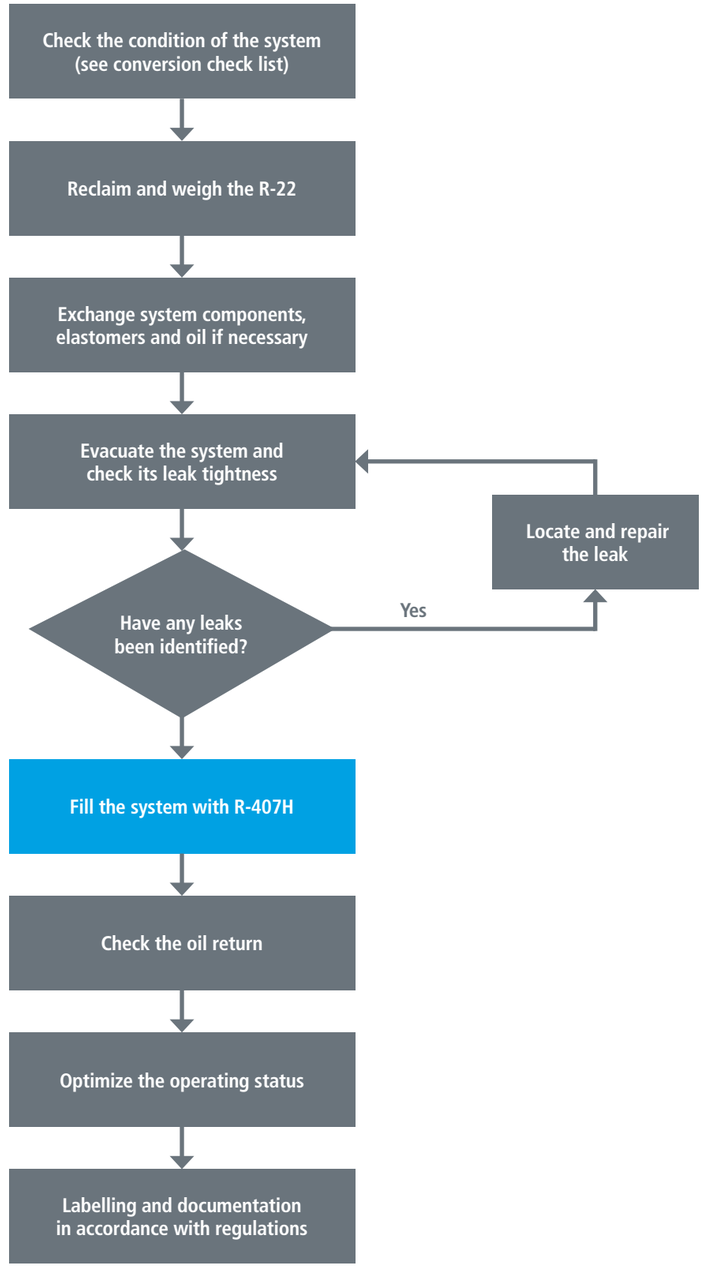
Table 1: The compatibility of elastomers with R-407H and oils

	Polyester	Polyamide	Epoxy
POE	O	+	+
MO	O	+	+

Table 2: The compatibility of polymers with R-407H and oils

Other types of elastomers and polymers can be tested for their compatibility with R-407H on request. In such a case, please contact our technical service team.

Flow diagram for the conversion to R-407H



The conversion of R-22 systems to R-407H in detail

Inspecting and documenting the system condition

The conversion of a system from R-22 to R-407H begins with the inspection and documentation of the current system status. It should be the basis for the final decision whether to opt for a retrofit solution with R-407H or for a continuing operation with R-22.

The following points have to be identified:

- What overall status of the system? What would be the consequences of a system failure?
- Inspection of the logbook and system for indication of refrigerant leaks.
- Is the system suitable for a zeotropic refrigerant e.g. no flooded evaporators and pumped systems?
- What type of oil is currently in the system?
- Are the installed solenoid valves and liquid separators suitable for R-407H?
- Inspection of the suitability of the elastomer, plastic and sealing materials used for seals, O-rings, solenoid valves etc.
- What are the current operating temperatures and pressures?
- Will R-407H pressures increase or decrease at those same temperatures? Will the system tolerate the change in pressure?
- Is the system currently performing at expected efficiency? At expected Capacity?
- Will the system reach the required performance requirements with R-407H?
- Does the system have any performance or capacity reserves?

Removal and recovery of the R-22

- The removal and reclaim of R-22 from the system is required.
- The removed quantity of refrigerant must be filled into DOT steel cylinder.
- The cylinder must be weighed during the reclaiming process to avoid overfilling.
- The specified bulk factors must not be exceeded. The weight of the extracted R-22 must be recorded in the system log book.
- The system should not be left under vacuum or filled with air when idle. Fill with dry nitrogen to prevent the penetration of humidity after removing the refrigerant from the system.

Replace system components

The following system components must be replaced or adjusted:

- Filter dryer, replace with HFC compatible
- Elastomer materials, e.g. in O-rings, solenoid valves, shaft seals
- Expansion valves, nozzle sets
- Exchange of the refrigeration machine oil

Evacuation and leak test

- The system should be evacuated to a vacuum below 500 microns to remove any humidity from the system and to ensure that no air or nitrogen or other non-condensable can impact the system's performance.
- After the system is evacuated, a vacuum pressure test must be carried out and documented (see conversion checklist). A vacuum loss indicates a system leak; any leaks must be repaired before filling the system with R-407H.

Introducing R-407H

R-407H is a zeotropic refrigerant mixture. The same handling instructions apply to it that applies to R-407A and HFO Blends. Follow all required and recommended safety measures.

- R-407H must be filled into a system from the liquid phase only. Care should be taken that while filling the system no liquid is introduced into the compressor.
- As R-22 and R-407H have different densities, thus the quantities to be used are also different. Depending on the optimum filling level of a given system, and due to temperature variations, the optimum filling weight for R-407H may differ from +8% to -2% of the optimum weight of R-22.
  - For systems with a Liquid Receiver, first fill to 90% max of the volume identified on the name plate as liquid; then adjust.
  - For systems without a liquid receiver, fill to 95% of the R-22 quantity removed. Then, the remaining quantity of R-407H should be added while the system is being adjusted.
- The system must be allowed to reach a stable operating condition after starting.
- Refrigerant should be added in the event of excessive superheat at the evaporator (see vapor pressure table). However, small quantities of liquid R-407H should be introduced into the system at a time until the system reaches the specified operating parameters.
- Under no circumstances should the system be filled until the sight glass shows no more bubbles, as this may lead to overfilling. Overfilling must be avoided under all circumstances, as this has a negative impact on performance.
- When the system has been filled completely, the total refrigerant quantity should be recorded in the logbook.

Checking the oil return

- During the initial start-up phase the oil level at the compressor must be checked. If the oil level falls below the minimum (e.g. the lower level indicated at the inspection glass, or below compressor manufacturer's specifications), add oil until the oil level reaches the mark. Under no circumstances should more oil be filled in before the oil return has stabilized.

Optimization of the operating status

- When the system has been filled with refrigerant and has reached stable operating conditions sub cooling to the evaporators should adjusted per the help of the wet vapor table. The subcooling should be set from the midpoint.
- Furthermore, all pressure controls, e.g. condenser pressure or suction pressure controls, should be adjusted to R-407H with the help of the wet vapor table.

Labeling and documentation in accordance with legal requirements

- The refrigerant used – R-407H - must be clearly identified and the filling quantity must be specified in the area near the service connections. Furthermore, the refrigerating machine oil should always be identified.

Physical data

	R-22	R-404A	R-507A	R-407H
Global Warming Potential (GWP AR5)	1760	3922	3985	1378
Ozone Depletion Potential (ODP 1)	0.055	0	0	0
Boiling Point at 1atm (°F)	-41.5	-46.2	-52.1	-48.28
Critical Pressure (psia)	723.7	540.9	538.1	703.4
Liquid Density at 77°F (lb/ft³)	74.3	65.2	65.4	69.4
Vapor Density at 77°F (lb/ft³)	2.76	4.1	4.3	2.6
Components	R-22	R-125 R-134a R-143a	R-125 R-143a	R-32 R-125 R-134a

Check list for system conversion with R-407H: System condition before the conversion

	Preparation before the conversion	Comments
☐	**Overall system condition** Is the refrigeration system in a reliable condition? Could a system failure cause major damage to products or to production processes?	
☐	**Inspection of the system log** Is it the logbook for this system? Has the system received regular maintenance? Has the system required frequent repairs? Are there any signs indicating problems with leak tightness?	
☐	**Oil management** Flooded evaporator (yes/no)? Collector in suction gas stream? Compressor location? Liquid collector with oil return system? Is the oil return system already critical before the conversion?	
☐	**Inspect the elastomers and other materials used for the construction of the system** Are the seals/O-rings/shaft seals/membranes inside the solenoid valves suitable for use with R-407H. Solenoid Valves in particular often require gasket replacement.	
☐	**Pressure / temperature measurements & performance data** Does the pressure/temperature match R-22 expected values? Superheat? Refrigerating Capacity and performance coefficient?	
☐	**Assessment of the convertibility to R-407H** Does the information in hand suggest that the system is suitable for a conversion to R-407H?	
☐	**Allocation of the necessary retrofitting components** e.g. filters / seals / expansion valve and any other materials	

Check list for system conversions with R-407H: System status during the conversion

	Conversion operations	Comments
☐	**Pressure / temperature measurements** Identify the refrigerant used by comparing the measured pressure- temperature values (e.g. at the condenser outlet) with the wet vapor table	Pressure, psig: Temperature, °F: R-22 used y/n:
☐	**Removal of the refrigerant with suction** **Note:** use clearly labeled cylinders to store the reclaimed refrigerant only. Provide sufficient cylinder volume.	End pressure, psig: Weight after, lb: Weight before, lb: Net weight R-22:
☐	**Replace any identified system components** Including the replacement of the refrigeration machine oil	
☐	**Evacuation and leak test** End pressure after evacuation < 500 microns	End vacuum: after 1 hr: after 8 hrs: after 12 hrs:
☐	**Filling with R-407H** 105%-108% of the reclaimed quantity of R-22 remaining quantity depends on the system condition	Filling quantity, lb:
☐	**Inspection of oil return**	Oil level ok: after 24 hrs: after 1 week:
☐	**Optimization of the operating status** Adjust superheat, adjust the pressure control, add POE oil if necessary to improve oil return	Superheat: Pressure check: Added POE, lb:
☐	**Labeling**	

Wet vapor table R-404A / R-507A / R-407H

	R-22	R-507A	R-404A			R-407H		
Temp (°F)	Bubble/Dew Pressure (psig)	Bubble/Dew Pressure (psig)	Bubble Pressure (psig)	Dew Pressure (psig)	Average Pressure (psig)	Bubble Pressure (psig)	Dew Pressure (psig)	Average Pressure (psig)
-40	0.6	5.4	4.9	4.3	4.6	3.6	-1.7	0.9
-35	2.6	8.1	7.5	6.8	7.2	6.0	0.3	3.1
-30	4.9	11.0	10.3	9.6	10.0	8.7	2.4	5.6
-25	7.4	14.1	13.4	12.7	13.1	11.7	4.8	8.3
-20	10.2	17.6	16.8	16.0	16.4	15.0	7.4	11.2
-15	13.2	21.4	20.5	19.7	20.1	18.6	10.4	14.5
-10	16.5	25.5	24.6	23.6	24.1	22.5	13.6	18.0
-5	20.1	30.0	28.9	27.9	28.4	26.8	17.1	21.9
0	24.0	34.8	33.7	32.6	33.1	31.4	20.9	26.2
5	28.3	40.1	38.8	37.7	38.2	36.4	25.2	30.8
10	32.8	45.7	44.3	43.1	43.7	41.9	29.7	35.8
15	37.8	51.8	50.2	49.0	49.6	47.7	34.7	41.2
20	43.1	58.3	56.6	55.3	55.9	54.0	40.1	47.1
25	48.8	65.3	63.4	62.1	62.7	60.8	46.0	53.4
30	55.0	72.7	70.7	69.3	70.0	68.1	52.3	60.2
35	61.5	80.7	78.6	77.1	77.8	75.9	59.1	67.5
40	68.6	89.3	86.9	85.4	86.1	84.2	66.4	75.3
45	76.1	98.3	95.8	94.2	95.0	93.1	74.3	83.7
50	84.1	108.0	105.3	103.6	104.4	102.6	82.7	92.6
55	92.6	118.3	115.3	113.6	114.5	112.7	91.7	102.2
60	101.6	129.2	126.0	124.2	125.1	123.4	101.4	112.4
65	111.2	140.7	137.3	135.5	136.4	134.8	111.7	123.2
70	121.4	153.0	149.3	147.4	148.4	146.9	122.6	134.8
75	132.2	165.9	162.0	160.1	161.0	159.7	134.3	147.0
80	143.6	179.6	175.4	173.4	174.4	173.2	146.7	160.0
85	155.7	194.1	189.5	187.5	188.5	187.5	159.9	173.7
90	168.4	209.3	204.5	202.4	203.4	202.6	173.9	188.2
95	181.8	225.4	220.2	218.1	219.1	218.5	188.8	203.6
100	195.9	242.3	236.8	234.6	235.7	235.2	204.5	219.8
105	210.8	260.1	254.2	252.1	253.1	252.8	221.1	236.9
110	226.4	278.8	272.5	270.4	271.4	271.4	238.6	255.0
115	242.8	298.5	291.8	289.6	290.7	290.8	257.2	274.0
120	260.0	319.2	312.1	309.9	311.0	311.2	276.7	294.0
125	278.0	340.9	333.3	331.2	332.2	332.6	297.4	315.0
130	296.9	363.8	355.6	353.5	354.6	355.0	319.1	337.1
135	316.7	387.8	379.1	377.0	378.1	378.5	342.1	360.3
140	337.4	413.0	403.7	401.7	402.7	403.1	366.3	384.7
145	359.0	439.5	429.6	427.7	428.6	428.8	391.7	410.2
150	381.7	467.5	456.8	455.1	455.9	455.6	418.6	437.1

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