DuPont™ Suva®
refrigerants

ART-34

Retrofit Guidelines for Suva® 407C

Introduction

Over the past five decades, HCFC-22 (R22) has been used as a refrigerant in various refrigeration, industrial cooling, air conditioning, and heating applications. The low ozone depleting potential of R22 compared to CFC-11 and CFC-12, along with its excellent refrigerant properties have helped facilitate the transition from CFCs. However, HCFCs, including R22, are scheduled for eventual phaseout under the Montreal Protocol. DuPont supports the current Montreal Protocol phaseout schedule for HCFCs and is committed to helping the industry prepare for the eventual phaseout of R22.

DuPont has developed Suva® 407C as the similar pressure replacement for R22 in positive displacement, direct expansion air conditioners and heat pumps. Suva® 407C is the registered trademark for a near-azeotropic blend of HFC-32/HFC-125/HFC-134a with a corresponding composition of 23/25/52 wt%. Suva® 407C is commercially available for retrofit of existing equipment and as a long-term replacement option for R22 in new equipment.

Using these retrofit guidelines, many R22 systems can be retrofitted for use with Suva® 407C to allow existing equipment to continue to operate safely and efficiently, even after R22 is no longer available.

Properties and Safety

Suva® 407C offers improved environmental properties versus R22, with an equivalent Global Warming Potential (GWP) and zero Ozone Depletion Potential (ODP). Refer to DuPont Technical Bulletin ART-14 for more detailed information on properties and performance characteristics of Suva® 407C. Refer to the Material Safety Data Sheet (MSDS) for safety information on the use of Suva® 407C.

Table 1
DuPont™ Suva® 407C Physical Properties

Property	Suva® 407C	R22
Boiling Pt. (1 atm) °C (°F)	–43.56 (–46.40)	–40.80 (–41.40)
Vapor Pressure, Sat. Liquid at 25°C (77°F) kPa (psia)	1174 (170.29)	1043 (151.4)
Liquid Density at 25°C (77°F) kg/m³ (lb/ft³)	1134 (70.8)	1195 (74.5)
Density, Sat. Vapor at 25°C (77°F) kg/m³ (lb/ft³)	41.98 (2.62)	44.21 (2.76)
Ozone Depletion Potential as Compared to R-11 (R-11 = 1)	0	0.05
Global Warming Potential CO_2 = 1.0 100 year ITH*	1600	1700
Capacity as Compared to R22*	1.00	1.00
Energy Eff. (COP)**	6.27	6.43

*Integrated Time Horizon

**Conditions: 45°F evaporator/110°F condenser/5°F subcooling/15°F superheat

Lubricants

Lubricant selection is based on several factors, which can include lubricant return to the compressor, lubricity, and materials compatibility. Polyol ester lubricants are recommended for use in most HFC systems. There are many polyol ester lubricant manufacturers; to determine which lubricant is recommended for the refrigeration system, contact the compressor manufacturer, equipment manufacturer, or a DuPont distributor.

Special care should be taken when handling polyol ester lubricants due to their tendency to absorb water. Contact with air should be minimized, and the lubricant should be stored in a sealed metal container.

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When retrofitting R22/mineral oil systems to Suva® 407C/polyol ester lubricant to achieve equivalent miscibility, the residual mineral oil should be around 5 wt% or less of the total lubricant used in the system. Allowable residual mineral oil is highly dependent on system configuration and operating conditions. If the system shows signs of poor heat transfer in the evaporator or poor oil return to the compressor, it may be necessary to further reduce the residual mineral oil. A series of successive lubricant changes using polyol esters can normally reduce the mineral oil concentration to low levels. Lubricant manufacturers are presently developing field test methods for determining the weight percent mineral oil in polyol ester lubricant. Contact the lubricant manufacturer for the recommended test method.

Performance Characteristics in Existing R22 Designs

Suva® 407C provides similar energy efficiency and capacity to R22 with a lower discharge temperature and slightly higher discharge pressure. As a result, minimal system modifications are anticipated when retrofitting R22 systems with Suva® 407C. Original equipment manufacturers should be contacted to determine if discharge pressure controls will need to be adjusted to compensate for the higher discharge pressure. **Table 2** summarizes the actual performance of Suva® 407C versus R22 for both cooling and heating modes in different units designed for R22. The units were not modified or optimized for performance with Suva® 407C.

Table 2
Performance of DuPont™ Suva® 407C Relative to R22 in Multiple Air Conditioners and Heat Pumps

	Suva® 407C
Range of Performance: Cooling Mode*	
Relative Capacity, %	98 to 106
Relative Energy Efficiency Ratio (EER), %	93 to 97
Change in Discharge Temperature, °C (°F)	–8.3 to –4.4 (–15 to –8)
Change in Discharge Pressure, kPa (psi)	+103 to +276 (+15 to +40)
Range of Performance: Heating Mode**	
Relative Capacity, %	93 to 106
Relative Energy Efficiency Ratio (EER), %	94 to 97
Change in Discharge Temperature, °C (°F)	–10 to 0 (–18 to 0)
Change in Discharge Pressure, kPa (psi)	+62 to +234 (+9 to +34)

Values compared to R22 in unmodified split system heat pumps and an unmodified window air conditioner using the:

*DOE cooling test conditions A and B and

**DOE heating test conditions E and H.

Note that Suva® 407C was not designed for use in conjunction with other refrigerants. Adding Suva® 407C to any other refrigerant can form mixtures that could cause system performance problems.

The chemical compatibility of plastics and elastomers should be considered before retrofitting to Suva® 407C and polyol ester. Testing shows that there will be no one family of elastomers or plastics that will work with all the alternative refrigerants. It is recommended that gaskets, shaft seals, and O-rings be reviewed with the equipment manufacturer before retrofit. Also, see P-407C/410A bulletin for elastomer information.

Influence of Leak/Recharge on Performance

Suva® 407C has excellent refrigerant behavior, even in the event of vapor leaks from a two-phase region of a refrigeration system and subsequent refrigerant recharges.

If there is a Suva® 407C leak from an operating unit in a two-phase region where mixing occurs (heat exchangers or expansion device), both the vapor and liquid will leak from the unit. The composition of the refrigerant left in the system will remain essentially unchanged from the original composition. After recharging Suva® 407C to the system to get back to the original charge size, the performance of the unit will be the same as its original performance with Suva® 407C.

However, if the unit is not operating and there is a vapor leak from a static two-phase region, the composition of the refrigerant that remains in the unit will change. The remaining refrigerant will be more concentrated in the high boiling component (HFC-134a) and less concentrated in the lower boiling components (HFC-32 and HFC-125). The effect of this composition shift on the performance of Suva® 407C is summarized in **Table 3**. These data reflect the theoretical performance of Suva® 407C for multiple recharges of a system after 50 wt% of the refrigerant charge is lost through a vapor leak above a two-phase region.

Three important observations from the data generated in this leak/recharge study are:

During a vapor leak, the HFC-32 (the flammable mixture component) remaining in the system decreases in concentration, such that the mixture remains nonflammable.

Energy efficiency is maintained and discharge temperature and discharge pressure decrease during the vapor leak/recharge scenario.

Table 3
Theoretical Unit Performance After 50 wt% Vapor Leaks and Recharges of DuPont™ Suva® 407C

			Compressor Discharge	
Recharge No.	Rel. COP,* %	Rel. Cap.,** %	Temperature, °C (°F)	Pressure, kPa (psig)
0	100	100	81.1 (178)	1903 (261)
1	101	95	80.6 (177)	1800 (246)
2	101	93	80.6 (177)	1751 (239)
3	101	92	80.6 (177)	1731 (236)
4	101	91	80.6 (177)	1724 (235)
5	101	91	80.6 (177)	1724 (235)

*Coefficient of Performance (measure of energy efficiency) relative to the Coefficient of Performance of the original charge of Suva® 407C.
**Refrigerant cooling capacity relative to the capacity of the original charge of Suva® 407C.

Capacity loss is limited to 9% as the performance of Suva® 407C levels out after four 50 wt% leak/recharges. **Note further that the theoretical study reflects a worst case scenario. In practice, lesser changes are normally experienced, as illustrated by results from a heat pump leak experiment which showed the capacity loss was maintained at 4% after the second recharge.**

Charging a Unit with Suva® 407C

As with any other refrigerant blend, when charging equipment with Suva® 407C, remove liquid refrigerant from the cylinder to charge the unit. The proper cylinder position for liquid removal is indicated by arrows ont he cylidner and cylinder box.

Overview of Retrofit Process

Retrofit of an existing R22 system with Suva® 407C can be accomplished using service practices and equipment commonly used by trained mechanics or service contractors in the field.

The key steps involved in the retrofit are:

- Baseline data with R22.
- Remove mineral oil or alkylbenzene oil from compressor, and replace with a recommended polyol ester (POE) lubricant. Run system for 48 to 72 hr with R22, and determine residual oil content. Perform additional lubricant changes if necessary.
- Recover R22 charge from the system.
- Replace filter/drier with new drier compatible with Suva® 407C/POE.
- Charge system with Suva® 407C.
- Start system, and adjust charge and/or controls to achieve desired operation.

For the majority of systems, the compressor lubricant change, a filter/drier change, and a possible adjustment to the superheat setting (in systems with expansion valves) will be the only system modifications required in a retrofit to Suva® 407C. For systems that are still under warranty, we recommend contacting the equipment or compressor manufacturers prior to performing the retrofit. Some equipment or compressor warranties may be impacted by a change from the refrigerant or lubricant originally specified for the sytem or compressor.

Equipment and Supplies Needed for Retrofit

- Safety equipment (gloves, glasses)
- Manifold gauges
- Thermocouples to read line temperatures
- Vacuum pump
- Leak detection equipment
- Scale
- Recovery unit
- Recovery cylinder
- Container for recovered lubricant
- Replacement lubricant
- Replacement refrigerant
- Replacement filter/drier
- Labels indicating the refrigerant and lubricant charged to the system

Retrofit Procedure

Summarized below is a more detailed discussion of the recommended procedure for retrofitting an R22 system to Suva® 407C.

1. **Baseline Data with R22**. For service contractors performing their initial retrofits with Suva® 407C, it is recommended that system performance data be collected while R22 remains in the system. Check for correct refrigerant charge and operating conditions. The baseline of temperatures and pressures with the correct charge of R22 at various points in the system (evaporator, condenser, compressor suction and discharge, expansion device, etc.) will be useful when optimizing operation of the system with Suva® 407C. A **System Data Sheet** is attached for recording this baseline data.

2. **Drain/Charge System Lubricant**. Where mineral oil or alkylbenzene oil is the existing lubricant in the system, it will have to be drained. This may require removing the compressor from the system, particularly with small hermetic compressors that have no oil drain. In this case, the lubricant can be drained from the suction line of the compressor. In most small systems, 90–95% of the lubricant can be removed from the compressor in this manner. Larger systems may require drainage from additional points in the system, particularly low spots around the evaporator, to remove the majority of the lubricant. In systems with an oil separator, any lubricant present in the separator should also be drained.

   In all cases, *measure* the volume of lubricant removed from the system. Compare to the compressor/system specifications to ensure that the majority of lubricant has been removed. Polyol ester lubricant is recommended for use with Suva® 407C. In order to achieve equivalent miscibility to R22/oil, the residual oil should be about 5 wt% or less of the total lubricant used in the system. In larger systems, the amount of residual mineral oil can be achieved by using a flushing technique. Three or more lubricant flushes may be required. Lubricant flushes involve:

   - Draining existing lubricant from the system, as described above.
   - Selecting a polyol ester lubricant with similar viscosity to the existing lubricant.
   - Charging an amount of polyol ester equal to the amount of lubricant removed.
   - Running the system with R22 for thorough mixing of polyol ester/existing lubricant (48 to 72 hr of operation may be required).

   Repeat these steps two more times. On the last flush, R22 will be replaced with Suva® 407C.

3. **Remove R22 Charge**. R22 should be removed from the system and collected in a recovery cylinder using a recovery device capable of pulling 10–20 in. Hg vacuum (34–67 kPa, 0.34–0.67 bar). If the correct R22 charge size for the system is not known, weigh the amount of refrigerant removed, as the initial quantity of Suva® 407C charged in the system will be determined from this figure.

4. **Reinstall Compressor** (if removed from system in step 2). Use normal service practices.

5. **Replace Filter/Drier**. It is routine practice to replace the filter/drier following system maintenance. There are two types of filter/driers commonly used in R22 equipment:

   a. Loose fill driers, which contain only the molecular sieve desiccant.

   b. Solid core driers, in which the molecular sieve desiccant is dispersed within a solid core binder.

   The XH-6 molecular sieve desiccant manufactured by UOP is typically used for R22. While this desiccant, as well as UOP's XH-9, is compatible with Suva® 407C, both desiccants will absorb HFC-32. The XH-11 desiccant from UOP is compatible with Suva® 407C and excludes HFC-32 making it a suitable replacement for use in loose fill driers with Suva® 407C. For solid core driers, consult the drier manufacturer for their recommended drier for use with Suva® 407C. In the United States, Sporlan® and Alco have solid core driers, which show acceptable compatibility with Suva® 407C.

6. **Reconnect System and Evacuate**. Use normal service practices. To remove air or other noncondensables in the system, evacuate the system to near full vacuum use (29.9 in, 500 μm, 0.14 kPa, 0.0014 bar).

   Leak Check System. Use normal service practices. If a leak detector is used, consult the leak detector manufacturer for unit's sensitivity to Suva® 407C. Reevacuate system following leak check if necessary.

7. **Charge System with Suva® 407C**. Remove liquid only from charging cylinder. *The proper cylinder position for liquid removal is indicated by arrows on the cylinder and cylinder box.* Once liquid is removed from the cylinder, the refrigerant can be charged to the system as liquid or vapor as desired. Use the manifold gauges or a throttling valve to flash the liquid to vapor if required.

The refrigerant system will typically require less weight of Suva® 407C than R22. The optimum charge will vary depending on the operating conditions, size of the evaporator and condenser, size of the receiver (if present), and the length of pipe or tubing runs in the system. For most systems, the optimum charge will be 90–95% by weight of the original equipment manufacturer R22 charge.

It is recommended that the system be initially charged with about 80% by weight of the correct R22 charge. Add the initial charge to the high pressure side of the system (compressor not running). When the system and cylinder pressures equilibrate, load the remainder of the refrigerant to the suction side of the system (compressor running). Liquid refrigerant should never enter the suction side of the compressor.

8. **Start Up System and Adjust Charge**. Start up the system and let conditions stabilize. If the system is undercharged, add additional Suva® 407C in small amounts until the system conditions reach the desired levels. Refer to the Suva® 407C Pressure-Temperature chart (**Table 4**) to compare system suction pressure and evaporator temperature with the suction pressure and evaporator temperature for R22.

   Suva® 407C will have higher discharge pressures and lower discharge temperatures when compared to R22 operation. A typical increase in discharge pressure would be from 15–40 psi (103–276 kPa); a typical decrease in discharge temperature would be from 0–10°C (0–18°F).

   Note: Label Components and System. After retrofitting the system with Suva® 407C, label the system components to identify the type of refrigerant (Suva® 407C) and lubricant in the system, so that the proper refrigerant and lubricant will be used to service the equipment in the future. Suva® refrigerant identification labels are available from DuPont.

Summary

With the phaseout of CFCs and HCFCs, existing refrigeration equipment will need to be replaced with new equipment or retrofitted with alternative refrigerants. Using the procedures described above, existing refrigeration R22 systems can be retrofitted for use with Suva® 407C, allowing them to continue in service for the remainder of their useful life.

Attached is a **Retrofit Checklist** and **System Data Sheet** and pressure-temperature charts for Suva® 407C to assist you in the retrofit process.

Table 4
Pressure-Temperature Chart—DuPont™ Suva® 407C Saturation Properties
(English and SI Units)

English						SI					
Pressure psig	Temperature (°F) Sat. Liq.	Sat. Vap.	Pressure psig	Temperature (°F) Sat. Liq.	Sat. Vap.	Pressure kPa	Temperature (°C) Sat. Liq.	Sat. Vap.	Pressure kPa	Temperature (°C) Sat. Liq.	Sat. Vap.
20.0*	–84	–71	120	62	72	10	–83	–75	800	11	17
15.0*	–71	–58	125	64	75	20	–73	–65	825	12	18
10.0*	–61	–48	130	66	77	30	–66	–59	850	14	19
5.0*	–53	–40	135	69	79	40	–61	–54	900	15	21
0	–46	–34	140	71	81	50	–57	–50	950	17	23
2	–42	–29	145	73	83	60	–54	–47	1000	19	25
4	–37	–24	150	75	85	70	–51	–44	1050	21	27
6	–33	–20	155	77	87	80	–48	–41	1100	23	28
8	–29	–17	160	79	89	90	–46	–39	1150	24	30
10	–26	–13	165	81	90	100	–43	–37	1200	26	31
12	–22	–10	170	82	92	110	–42	–35	1250	27	33
14	–19	–7	175	84	94	120	–40	–33	1300	29	34
16	–16	–4	180	86	96	130	–38	–31	1350	30	36
18	–13	–1	185	88	97	140	–37	–30	1400	32	37
20	–11	1	190	90	99	150	–35	–28	1450	33	38
22	–8	4	195	91	101	160	–33	–27	1500	34	40
24	–6	6	200	93	102	170	–32	–25	1550	36	41
26	–3	9	205	95	104	180	–31	–24	1600	37	42
28	–1	11	210	96	105	190	–29	–23	1650	38	43
30	1	13	215	98	107	200	–28	–21	1700	39	44
32	3	15	220	99	108	210	–27	–20	1750	41	46
34	5	17	225	101	110	230	–25	–18	1800	42	47
36	7	19	230	102	111	240	–24	–17	1850	43	48
38	9	21	235	104	113	250	–23	–16	1900	44	49
40	11	23	240	105	114	260	–22	–15	1950	45	50
42	13	25	245	107	116	270	–21	–14	2000	46	51
44	15	26	250	108	117	280	–20	–13	2050	47	52
46	16	28	255	110	118	290	–19	–12	2100	48	53
48	18	30	260	111	120	300	–18	–11	2150	49	54
50	20	31	265	112	121	310	–17	–10	2200	50	55
52	21	33	270	114	122	320	–16	–9	2250	51	56
54	23	35	275	115	123	330	–15	–9	2300	52	57
56	24	36	280	116	125	340	–15	–8	2350	53	57
58	26	37	285	118	126	350	–14	–7	2400	54	58
60	27	39	290	119	127	375	–12	–5	2450	55	59
62	29	40	295	120	128	400	–10	–3	2500	56	60
64	30	42	300	121	129	425	–8	–2	2600	58	62
66	32	43	310	124	132	450	–7	0	2700	59	63
68	33	44	320	126	134	475	–5	1	2800	61	65
70	34	46	330	129	136	500	–3	3	2900	63	67
75	38	49	340	131	138	525	–2	4	3000	64	68
80	41	52	350	133	141	550	–1	6	3100	66	69
85	44	55	360	135	143	575	1	7	3200	68	71
90	46	57	370	138	145	600	2	8	3300	69	72
95	49	60	380	140	147	625	3	10	3400	71	74
100	52	63	390	142	149	650	5	11	3500	72	75
105	55	65	400	144	151	675	6	12	3600	73	76
110	57	68	425	149	155	700	7	13	3700	75	77
115	59	70	450	154	160	725	8	14	3800	76	79
						750	9	15	3900	78	80
						775	10	16	4000	79	81

*Inches of Hg vacuum

Checklist for DuPont™ Suva® 407C Retrofit

_____ Establish baseline performance with R22. (See data sheet for recommended data.)

_____ Consult the original equipment manufacturer of the system components for their recommendation on the following:
- – Plastics compatibility
- – Elastomers compatibility
- – Lubricant (viscosity, manufacturer, additives)
- – Retrofit procedure to sustain warranty

_____ Drain lubricant charge from compressor (unless polyol ester lubricant is already in the system).*
- – Remove 90–95% of lubricant from the system.
- – Measure amount of lubricant removed and record. _____

_____ Charge polyol ester lubricant. Run system for 48–72 hr *minimum*.
- – Recharge with amount equivalent to amount of mineral oil removed.

_____ Repeat lubricant drain and ester charging until mineral oil content is less than 5%.

_____ Remove R22 charge from system.
(Need 10–20 in Hg vacuum [34–67 kPa, 0.34–0.67 bar] to remove charge.)

_____ Reinstall compressor (if removed).

_____ Replace filter drier with new drier approved for use with Suva® 407C.
- – Loose fill driers: use XH-11 desiccant or equivalent
- – Solid core driers: check with drier manufacturer for recommendation

_____ Reconnect system and evacuate with vacuum pump. (Evacuate to full vacuum [29.9 in Hg vacuum/0.14 kPa/0.0014 bar].)

_____ Leak check system. (Reevacuate system following leak check.)

_____ Charge system with Suva® 407C.
- – Initially charge 80% by weight of original equipment manufacturer specified R22 charge
- – Amount of refrigerant charged: _____

_____ Start up equipment and adjust charge until desired operating conditions are achieved.
- – If low in charge, add in increments of 2–3% of original R22 charge
- – Amount of refrigerant charged: _____

Total Refrigerant Charged (add 9 and 10) _____

_____ Label components and system for type of refrigerant (Suva® 407C) and lubricant (polyol ester).

_____ Conversion is complete!

*R22 charge should only be removed if compressor must be taken out of system to drain oil, such as for small hermetics.

System Data Sheet

Type of System/Location: _____

Equipment Mfg.: _____
Model No.: _____
Serial No.: _____
R22 charge size: _____

Compressor Mfg.: _____
Model No.: _____
Serial No.: _____
Original Lubricant:
Type/mfg.: _____
Charge size: _____
New Lubricant:
Type/mfg.: _____
1st Charge size: _____
2nd Charge size: _____
Additional Charge size: _____

Drier Mfg.: _____
Model No.: _____

Drier type (check one):
Loose fill: _____
Solid core: _____

Condenser cooling medium (air/water): _____

Expansion Device (check one): Capillary tube: _____
Expansion valve: _____

If Expansion valve:
Manufacturer: _____
Model No.: _____
Control/set point: _____
Location of sensor: _____

Other System Controls (ex.: head press control), Describe: _____
_____

(circle units used where applicable)

Date/Time				
Refrigerant				
Charge Size (lb, oz/g)				
Ambient Temp. (°F/°C)				
Relative Humidity				
Compressor:				
Suction T (°F/°C)				
Suction P (psig, psia/kPa, bar)				
Discharge T (°F/°C)				
Discharge P (psig, psia/kPa, bar)				
Box/Case T (°F/°C)				
Evaporator:				
Refrigerant Inlet T (°F/°C)				
Refrigerant Outlet T (°F/°C)				
Coil Air/H_2O In T (°F/°C)				
Coil Air/H_2O Out T (°F/°C)				
Refrigerant T at Superht. Ctl. Pt. (°F/°C)				
Condenser:				
Refrigerant Inlet T (°F/°C)				
Refrigerant Outlet T (°F/°C)				
Coil Air/H_2O In T (°F/°C)				
Coil Air/H_2O Out T (°F/°C)				
Exp. Device Inlet T (°F/°C)				
Motor Amps				
Run/Cycle Time				

Comments: _____

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