Freon™ 407C and 407A

Refrigerants (R-407C and R-407A)

Properties, Uses, Storage, and Handling

Chemours™

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Introduction

Background

Chlorodifluoromethane (R-22 or HCFC-22) has been used as a refrigerant in various refrigeration, industrial cooling, air conditioning, and heating applications for over five decades. The low ozone depletion potential of R-22 compared to CFC-11 (chlorofluorocarbon 11) and CFC-12 and its excellent refrigerant properties have helped facilitate the transition away from CFCs. However, R-22 will be phased out in the first quarter of the 21st century. In preparation for this phaseout, Chemours offers Freon™ 407C and Freon™ 407A, environmentally acceptable alternatives to R-22. Additionally, R-407A offers similar performance to R-404A in new medium and low temperature refrigeration systems.

Freon™ 407C and Freon™ 407A Refrigerant Descriptions

Freon™ 407C and Freon™ 407A are non-ozone depleting blends of three hydrofluorocarbon (HFC) refrigerants. Freon™ 407C exhibits performance characteristics similar to R-22.

The compositions of Freon™ 407C and Freon™ 407A are as follows:

	HFC-32	HFC-125	HFC-134a
Freon™ 407C (R-407C), wt%	23	25	52
Freon™ 407A (R-407A), wt%	20	40	40

Because Freon™ 407C and Freon™ 407A are mixtures of HFCs, they have zero ozone depletion potential.

Table 1 lists the chemical names and formulae of the components that make up Freon™ 407C and Freon™ 407A.

Table 1. Components of Freon™ 407C and Freon™ 407A: HFC-32/HFC-125/HFC-134a

Component	Chemical Name	Formula	CAS Number	Molecular Weight
HFC-32	Difluoromethane	CF_2H_2	75-10-5	52.0
HFC-125	Pentafluoroethane	CF_3CHF_2	354-33-6	120.0
HFC-134a	1,1,1,2-Tetrafluoroethane	CF_3CH_2F	811-97-2	102.0

Uses

Freon™ 407C refrigerant performs similarly to HCFC-22 under evaporator temperatures ranging from –7 to 10 °C (20 to 50 °F). It is designed for use in new equipment and as a service refrigerant for existing HCFC-22 air conditioning, heat pump, and medium temperature refrigeration equipment.

Freon™ 407A is intended for use in new medium and low temperature refrigeration systems that have traditionally used R-404A. R407A has a global warming potential about 50% lower than R-404A

Tables 2a and **2b** show theoretical performance of Freon™ 407C, Freon™ 407A, and HCFC-22. Freon™ 407C exhibits similar performance to HCFC-22 at air conditioning conditions, while Freon™ 407A exhibits similar performance to R-404A with lower capacity at low and medium temperature refrigeration conditions.

Physical Properties

General physical properties for Freon™ 407C and Freon™ 407A are shown in **Table 3**. The pressure-enthalpy diagrams for Freon™ 407C are shown in **Figures 1** and **2**.

Additional physical property data may be found in other Chemours publications. Thermodynamic properties booklets are also available for Freon™ 407C and Freon™ 407A in both English and metric units. Transport properties booklets are available for Freon™ 407A in both English and metric units

Table 2a. Theoretical Cycle Performance

	HCFC-22	Freon™ 407C (R-407C)
Refrigeration Capacity (HCFC-22 = 1.0)	1.00	1.00
Coefficient of Performance	6.43	6.27
Compression Ratio	2.66	2.83
Compressor Discharge Temperature, °C (°F)	77.3 (171.2)	75.1 (167.1)
Compressor Discharge Pressure, kPa abs (psia)	1662 (241.0)	1763 (255.6)
Temperature Glide, °C (°F)	0 (0)	4.9 (8.9)

Conditions: 43.3 °C (110 °F) condenser/7.2 °C (45 °F) evaporator/2.8 °C (5 °F) of subcooling/8.3 °C (15 °F) of superheat

Table 2b. Theoretical Cycle Performance

	Medium Temperature		Low Temperature	
	R-404A	R-407A	R-404A	R-407A
Relative Capacity (R-404A = 1.00)	1.00	0.89	1.00	0.86
Coefficient of Performance	2.6	2.4	1.4	1.5
Compression Ratio	4.4	5.8	10.5	14.5
Compressor Discharge Temperature, °C (°F)	68 (154)	91 (196)	78 (172)	104 (219)
Compressor Discharge Pressure, kPA abs (psia)	2034 (295)	2096 (304)	2034 (295)	2096 (304)
Temperature Glide , °C (°F)	~2.2 (4)	~4.4 (8)	~2.2 (4)	~4.4 (8)

LT conditions: -28.9 °C (-20 °F) evap, 43.3 °C (110 °F) cond, 5.5 °C (10 °F) SH and SC

MT conditions: -6.7 °C (20 °F) evap, 43.3 °C (110 °F) cond, 5.5 °C (10 °F) SH and SC

Table 3. General Property Information of Freon™ 407C, Freon™ 407A, and HCFC-22

Physical Property	Unit	Freon™ 407C (R-407C)	Freon™ 407A (R-407A)	HCFC-22
Molecular Weight, avg.	g/mol	86.20	90.11	86.47
Vapor Pressure at 25 °C (77 °F)	kPa abs (psia)	1174.1 (170.29)	1253.1 (181.74)	1043.1 (151.40)
Boiling Point (1 atm)	°C (°F)	–43.56 (–46.40)	-45.01 (-49.01)	–40.80 (–41.40)
Critical Temperature	°C (°F)	86.74 (188.13)	82.26 (180.06)	96.24 (205.24)
Critical Pressure	kPa abs (psia)	4619.10 (669.95)	4515.2 (654.9)	4980.71 (722.39)
Critical Density	kg/m³ (lb/ft³)	527.30 (32.92)	498.86 (31.14)	524.21 (32.73)
Liquid Density at 25 °C (77 °F)	kg/m³ (lb/ft³)	1134.0 (70.80)	1145.1 (71.49)	1194.68 (74.53)
Density, Saturated Vapor at 25 °C (77 °F)	kg/m³ (lb/ft³)	41.98 (2.62)	49.75 (3.11)	44.21 (2.76)
Specific Heat, Liquid at 25 °C (77 °F)	kJ/kg·K (Btu/lb·°F)	1.54 (0.367)	1.52 (0.363)	1.24 (0.296)
Specific Heat, Vapor at 25 °C (77 °F) (1 atm)	kJ/kg·K (Btu/lb·°F)	0.830 (0.198)	0.829 (0.198)	0.685 (0.157)
Vapor Pressure of Saturated Liquid at 25 °C (77 °F)	kPa abs (psia)	1173.4 (170.3)	1253.1 (181.74)	1043.1 (151.4)
Heat of Vaporization at Normal Boiling Point	kJ/kg (Btu/lb)	245.1 (105.4)	235.6 (101.34)	233.5 (100.4)
Thermal Conductivity at 25 °C (77 °F) Liquid Vapor (1 atm)	 W/m·K (Btu/hr·ft·°F) W/m·K (Btu/hr·ft·°F)	 0.0819 (0.0455) 0.01314 (0.00758)	 0.0795 (0.0460) 0.01368 (0.00791)	 0.0849 (0.0458) 0.01074 (0.00621)
Viscosity at 25 °C (77 °F) Liquid Vapor (1 atm)	 Pa·s Pa·s	 1.60×10^{-4} 1.23×10^{-5}	 1.51×10^{-4} 1.25×10^{-5}	 1.59×10^{-4} 1.30×10^{-5}
Flammability Limit in Air (1 atm)	vol%	None	None	None
Ozone Depletion Potential	CFC-11 = 1.0	0	0	0.05
Global Warming Potential (AR4)	CO_2 = 1.0 (100-yr ITH)	1774	2107	1810
TSCA Inventory Status	Included	Yes	Yes	Yes
Inhalation Exposure Limit*	ppm (8- and 12-hr TWA)	1000	1000	1000

*The exposure limit is calculated based on the Chemours Acceptable Exposure Limit (AEL) for each component of the refrigerant blend. AEL is an airborne exposure limit established by Chemours that specifies time-weighted average (TWA) concentrations to which nearly all workers may be repeatedly exposed without adverse effects during an 8- or 12-hr workday and a 40-hr work week.

Figure 1. Pressure-Enthalpy Diagram for Freon™ 407C (SI Units)

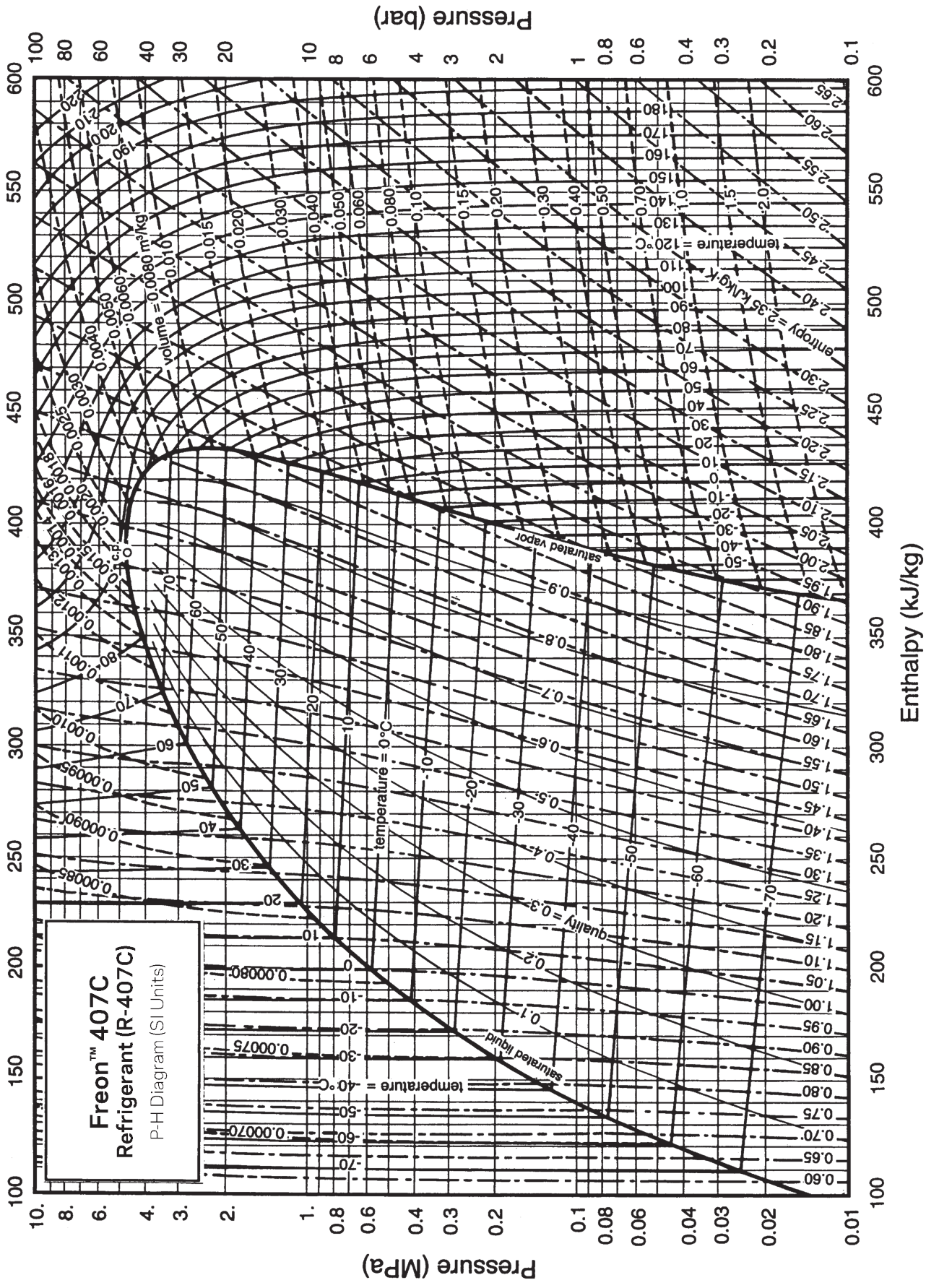


Figure 2. Pressure-Enthalpy Diagram for Freon™ 407C (ENG Units)

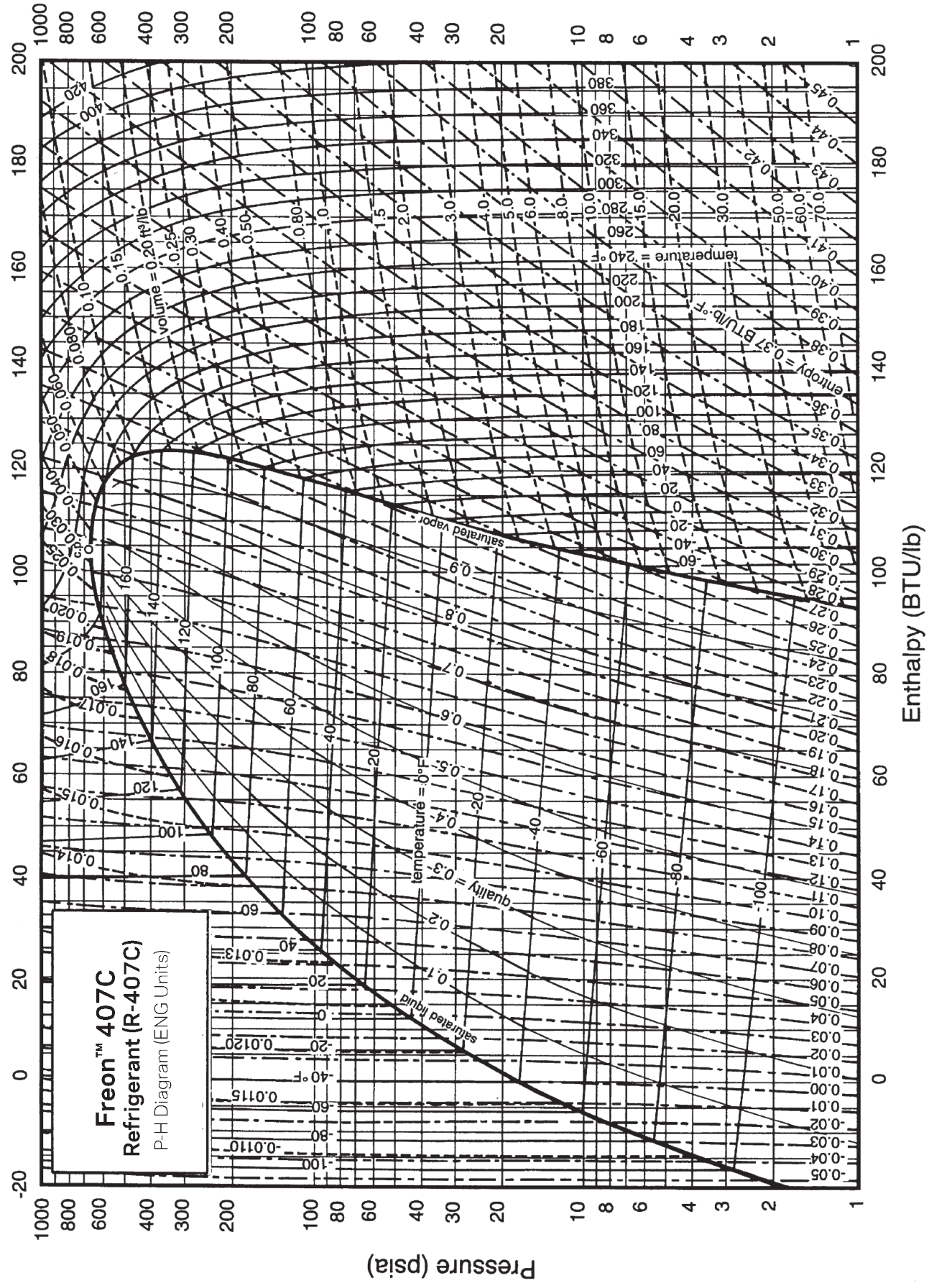


Figure 3. Pressure-Enthalpy Diagram for Freon™ 407A (SI Units)

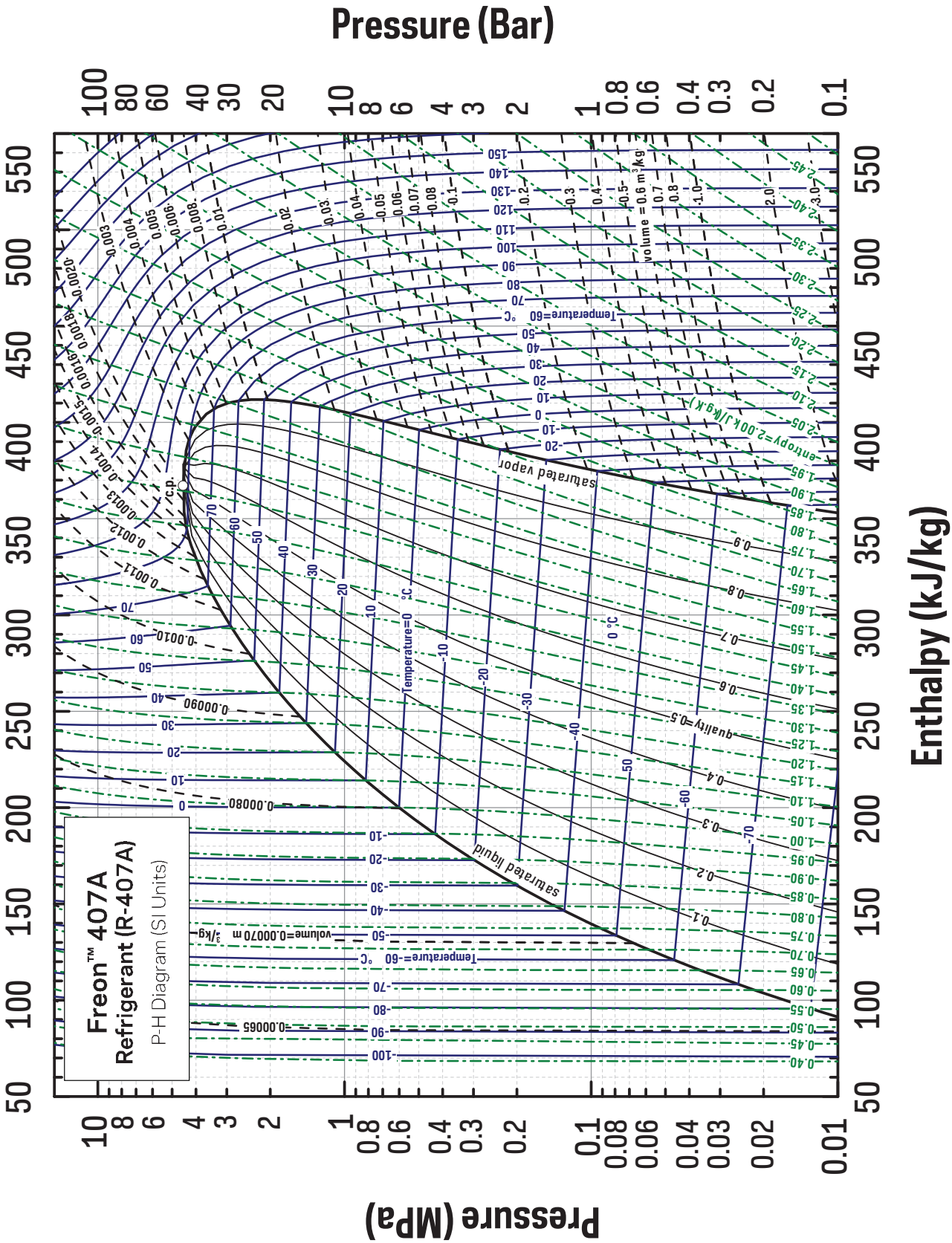
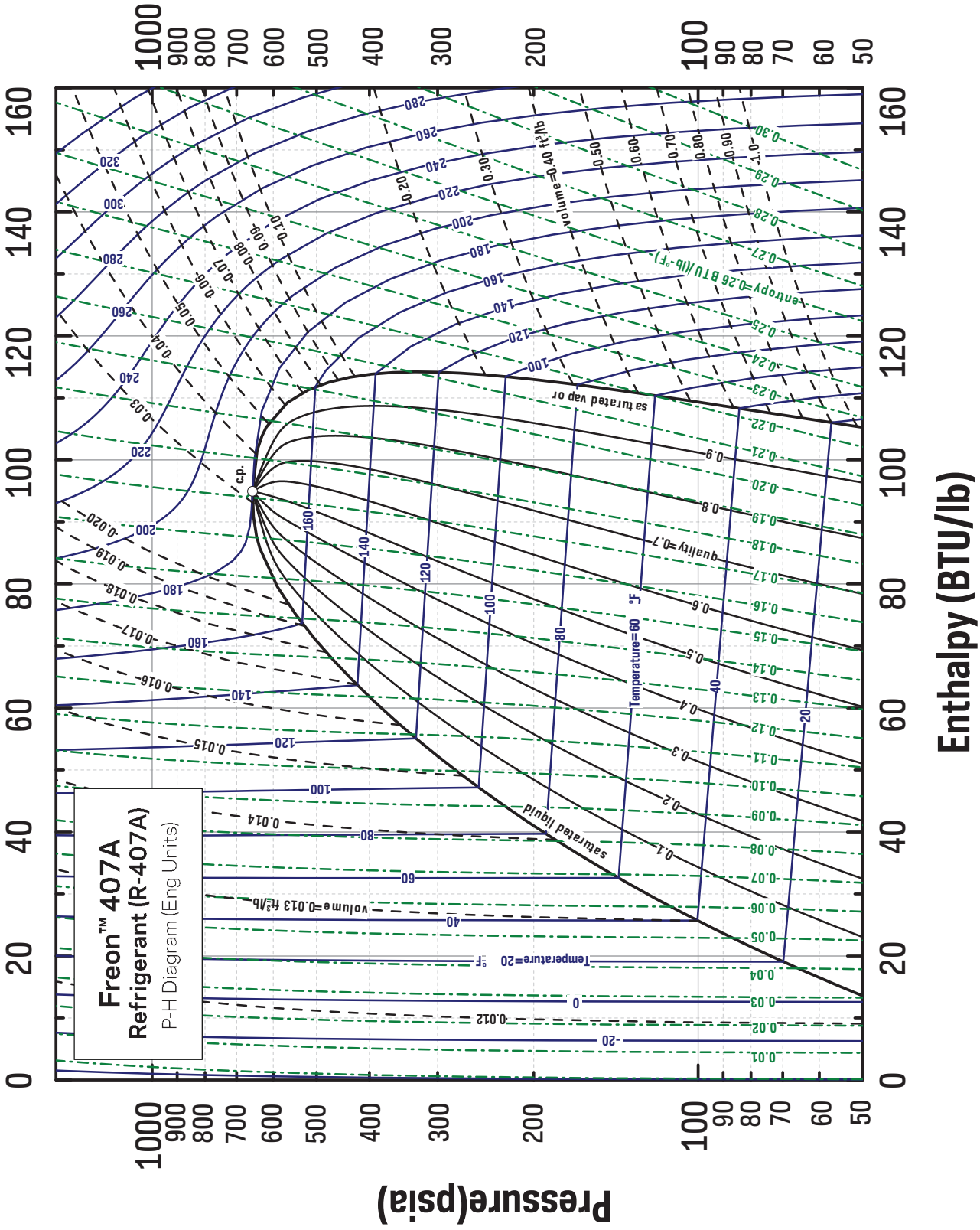


Figure 4. Pressure-Enthalpy Diagram for Freon™ 407A (ENG Units)



Chemical/Thermal Stability

Stability with Metals

Stability tests for refrigerants with metals are typically performed in the presence of refrigeration lubricants. This test is run in sealed glass tubes at temperatures much higher than those encountered in refrigeration and air conditioning systems and is therefore referred to as an accelerated aging test. Results of sealed tube stability tests for HCFC-22/mineral oil and alkylbenzene lubricants have shown long-term stability in contact with copper, steel, and aluminum. And the fact that HCFC-22/mineral oil and alkylbenzene systems have been performing in the field in air conditioner and refrigeration systems for the last 50 years verifies the results from these stability tests. Polyol ester lubricants (POEs) are among the proposed lubricants for use with Freon™ 407C and Freon™ 407A. Therefore, stability tests of Freon™ 407C with POEs and metals were performed. Freon™ 407A contains slightly different concentrations of the same components as Freon™ 407C, so the stability test results for Freon™ 407C can also be used for Freon™ 407A.

The test method followed was generally the same as ASHRAE 97 with several minor modifications. A 3-mL volume of refrigerant/lubricant solution was heated in the presence of copper, steel, and aluminum coupons in an oven for 14 days at 175 °C (347 °F) or 200 °C (392 °F). Both the neat refrigerant and a mixture of lubricant and refrigerant (50/50 volume ratio) were tested. Stability and visual ratings were obtained on both the liquid solutions and the metal coupons after the designated exposure time. The stability ratings range from 0 to 5, with 0 being the best and 5 being the worst. Visual ratings indicate how the metal or refrigerant or lubricant/refrigerant solution appeared to a visual inspection. A rating of "0" indicates no perceptible change in appearance. Any perceptible change of color, clarity, or surface finish changes the rating to "1." Mixtures of CFC refrigerants and conventional mineral oils generally get a rating of "3," which is the limit of acceptability. The new refrigerants and lubricants must outperform those being replaced in order to be considered acceptable.

After the visual ratings were obtained, sample tubes were opened, and the lubricant and refrigerant were analyzed. The lubricant was typically checked for halide content and breakdown products, while the refrigerant was examined for the presence of decomposition products. **Table 4** summarizes the data from these sealed tube stability tests for Freon™ 407C and various commercial POE lubricants. Stability and visual ratings are listed for the neat refrigerant, the lubricant/refrigerant solution, and the three metals that were present in the lubricant/refrigerant solutions. Samples were analyzed for decomposition products in most cases. Typical level measurements for decomposition products, if they are detected, are in the low parts per million (ppm) range.

Table 4. Stability of Freon™ 407C with Metals and Polyol Ester Lubricants

Property	Freon™ 407C with Castrol "Icematic" SW32	Freon™ 407C with Castrol "Icematic" SW22	Freon™ 407C with Lubrizol RL32
Stability and Visual Ratings			
Neat refrigerant	1, H	0	0
Refrigerant/lubricant	0	1, G	1
Copper	2, T	1, T	0
Iron	1, T	1, T	0
Aluminum	0	0	0
Fluoride ion	ND (<7 ppm)	ND (<7 ppm)	ND (<7 ppm)

Stability (Visual) Ratings: 0–5

0—Best
1—First detectable change
3—Equivalent to CFC/mineral oil (moderate discoloration or light corrosion)
5—Coked (heavy solids or corrosion)
ND—Not determined
P—Precipitate
T—Tarnish
G—Gel
H—Haze

The results obtained from these sealed tube stability tests for Freon™ 407C/POEs indicate acceptable chemical stability in the presence of common metals used in refrigeration and air conditioner systems.

Note: Lubricant/refrigerant combinations shown throughout this report are for purposes of comparing and illustrating the stability and compatibility of different lubricants with Freon™ refrigerants. No recommendation is made or implied. Contact your equipment manufacturer for the recommended lubricant for use with Freon™ refrigerants.

Thermal Decomposition

Like HCFC-22, Freon™ 407C and Freon™ 407A refrigerants will decompose when exposed to high temperature or flame sources. Decomposition may produce toxic and irritating compounds, such as hydrogen fluoride. The decomposition products released will irritate the nose and throat. Therefore, it is important to prevent exposure to decomposition products by following Chemours Safety Data Sheet (SDS) recommendations for handling.

Compatibility Concerns If HCFC-22 and Freon™ Refrigerants Are Mixed

HCFC-22 and Freon™ refrigerants are chemically compatible with each other. This means they do NOT react with each other and form other compounds. However, when these refrigerants are mixed by accident or deliberately, they will form mixtures that can be difficult to separate. Mixtures of HCFC-22 and Freon™ refrigerants cannot be separated in on-site recycle machines or in typical facilities of an off-site reclaimer. These mixtures will have to be disposed of by incineration.

Also, mixtures of HCFC-22 and Freon™ 407C or Freon™ 407A refrigerants will have performance properties different than either refrigerant alone. Therefore, we do not recommend mixing HCFC-22 and Freon™ refrigerants in any system.

Materials Compatibility

Because Freon™ refrigerants will be used in many different applications, it is important to review materials of construction for compatibility when designing new equipment, retrofitting existing equipment, or preparing storage and handling facilities. The following compatibility data is for Freon™ 407C with some elastomers and plastics commonly found in air conditioning and refrigeration systems. Freon™ 407A contains slightly different concentrations of the same components as Freon™ 407C, so the compatibility data for Freon™ 407C can also be used for Freon™ 407A.

Compatibility with Elastomers

Compatibility results are listed in **Table 5** for HCFC-22 neat, Freon™ 407C neat, and Freon™ 407C/polyol ester lubricant mixture in the presence of elastomers. It should be recognized that these data reflect compatibility in sealed tube tests, and that refrigerant compatibility in real systems can be influenced by the actual operating conditions, the nature of the polymers used, compounding formulations of the polymers, and the curing or vulcanization processes used to create the polymer. Polymers should always be tested under actual operating conditions before reaching final conclusions about their suitability.

The ratings shown in **Table 5** are based on samples of each elastomer subjected to aging in a sealed tube in the presence of the refrigerant and lubricant. For the neat refrigerant (both HCFC-22 and Freon™ 407C refrigerant), the aging occurred for two weeks at room temperature. For the Freon™ 407C refrigerant/polyol ester lubricant mixture, aging occurred for two weeks at 100 °C (212 °F). Physical properties of the sample elastomers were measured before and after aging.

Compatibility with Plastics

Compatibility results are listed in **Table 6** for R-22 neat, Freon™ 407C neat, and Freon™ 407C/polyol ester lubricant mixture in the presence of plastics. It should be recognized that these data reflect compatibility in sealed tube tests, and that refrigerant compatibility in real systems can be influenced by the actual operating conditions, the nature of the polymers used, and the compounding formulations of the polymers. Polymers should always be tested under actual operating conditions before reaching final conclusions about their suitability.

The ratings shown in **Table 6** are based on samples of each plastic subjected to aging in a sealed tube in the presence of the refrigerant and lubricant. For the neat refrigerant (both HCFC-22 and Freon™ 407C refrigerant), the aging occurred for two weeks at room temperature. For the Freon™ 407C refrigerant/polyol ester lubricant mixture, aging occurred for two weeks at 100 °C (212 °F). Physical properties of the sample plastics were measured before and after aging.

Refrigerant comes in contact with the motor windings in hermetic and semi-hermetic compressors. As a result, the motor materials must be compatible with the refrigerant and lubricant used in the system. Equipment manufacturers have tested the compatibility of their motor materials with Freon™ refrigerants and polyol ester lubricants. Be sure to check with the manufacturer of your equipment before using Freon™ refrigerant in any hermetic or semi-hermetic compressor.

Table 5. Compatibility of Freon™ 407C Refrigerant with Selected Elastomers

	R-22			Freon™ 407C (R-407C)			Freon™ 407C/Polyol Ester		
Material	Rating	Linear Swell, %	Hardness Change, Units	Rating	Linear Swell, %	Hardness Change, Units	Rating	Linear Swell, %	Hardness Change, Units
Alcryn	0	–3	0	0	1	4	0	0	–10
Buna S	2a	1	–21	0	1	–10	1	6	–38
Butyl Rubber	0	0	–7	0	–1	0	0	–1	–8
Chlorosulfonated Polyethylene	1	0	–7	0	0	0	1	6	–12
EPDM	0	–1	–8	0	0	–6	0	–1	0
Ethylene Acrylic	2b	19	–12	0	8	–7	2	16	–12
Hytrel	0	9	–2	0	2	0	0	3	0
Kalrez	1	11	—	1	5	–16	1	6	–23
Natural Rubber	1	11	–9	0	–1	–3	0	5	–10
NBR	2b	—	–21	0	0	–1	0	5	–8
Neoprene	2a	15	–20	0	1	–1	0	1	–10
Polysulfide	1	2	–13	0	0	1	0	0	5
Polyurethane	2	21	–17	0	4	–6	1c	7	–30
Santoprene	0	1	–1	0	0	1	0	–1	–3
Silicone	1	11	–3	0	2	–10	1	6	–13
Viton™ A	1	21	–4	2	14	–12	2	23	–15
Viton™ B	2	18	–17	2	15	–28	2	18	–32

Rating

0—Both % linear swell and hardness change are less than 10

1—Either swell OR hardness change greater than 10

2—Both swell AND hardness change greater than 10

Comments

a—Sample popped due to rapid degassing

b—Sample distorted

c—Significant loss of tensile properties

Compatibility with Desiccants

In refrigeration systems, keeping the refrigerant and lubricant free of moisture is very important. Dryers filled with moisture-absorbing desiccant are typically used to prevent moisture accumulation. The XH-6 desiccant produced by UOP is typically used for R-22. While this desiccant, as well as UOP's XH-9, is compatible with Freon™ 407C and Freon™ 407A, both desiccants will absorb R32. The XH-11 desiccant from UOP is compatible with Freon™ 407C and Freon™ 407A and will exclude R32. Sporlan® and Emerson offer solid core driers that are compatible with Freon™ 407C and Freon™ 407A.

Refrigeration Lubricants

Most compressors require a lubricant to protect internal moving parts. The compressor manufacturer usually recommends the type of lubricant and proper viscosity that should be used to ensure acceptable operation and equipment durability. Recommendations are based on several criteria, which can include:

- Lubricity
- Lubricant/refrigerant solubility
- Lubricant/refrigerant miscibility
- Compatibility with materials of construction
- Thermal stability and compatibility with other lubricants

It is important to follow the manufacturer's recommendations for lubricants to be used with their equipment.

Table 6. Compatibility of Freon™ 407C Refrigerant with Selected Plastics

Material	R-22		Freon™ 407C (R-407C)		Freon™ 407C/Polyol Ester	
	Rating	Weight Change, %	Rating	Weight Change, %	Rating	Weight Change, %
High-Density Polyethylene	1	3	0	1	1	2
Polypropylene	1	9	0	1	1	5
Polystyrene	2c	—	1	4	2c	28
Polyvinyl Chloride	1	2	0	0	0	3
Fluoropolymers						
PTFE	1	4	1	2	1	2
ETFE	1	8	1	4	1	4
PVDF	1	3	1	2	1	7
ABS	2c	—	1	2	2c	14
Epoxy	0	0	0	0	0	1
Acetal	1	8	0	1	1	2
Modified Polyphenylene Oxide	2b	33	1	2	1	3
Polycarbonate	2b	32	1	2	1	4
Poly(butylene terephthalate)	0	1	0	0	0	1
Nylon	0	1	0	0	1b	0
Polyetherimide	1	8	0	1	0	1
Polyimide	0	0	0	1	0	0
Polyphenylene Sulfide	1	5	1	2	1	3
Polysulfone	2	13	0	1	0	1

Rating

0—Best by visual inspection and weight change

1—Borderline by visual inspection and weight change

2—Worst by visual inspection and weight change

Comments

a—No change

b—Surface change

c—Destroyed or dissolved

Lubricant return to the compressors is very important as well. One factor that affects this is the liquid-phase lubricant/refrigerant miscibility, particularly at evaporator temperatures. Miscibility is the ability of two liquids to mix and form a single liquid phase—similar to water and alcohol. Ideally, the lubricant/refrigerant pair have sufficient miscibility or mutual solubility to allow the lubricant to flow with the liquid refrigerant and return to the compressor. Even if the lubricant/refrigerant pair are not miscible (two liquid phases form) in the evaporator, they may still have some degree of solubility. Solubility of refrigerant in lubricant lowers lubricant viscosity, which helps it flow through the evaporator and return to the compressor. This is why many refrigeration systems can operate properly, even though the lubricant and refrigerant are immiscible (yet partially soluble) at evaporation temperatures. Other factors, such as refrigerant vapor velocity and system geometry, play key roles in lubricant return. Overall, it is important to note that lubricant/refrigerant miscibility is helpful, but not necessarily essential for proper system operation.

Note that HCFC-22/mineral oil and HCFC-22/alkylbenzene liquid phase miscibility are listed for reference. In general, HCFC-22 and mineral oil are miscible over most of the expected ranges of operating conditions for normal air conditioning and high to medium temperature operation. HCFC-22 and alkylbenzene are miscible over a much wider range of temperatures. Miscibility is generally believed to aid lubricant return to the compressor. Therefore, it may be desirable in a retrofit of an existing system of this type to use a miscible lubricant with Freon™ HFC refrigerants. In general, Freon™ HFC refrigerants, such as Freon™ 407C and Freon™ 407A, are miscible with polyol ester lubricant and immiscible with alkylbenzene and mineral oil lubricant. Another important point is that residual mineral oil or alkylbenzene left in a refrigeration system after a retrofit to any HFC refrigerant is performed decreases the lubricant/refrigerant miscibility. This is one of the reasons why three oil changes are generally recommended when a system is being converted or retrofitted to use HFC refrigerants and POE lubricants.

Table 7 lists the liquid phase miscibility of Freon™ 407C refrigerant with multiple lubricants. The miscibility is determined by several factors: the relative amounts of refrigerant and lubricant present, the temperature, the chemical makeup of the lubricant and refrigerant, and the viscosity of the lubricant. The table shows the temperature range over which several different compositions of refrigerant and lubricants are fully miscible.

Compressor and equipment manufacturers are testing and recommending lubricants for use in their equipment with Freon™ 407C and Freon™ 407A refrigerants. There will be continuing research and development of new lubricants by the equipment manufacturers in years to come. Therefore, we strongly recommend that you review your system lubricant needs with equipment manufacturers before any unit installation or retrofit to Freon™ 407C or Freon™ 407A refrigerant.

Safety

Inhalation Toxicity

Freon™ 407C and Freon™ 407A refrigerants pose no acute or chronic hazard when handled in accordance with Chemours recommendations and exposures are maintained at or below recommended exposure limits, such as the Chemours Acceptable Exposure Limit (AEL) of 1000 ppm. An AEL is an airborne exposure limit established by Chemours that specifies time-weighted average (TWA) airborne concentrations, usually 8 hr, to which nearly all workers may be repeatedly exposed without adverse effects. In practice, short-term exposures should not exceed three times the established exposure limit for more than a total of 30 min during a workday.

The exposure limits of 1000 ppm for Freon™ 407C and Freon™ 407A refrigerants are the same level as the Threshold Limit Value (TLV) established for HCFC-22. However, like HCFC-22, inhalation exposure above the recommended exposure limit to the vapors of Freon™ 407C or Freon™ 407A refrigerants may cause human health effects that can include temporary nervous system depression with anesthetic effects, such as dizziness, headache, confusion, loss of coordination, and even loss of consciousness. If you experience any of the above initial symptoms, move to fresh air and seek medical attention as a precaution. Gross overexposure may be fatal.

Table 7. Miscibility of Freon™ 407C Refrigerant in Various Lubricants (Miscible Temperature Range Shown in °C)

Freon™ 407C (R-407C) in Various Lubricants Combinations Tested (% Refrigerant in Mixture)

	Mobil EAL32		Lubrikuhl 32		Castrol SW32	
wt%	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
95	–60	80	–60	80	–60	80
90	–60	80	–50	80	–55	80
80	–60	80	–50	80	No Data	No Data
60	–60	80	–60	80	–60	80
30	–60	80	–60	80	–60	80

Cardiac Sensitization

An effect that occurs with most hydrocarbons and halocarbons at high concentrations is that the human heart can become sensitized to adrenalin (cardiac sensitization). This can lead to cardiac irregularities, such as irregular pulse, palpitations, inadequate circulation, and even cardiac arrest. The likelihood of these cardiac problems increases if you are under physical or emotional stress (due to the potential for increased amounts of adrenalin in your system). Freon™ 407C and Freon™ 407A refrigerants can cause cardiac sensitization at inhalation levels well above the recommended exposure limit, but the effect level varies from person to person. If you experience any of the above symptoms of cardiac sensitization, move to fresh air and seek medical attention as a precaution. Gross overexposure may be fatal.

As part of treatment for cardiac sensitization, DO NOT treat the patient with catecholamines, such as adrenaline, because these drugs could increase the risk of cardiac problems.

Skin and Eye Contact

Always wear protective clothing when there is a risk of exposure to liquid Freon™ 407C or Freon™ 407A refrigerants. In liquid form, Freon™ 407C and Freon™ 407A refrigerants can cause frostbite. Where splashing of liquid

refrigerant is possible, always wear eye protection. If skin or eyes are splashed with liquid Freon™ 407C or Freon™ 407A refrigerant, flush area with lukewarm water (do not use hot water). If frostbite has occurred, call a physician. If eyes are splashed, immediately flush with plenty of water for at least 15 min. Call a physician.

Spills or Leaks

If a large release of vapor occurs, such as from a large spill or leak, the vapors may concentrate near the floor or in low spots and displace the oxygen available for breathing. This could cause suffocation. When a large spill or leak occurs, always wear appropriate respiratory and other personal protective equipment. Evacuate everyone from the area until it has been ventilated. Use blowers or fans to circulate the air at floor level. Do not re-enter the affected area unless you are equipped with a self-contained breathing apparatus.

Nonflammability

Nonflammability is an essential requirement for refrigerants used in the air conditioning industry. Although HFC-32 is a flammable compound, Freon™ 407C and Freon™ 407A refrigerants are formulated such that they remain nonflammable during shipping, handling, storage, use, and if they leak from a unit. Freon™ 407C and Freon™ 407A refrigerants are classified as A1/A1 refrigerants by ASHRAE. Also, Freon™ 407C refrigerant has been certified as practically nonflammable (the same as R-22) by Underwriters Laboratories, Inc. (USA) and is on their list of recognized refrigerants.

Combustibility of Freon™ 407C and Freon™ 407A

Freon™ 407C and 407A are not flammable in air at temperatures up to 100 °C (212 °F) at atmospheric pressure. However, mixtures of 407C or 407A with high concentrations of air at elevated pressure and/or temperature can become combustible in the presence of an ignition source. 407C and 407A can also become combustible in an oxygen-enriched environment (oxygen concentrations greater than that in air). Whether a mixture containing 407C or 407A and air, or 407C or 407A in an oxygen-enriched atmosphere becomes combustible depends on the inter-relationship of 1) the temperature, 2) the pressure, and 3) the proportion of oxygen in the mixture. In general, 407C or 407A should not be allowed to exist with air above atmospheric pressure or at high temperatures or in an oxygen-enriched environment. For example: 407C or 407A should NOT be mixed with air under pressure for leak testing or other purposes.

Refrigerants should not be exposed to open flames or electrical heating elements. High temperatures and flames can cause refrigerants to decompose, releasing toxic and irritating fumes. In addition, a torch flame can become dramatically larger or change color if used in high concentrations of many refrigerants, including R-500 or R-22, as well as many alternative refrigerants. This flame enhancement can cause surprise or even injury. Always recover refrigerants, evacuate equipment, and ventilate work areas properly before using any open flames.

Based on the above information, the following operating practices are recommended.

- Do Not Mix with Air for Leak Testing
  - Equipment should never be leak tested with a pressurized mixture of 407C or 407A and air. Pressurized mixtures of dry nitrogen and 407C or 407A can be used for leak testing.
- Bulk Delivery and Storage
  - Tanks should normally be evacuated prior to initial filling and should never be filled while under positive air pressure.
  - Tank pressure should never be allowed to exceed the maximum allowable working pressure when filling with 407C or 407A. Relief devices on either the tanks or the supply system should be present and in good operating condition.
  - Tank pressures should be monitored routinely.
  - Air lines should never be connected to storage tanks.
- Filling and Charging Operations
  - Before evacuating cylinders or refrigeration equipment, any remaining refrigerant should be removed by a recovery system.
  - Vacuum pump discharge lines should be free of restrictions that could increase discharge pressures and result in the formation of combustible mixtures.
  - Cylinders or refrigeration equipment should be evacuated at the start of filling and never filled while under positive air pressure.
  - Filled cylinders should periodically be analyzed for air (nonabsorbable gas [NAG]).

- Refrigerant Recovery Systems

  Efficient recovery of refrigerant from equipment or containers requires evacuation at the end of the recovery cycle. Suction lines to a recovery compressor should be periodically checked for leaks to prevent compressing air into the recovery cylinder during evacuation. In addition, the recovery cylinder pressure should be monitored and evacuation stopped in the event of a rapid pressure rise, indicating the presence of air. The recovery cylinder contents should then be analyzed for NAG, and the recovery system leak checked if air is present. Do not continue to evacuate a refrigeration system that has a major leak.

- Combustibility with Chlorine

  Experimental data have also been reported that indicate combustibility of HFC-134a (a component of Freon™ 407C and Freon™ 407A) in the presence of chlorine.

Air Monitors and Leak Detection

Service personnel have used leak detection equipment for years when servicing equipment. Leak detectors exist not only for pinpointing specific leaks, but also for monitoring an entire room on a continual basis for the absence of oxygen or presence of refrigerant. There are several reasons for leak pinpointing or area monitoring, including: conservation of refrigerants, protection of employees and valuable equipment, and reduction of fugitive emissions.

Prior to the purchase of a detector or monitor, make sure you consider your requirements or criteria for the monitor, such as sensitivity, detection limits, and selectivity.

Types of Detectors

Using selectivity as a criteria, leak detectors can be placed into one of three categories: nonselective, halogen-selective, or compound-specific. In general, as the specificity of the monitor increases, so does the complexity and cost. Other methods used to find leaks are to add fluorescent additives to the system or coat the suspect area with a soapy-water solution and look for soap bubbles.

A detailed discussion of leak detection is given in the Chemours technical bulletin, "Leak Detector Guidance for Freon™ Refrigerants".

Nonselective Detectors

Nonselective detectors are those that will detect any type of emission or vapor present, regardless of its chemical composition. These detectors are typically quite simple to use, very durable, inexpensive, and usually portable. However, their inability to be calibrated, long-term drift, and lack of selectivity and sensitivity limit their use for area monitoring.

Halogen-Selective Detectors

Halogen-selective detectors use a specialized sensor that allows the monitor to detect compounds containing fluorine, chlorine, bromine, and iodine without interference from other species. The major advantage of such a detector is a reduction in the number of "nuisance alarms"—false alarms caused by the presence of some compound in the area other than the target compound.

These detectors are typically easy to use, feature higher sensitivity than the nonselective detectors (detection limits are typically <5 ppm when used as an area monitor and <0.05 oz/yr when used as a leak pinpointer), and are very durable. In addition, due to the partial specificity of the detector, these instruments can be calibrated easily.

Compound-Specific Detectors

The most complex detectors, which are also the most expensive, are compound-specific detectors. These units are typically capable of detecting the presence of a single species without interference from other compounds.

Fluorescent Additives

Fluorescent additives have been used in refrigeration systems for several years. These additives, invisible under ordinary lighting, but visible under ultraviolet (UV) light, are used to pinpoint leaks in systems. The additives are typically placed into the refrigeration lubricant when the system is serviced. Leaks are detected by using a UV light to search for additive that has escaped from the system. The color of the additive when subjected to UV light is normally a bright green or yellow and is easily seen.

As a leak pinpointer, fluorescent additives work very well, because large areas can be rapidly checked by a single individual. And, the recent introduction of battery-powered UV lights has made this task even simpler. Leak rates of less than 0.25 oz/yr can be found with the additives. The only drawback to the use of additives is that some areas may be visually unobservable due to cramped spaces.

One cautionary note concerning the use of fluorescent additives: the compatibility of the specific additive with the lubricant and refrigerant should be tested prior to use. For detailed information about which lubricants and refrigerants have been tested with which additives, contact the fluorescent additive manufacturer.

Storage and Handling

Shipping Containers in the United States

Freon™ 407C and Freon™ 407A refrigerant blends are liquefied gases. According to the U.S. Department of Transportation (DOT), a nonflammable compressed gas is defined as a nonflammable material having an absolute pressure greater than 40 psi at 21 °C (70 °F) and/or an absolute pressure greater than 104 psi at 54 °C (130 °F).

The appropriate DOT designations for both Freon™ 407C and Freon™ 407A are as follows:

Proper shipping name for Freon™ 407A: Liquefied Gas, N.O.S. (contains difluoromethane and pentafluoroethane)

Proper shipping name for Freon™ 407C: Liquefied Gas, N.O.S. (contains difluoromethane, pentafluoroethane, and 1,1,1,2-tetrafluoroethane)

Hazard Class: Nonflammable Gas

UN/NA No.: UN3163

Three different types of containers can be used to ship Freon™ 407C; their water capacity, dimensions, and DOT specifications are provided in **Table 8.**

Table 8. Specifications of Shipping Containers for Freon™ 407C (R-407C)

Water Capacity	Dimensions	DOT Specification
30 lb	10 x 10 x 17 in (box)	39
123 lb	55 in H x 10 in OD	4BW400
1682 lb ton	82 in L x 30 in OD	110A500W

The 30 lb cylinder, known as a Dispos-A-Can® (DAC), fits into a box that measures 10 x 10 x 17 in and is a single-use container. The DAC valve will be standard for Freon™ 407C.

Three different types of containers can be used to ship Freon™ 407A; their water capacity, dimensions, and DOT specifications are provided in **Table 9**.

Table 9. Specifications of Shipping Containers for Freon™ 407A (R-407A)

Water Capacity	Dimensions	DOT Specification
30 lb	10 x 10 x 17 in (box)	39
123 lb	55 in H x 10 in OD	4BW400
1682 lb ton	82 in L x 30 in OD	110A500W

Table 10. Package Offering for Freon™ 407C and Freon™ 407A

Refrigerant	Color	PMS No.	Net Weight (lb) of Freon™ 407C and Freon™ 407A		
			30 lb Water Capacity	125 lb Water Capacity	Ton Cylinder
Freon™ 407C (R-407C)	Medium Brown	471	29	115	1550
Freon™ 407A (R-407A)	Lime Green	368	25	100	1350

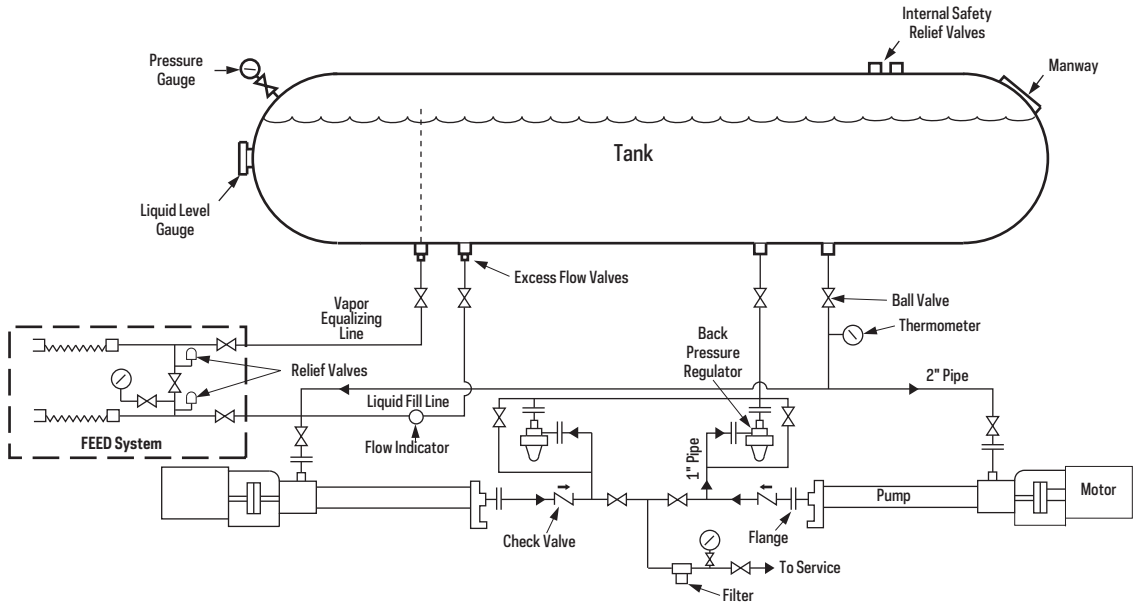
Bulk Storage Systems

Chemours can supply storage systems to its Freon™ 407C customers. The systems are prefabricated, tested, and ready to install on-site. The units are designed to optimize economy, efficiency, and safety in the storage and dispensing of Freon™ 407C. The delivered systems include all components, such as storage tanks, pumps, piping, valves, motors, and gauges, as an integrated unit. All systems are equipped with the Chemours Fluorochemical Emission Elimination Delivery (FEED) system to prevent emissions during deliveries and with dual pumps to provide an installed spare. The units are skid-mounted and require only placement on a concrete pad and connection to electrical and process systems.

A typical bulk storage system is shown in **Figure 5**.

Your Chemours marketing representative can arrange for guidance on site selection, purchase, installation, startup, and maintenance.

Figure 5. Typical Bulk Storage System



Converting Bulk Storage Tanks from HCFC-22 to Freon™ 407C or Freon™ 407A

Before switching from HCFC-22 to Freon™ 407C or 407A, the existing storage equipment must be checked to verify that it is adequate. Storage tanks built to the specifications of the American Society of Mechanical Engineers (ASME) Pressure Vessel Code are required to have a metal nameplate indicating each tank's maximum allowable working pressure (MAWP). The rating must be 300 psig (2065 kPa abs) or higher for Freon™ 407C or Freon™ 407A service. The set pressure and capacity of the relief devices on the top of the tanks must also be verified and changed, if necessary.

Note: Most bulk storage tanks currently in service for HCFC-22 are NOT suitable for Freon™ 407C or Freon™ 407A due to an inadequate pressure rating.

We recommend that storage tanks be completely emptied of all HCFC-22 liquid and vapor before introducing Freon™ 407C or Freon™ 407A. In general, converting a storage tank from HCFC-22 requires:

1. Removing HCFC-22 from the storage tank, lines, and equipment.
2. Evacuating the storage tank to 25 in of mercury vacuum (16.7 kPa abs) and purging with compressed dry nitrogen.
3. Making necessary repairs to the tank after initial evacuation and purging.
4. Repeating Step 2 until HCFC-22 and moisture analyses are within acceptable limits.
5. Refilling system with the appropriate refrigerant (Freon™ 407C or Freon™ 407A).

The preceding is a simplified outline of what is actually a lengthy procedure. Your Chemours marketing representative can assist in obtaining the equipment, instrumentation, and technical assistance to safely and effectively make the conversion.

Material Compatibility Concerns

Most metal components suitable for use with HCFC-22 are also compatible with Freon™ 407C and Freon™ 407A, including standard types of carbon steel, aluminum, and copper. Some elastomeric or non-metallic components suitable for HCFC-22 may not be adequate. Therefore, all elastomeric or nonmetallic components throughout the system must be identified and their compatibility with Freon™ 407C or Freon™ 407A verified. See Material Compatibility section. For complete reliability, any component that cannot be properly identified should be replaced.

In a fluorocarbon storage system, elastomers are most commonly found in:

- Packing and seats of manual valves
- Pressure-relief device seats
- Flange and manway gaskets
- Mechanical pump seals
- Wet-end pump gaskets and O-rings

- Filter O-rings
- Sight-flow indicator gaskets
- Back-pressure regulator diaphragms and O-rings

Handling Precautions for Freon™ 407C and Freon™ 407A Shipping Containers

The following rules for handling Freon™ 407C and Freon™ 407A containers are strongly recommended:

- Use personal protective equipment, such as side shield glasses, gloves, and safety shoes when handling containers.
- Avoid skin contact with liquid Freon™ 407C or Freon™ 407A, because it may cause frostbite.
- Never heat a container to a temperature higher than 52 °C (125 °F).
- Never apply direct flame or live steam to a container or valve.
- Never refill disposable cylinders with anything. The shipment of refilled disposable cylinders is prohibited by DOT regulations.
- Never refill returnable cylinders without Chemours consent. DOT regulations forbid transportation of returnable cylinders refilled without Chemours authorization.
- Never use a lifting magnet or sling (rope or chain) when handling containers. A crane may be used when a safe cradle or platform is used to hold the container.
- Never use container for rollers, supports, or any purpose other than to carry Freon™ 407C or Freon™ 407A.
- Protect containers from any object that will result in cut or other abrasion in the surface of the metal.
- Never tamper with the safety devices in the valves or containers.
- Never attempt to repair or alter containers or valves.
- Never force connections that do not fit. Make sure the threads on the regulators or other auxiliary equipment are the same as those on the container valve outlet.
- Keep valves tightly closed and valve caps and hoods in place when the containers are not in use.
- Store containers under a roof to protect them from weather extremes.
- Use a vapor recovery system to collect Freon™ 407C and Freon™ 407A vapors from lines after unloading a container.

Recovery, Recycle, Reclamation, and Disposal

Responsible uses of Freon™ refrigerants requires that the product be recovered for reuse or disposal whenever possible. Chemours purchases used refrigerants for reclamation through its distributor networks in the United States, Canada, and Europe. In the United States, used Freon™ refrigerants are accepted as part of this program. Recovery and reuse of Freon™ refrigerants makes sense from an environmental and economic standpoint. In addition, the U.S. Clean Air Act prohibits known venting of CFC, HCFC, and HFC refrigerants during the maintenance, servicing, or disposal or refrigeration equipment.

Recovery

Recovery refers to the removal of Freon™ 407C or Freon™ 407A from equipment and collection in an appropriate external container. As defined by the Air Conditioning and Refrigeration Institute (ARI), a U.S. organization, recovery does not involve processing or analytical testing. Freon™ 407C or Freon™ 407A may be recovered from refrigeration equipment using permanent on-site equipment or one of the portable recovery devices now on the market. The portable devices contain a small compressor and an air-cooled condenser and may be used for vapor or liquid recovery. At the end of the recovery cycle, the system is evacuated to remove vapors. In the United States, the Environmental Protection Agency (EPA) sets standards for recovery equipment. Before purchasing a specific recovery unit, check with the manufacturer to be sure that it can be used to recover Freon™ 407C or Freon™ 407A.

Recycle

Refrigerant recycle refers to the reduction of used refrigerant contaminants using devices that reduce oil, water, acidity, and particulates. Recycle is usually a field or shop procedure with no analytical testing of refrigerant. Before using one of these devices with Freon™ 407C or Freon™ 407A, consult the manufacturer to confirm compatibility.

Reclamation

Reclamation refers to the reprocessing of used Freon™ 407C and Freon™ 407A to new product specifications. Quality of reclaimed product is verified by chemical analysis. In the United States, Freon™ 407C and Freon™ 407A are included in the Chemours refrigerant reclamation program. Contact Chemours or one of its authorized distributors for further information.

Reclamation offers advantages over on-site refrigerant recycling procedures, because these systems cannot guarantee complete removal of contaminants. Putting refrigerants that do not meet new product specifications back into expensive equipment may cause damage.

Disposal

Disposal refers to the destruction of used Freon™ 407C or Freon™ 407A. Disposal may be necessary when Freon™ 407C or Freon™ 407A has become badly contaminated with other products and no longer meets the acceptance specifications of Chemours or other reclaimers. Licensed waste disposal firms are available for this purpose. Be sure to check the qualifications of any firm before sending them used Freon™ 407C or Freon™ 407A.

For more information on the Freon™ family of refrigerants, or other refrigerant products, visit freon.com or call (800) 235-7882.

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