Freon™ HP80, HP81, and 404A

Refrigerants (R-402A, R-402B, and R-404A)

Properties, Uses, Storage, and Handling

Chemours™

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Introduction

Chlorofluorocarbons (CFCs), which were developed over 60 years ago, have many unique properties. They are low in toxicity, nonflammable, noncorrosive, and compatible with other materials. In addition, they offer the thermodynamic and physical properties that make them ideal for a variety of uses. CFCs are used as refrigerants; blowing agents in the manufacture of insulation, packaging, and cushioning foams; and cleaning agents for metal and electronic components; as well as in many other applications.

However, the stability of these compounds, coupled with their chlorine content, has linked them to depletion of the Earth's protective ozone layer. As a result, Chemours has phased out production of CFCs and introduced acceptable alternatives, such as the Freon™ HP refrigerant family.

Freon™ HP Refrigerants

The products designated as Freon™ HP refrigerants are intended as replacements for R-502 in medium- and low-temperature refrigeration systems. The Freon™ HP refrigerant family contains two different types of refrigerants. Both types involve the use of refrigerant blends to achieve alternatives that will act very much like R-502 in refrigeration systems.

The first type of blends incorporate the following refrigerants in two compositions to optimize different performance characteristics:

	HCFC-22	HFC-125	Propane
Freon™ HP80 (R-402A), wt%	38	60	2
Freon™ HP81 (R-402B), wt%	60	38	2

In addition, Chemours has formulated a mixture based on all-HFC refrigerants, which results in no ozone depletion factor. This refrigerant is called Freon™ 404A (R-404A), and its composition is:

	HFC-125	HFC-143a	HFC-134a
Freon™ 404A (R-404A), wt%	44	52	4

The individual components of the three mixtures are listed in **Table 1** to show their chemical names and formulae. In addition, the physical properties of the Freon™ HP refrigerants are listed in **Table 3**.

Uses

The Freon™ HP refrigerants can be used in virtually all R-502-based applications, either as a result of retrofitting existing equipment that uses R-502 or following development of new equipment designed to use Freon™ HP products.

R-502 currently serves a wide range of applications in the refrigeration industry. It is used widely in supermarket applications, food service and warehousing, transport refrigeration, cascade systems for very low temperatures, and other assorted applications. It offers good capacity and efficiency without suffering from the high compressor discharge temperatures that can be seen with HCFC-22 single-stage equipment.

Freon™ HP80 and HP81, which contain HCFC-22, are each formulated to optimize different performance characteristics.

Freon™ HP80 offers compressor discharge temperatures equivalent to R-502, with improved capacity versus R-502, and slightly lower theoretical efficiency.

Freon™ HP81 offers the highest efficiency versus R-502, with slightly better capacity. However, the higher HCFC-22 content results in compressor discharge temperatures in the range of 14 °C (25 °F) higher than that of R-502, which makes Freon™ HP81 most suited for medium-temperature systems such as ice machines.

Table 1. Refrigerant Information

Refrigerant	Chemical Name	Formula	CAS No.	Molecular Weight
HCFC-22	Chlorodifluoromethane	CF_2HCl	75-45-6	6.47
HFC-125	Pentafluoroethane	CF_3CHF_2	354-33-6	120.02
HFC-134a	1,1,1,2-Tetrafluoroethane	CF_3CH_2F	811-97-2	102.0
HFC-143a	1,1,1-Trifluoroethane	CF_3CH3	420-46-2	4.08
HC-290	Propane	C_3H8	74-98-6	4.1

Freon™ 404A (R-404A) offers the best overall properties when compared with R-502. Capacity and efficiency values should be equivalent to R-502, and compressor discharge temperatures may be up to 9 °C (14 °F) lower than R-502, which may equate to longer compressor life and better lubricant stability.

In addition, the heat transfer characteristics of all the Freon™ HP products appear to be better than R-502, so any loss of compression efficiency may be offset by improvements in heat transfer.

Due to the differences in operating characteristics described above, Freon™ HP80 and HP81 are typically selected for different applications. Freon™ HP81 is preferred where higher energy efficiency and capacity are needed and higher discharge temperatures will not create operating difficulties. Both Freon™ HP80 and Freon™ 404A (R-404A) are full-range R-502 replacements, with Freon™ HP80 preferred for retrofitting of existing systems, and Freon™ 404A (R-404A) preferred for new equipment. Freon™ 404A (R-404A) can also be used for retrofitting existing equipment where HFCs are desired. **Table 2** shows markets that currently use each of these refrigerants.

Table 2. Freon™ HP Refrigerant Market Applications

Product	Medium Temperature	Low Temperature
Freon™ HP81	Ice Machines Food Service Vending Supermarket	To Be Determined
Freon™ HP80	Supermarket Transport	Supermarket Transport Food Service
Freon™ 404A (R-404A)	All	

Physical Properties

General physical properties of the Freon™ HP refrigerants are shown in **Table 3**. Pressure enthalpy diagrams for Freon™ HP refrigerants are shown in **Figures 1–6**. Additional physical property data may be found in other Chemours publications.

Chemical/Thermal Stability

Stability with Metals

Stability tests for refrigerant with metals are typically performed in the presence of refrigeration lubricants. Results of sealed tube stability tests available for R-502/mineral oil and alkylbenzene lubricants have shown long-term stability in contact with copper, steel, and aluminum in actual refrigeration systems. Mineral oils, alkylbenzene, mixtures of mineral oil/alkylbenzene and polyol esters (POE) are all possible candidates for use with Freon™ HP80 and HP81; POEs are proposed lubricants for use with Freon™ 404A (R-404A).

The 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). Both the neat lubricant and a mixture of lubricant and refrigerant (50/50 volume ratio) were tested. Visual ratings were obtained on both the liquid solutions and the metal coupons after the designated exposure time. The visual ratings range from 0-5, with 0 being best.

After the visual ratings were obtained, sample tubes were opened and the lubricant and refrigerant (if present) were analyzed. The lubricant was typically checked for halide content and viscosity, while the refrigerant was examined for the presence of decomposition products. **Table 4** summarizes typical data for Freon™ HP refrigerants. Visual ratings are listed for the neat lubricant, the lubricant/refrigerant solution, and the three metals that were present in the lubricant/refrigerant solutions. Viscosity was determined on the unused lubricant, the tested neat lubricant, and the lubricant tested in the presence of refrigerant. Decomposition products were determined in some cases. Typical measurements for decomposition products are in the low parts per million (ppm) range.

Freon™ HP81 tests with various lubricants indicate it has adequate chemical stability with these lubricants. In addition, we believe that HP80 will have similar behavior due to the same refrigerants being used in the formulation. Freon™ 404A (R-404A) tests with common POE lubricants indicate that chemical stability of Freon™ 404A (R-404A) with common metals used in refrigeration systems is acceptable.

Note: Lubricant/refrigerant combinations shown throughout this report are for the purposes of comparing the stability and compatibility of different lubricants with the Freon™ HP products. No recommendation is made or implied that these combinations will operate successfully in refrigeration systems.

Table 3. General Property Information

Physical Property	Unit	Freon™ HP80 (R-402A)	Freon™ HP81 (R-402B)	Freon™ 404A (R-404A)
Molecular Weight, avg.	g/mol	101.55	94.71	97.6
Boiling Point (1 atm)	°C (°F)	−49.2 (−56.5)	−47.4 (−53.2)	−46.5 (−51.6)
Freezing Point (1 atm)	°C (°F)	N/A	N/A	N/A
Critical Temperature	°C (°F)	75.5 (167.9)	82.6 (180.7)	72.1 (161.7)
Critical Pressure	kPa (psia)	4135 (599.7)	4445 (644.8)	3732 (541.2)
Critical Density	kg/m³ (lb/ft³)	541.7 (33.82)	530.7 (33.13)	484.5 (30.23)
Liquid Density at 25 °C (77 °F)	kg/m³ (lb/ft³)	1151 (71.86)	1156 (72.14)	1048 (65.45)
Density, Saturated. Vapor at -15 °C (5 °F)	kg/m³ (lb/ft³)	19.93 (1.24)	16.90 (1.05)	18.20 (1.14)
Specific Heat, Liquid at 25 °C (77 °F)	kJ/kg·K (Btu/lb·°F)	1.3 (0.328)	1.34 (0.320)	1.53 (0.367)
Specific Heat, Vapor at 25 °C (77 °F) (1 atm)	kJ/kg·K (Btu/lb·°F)	0.755 (0.181)	0.725 (0.173)	0.870 (0.207)
Vapor Pressure at 25 °C (77 °F)	kPa (psia)	1337 (194.0)	1254 (181.9)	1255 (182.0)
Heat of Vaporization at Boiling Point	kJ/kg (Btu/lb)	194.0 (83.5)	210.0 (90.3)	202.1 (87.0)
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)	 6.91E-2 (4.00E-2) 1.266E-2 (7.32E-3)	 7.35E-2 (4.25E-2) 1.205E-2 (6.96E-3)	 6.83E-2 (3.94E-2) 1.346E-2 (7.78E-3)
Viscosity at 25 °C (77 °F) Liquid Vapor (1 atm)	 Pa·s Pa·s	 1.38E-4 1.29E-5	 1.45E-4 1.28E-5	 1.28E-4 1.22E-5
Flammability Limit in Air (1 atm)	vol%	None	None	None
Ozone Depletion Potential	(CFC-12 = 1.0)	0.02	0.03	0.0
Halocarbon Global Warming Potential	(CFC-11 = 1.0)	0.63	0.52	0.94
TSCA Inventory Status	Reported/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 inhalation 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.

Thermal Decomposition

Like R-502, Freon™ HP refrigerants will decompose when exposed to high temperature or flame sources. Decomposition may produce toxic and irritating compounds, such as hydrogen chloride and hydrogen fluoride. The decomposition products released will irritate the nose and throat. Therefore, it is important to prevent decomposition by following Chemours Safety Data Sheet (SDS) recommendations for handling and use.

Compatibility Concerns If R-502 and Freon™ HP Refrigerants Are Mixed

R-502 and Freon™ HP refrigerants are chemically compatible with each other; this means that they do not react with each other and form other compounds. However, when the different refrigerants are mixed by accident or deliberately, they will form mixtures that can be very difficult to separate. Therefore, mixtures of R-502 and Freon™ HP refrigerants cannot be separated in on-site recycle machines or in the typical facilities of an off-site reclaimer. These mixtures will have to be disposed of by incineration.

Also, mixtures of R-502 and Freon™ HP refrigerants will have performance properties different from either refrigerant alone. These properties may not be acceptable for your systems. Therefore, we do not recommend mixing R-502 and Freon™ HP refrigerants in any system. First remove the R-502 properly (see Recovery discussion) and then charge the new refrigerant.

Figure 1. Freon™ 404A (R-404A) Pressure-Enthalpy Diagram (SI Units)

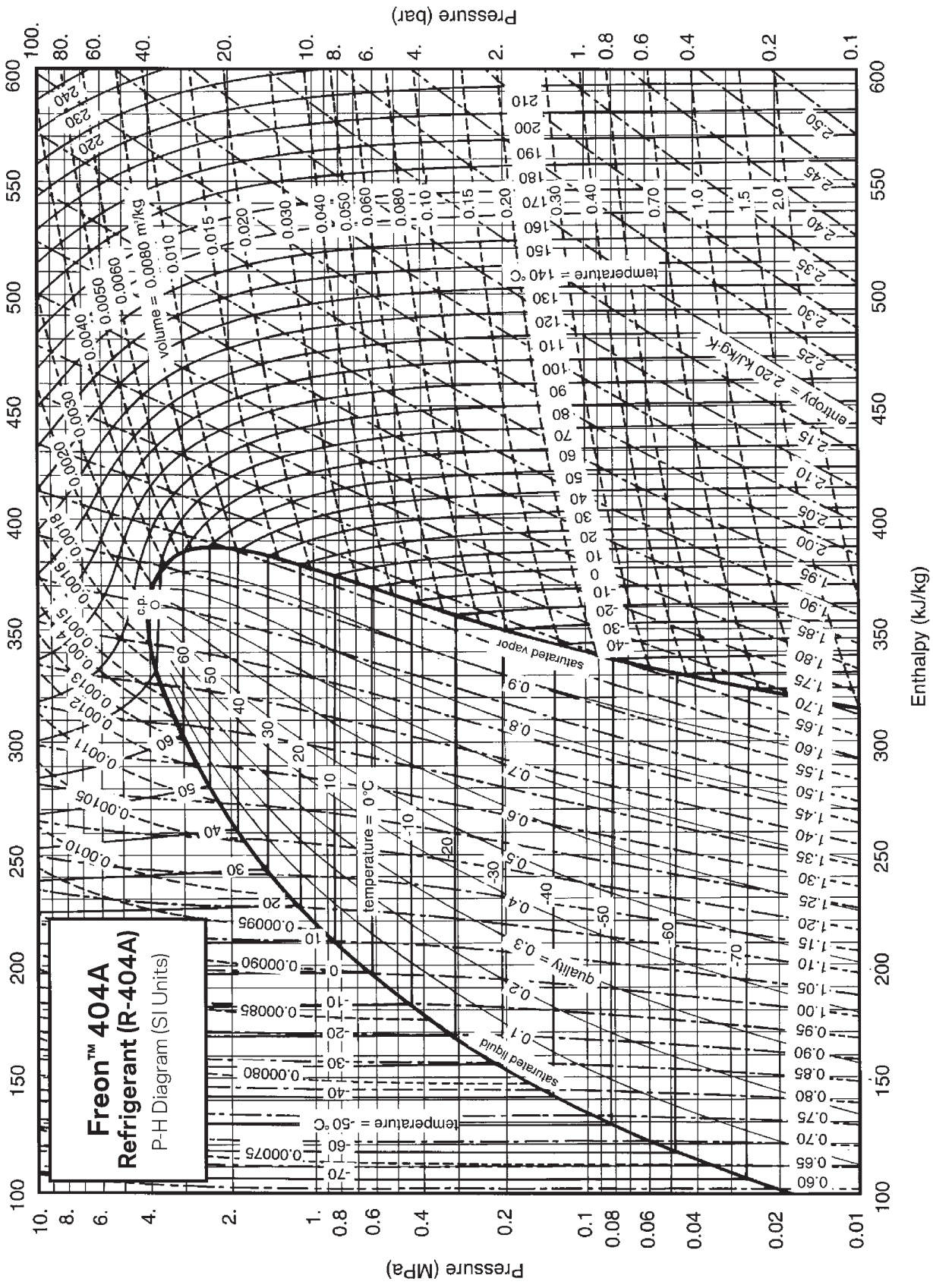


Figure 2. Freon™ 404A (R-404A) Pressure-Enthalpy Diagram (ENG Units)

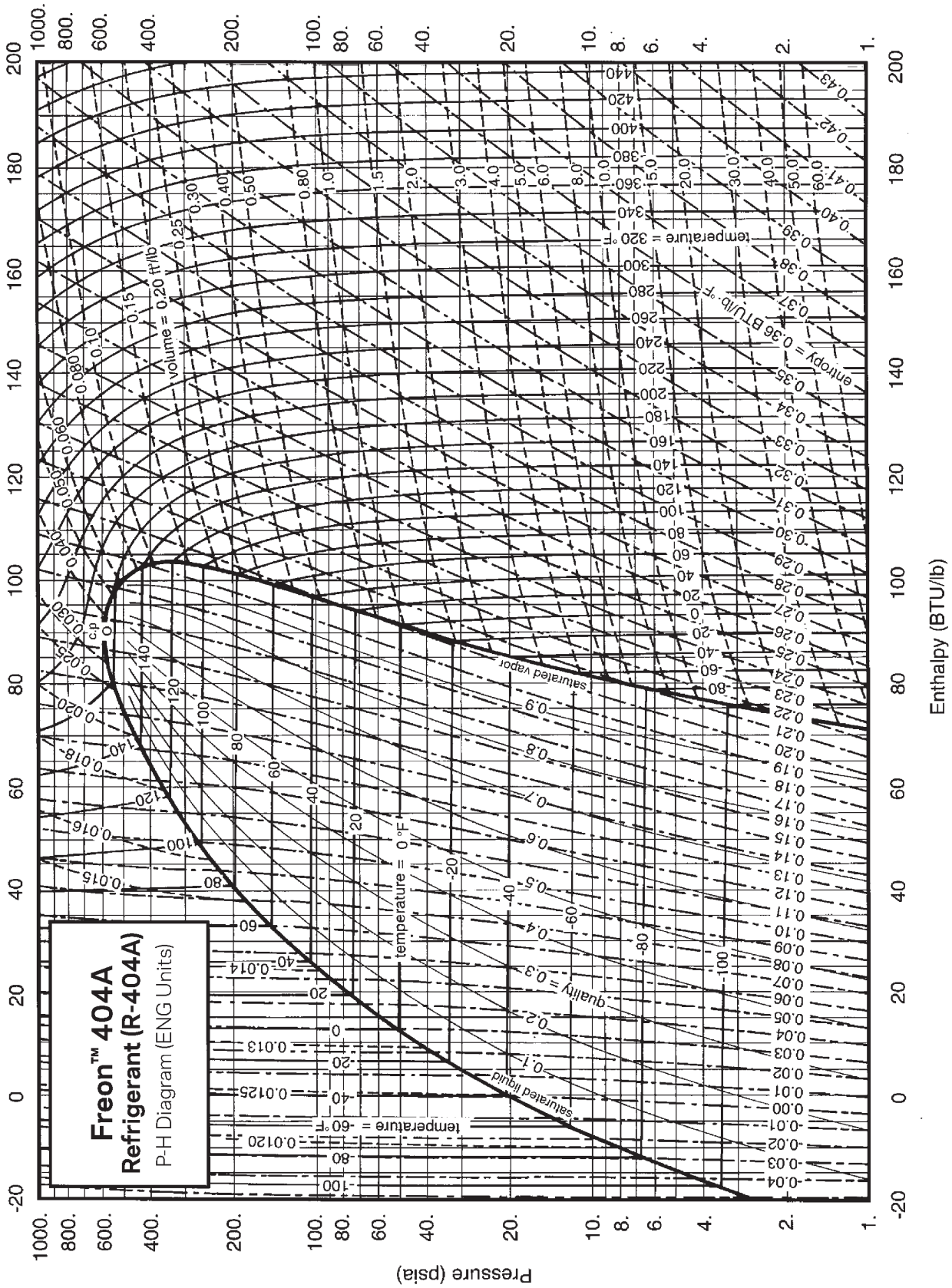


Figure 3. Freon™ HP80 (R-402A) Pressure-Enthalpy Diagram (SI Units)

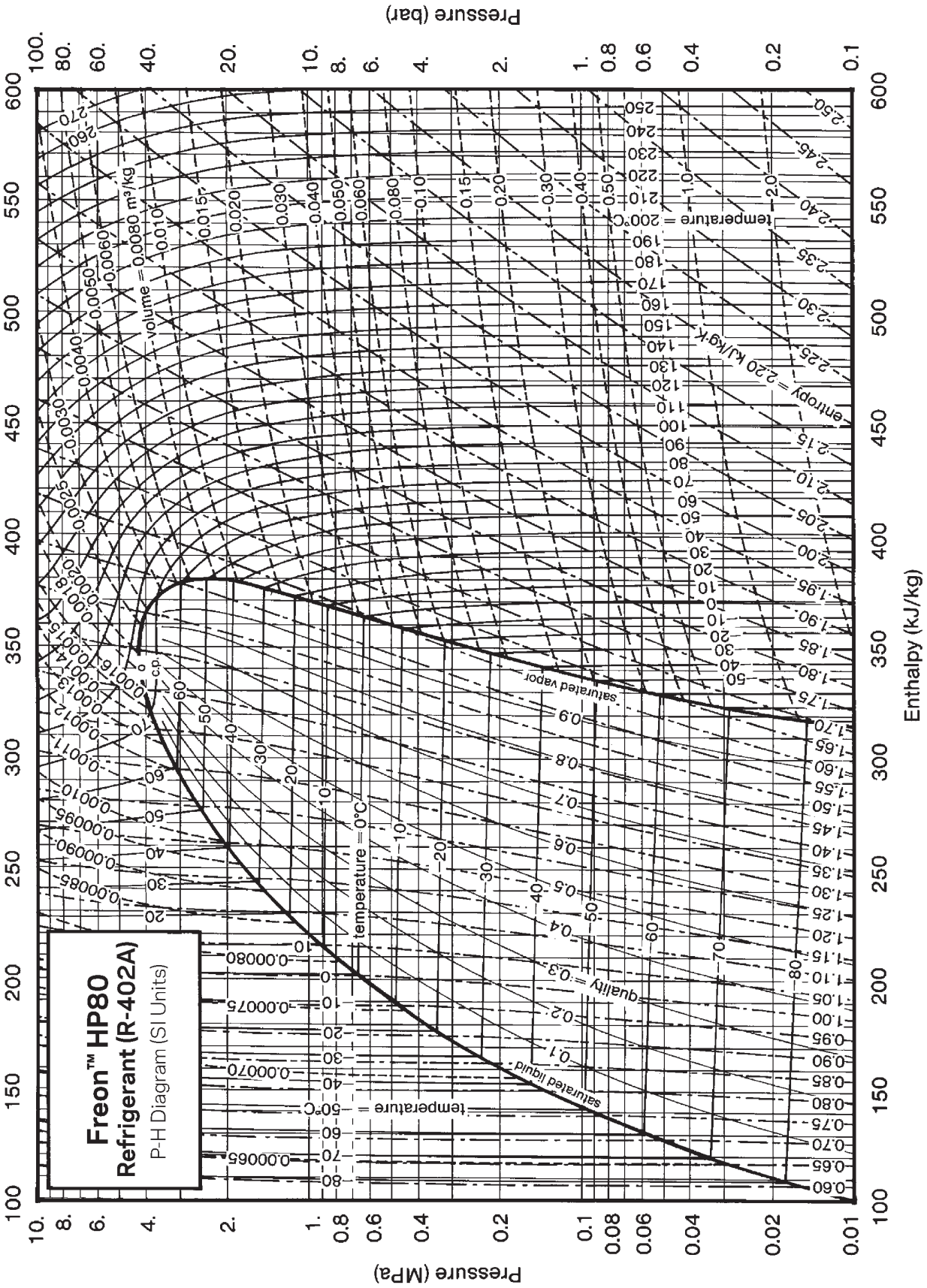


Figure 4. Freon™ HP80 (R-402A) Pressure-Enthalpy Diagram (ENG Units)

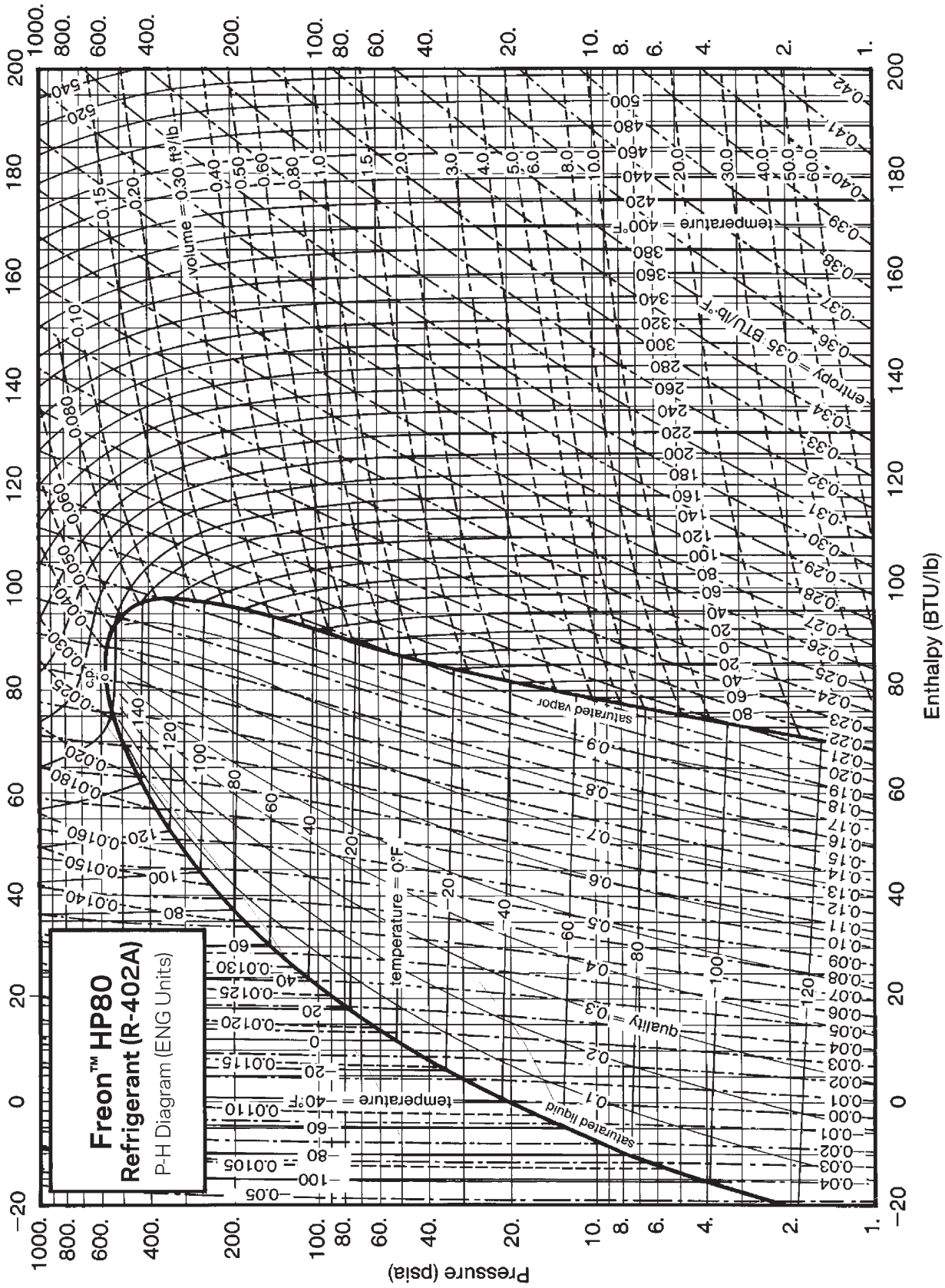


Figure 5. Freon™ HP81 (R-402B) Pressure-Enthalpy Diagram (SI Units)

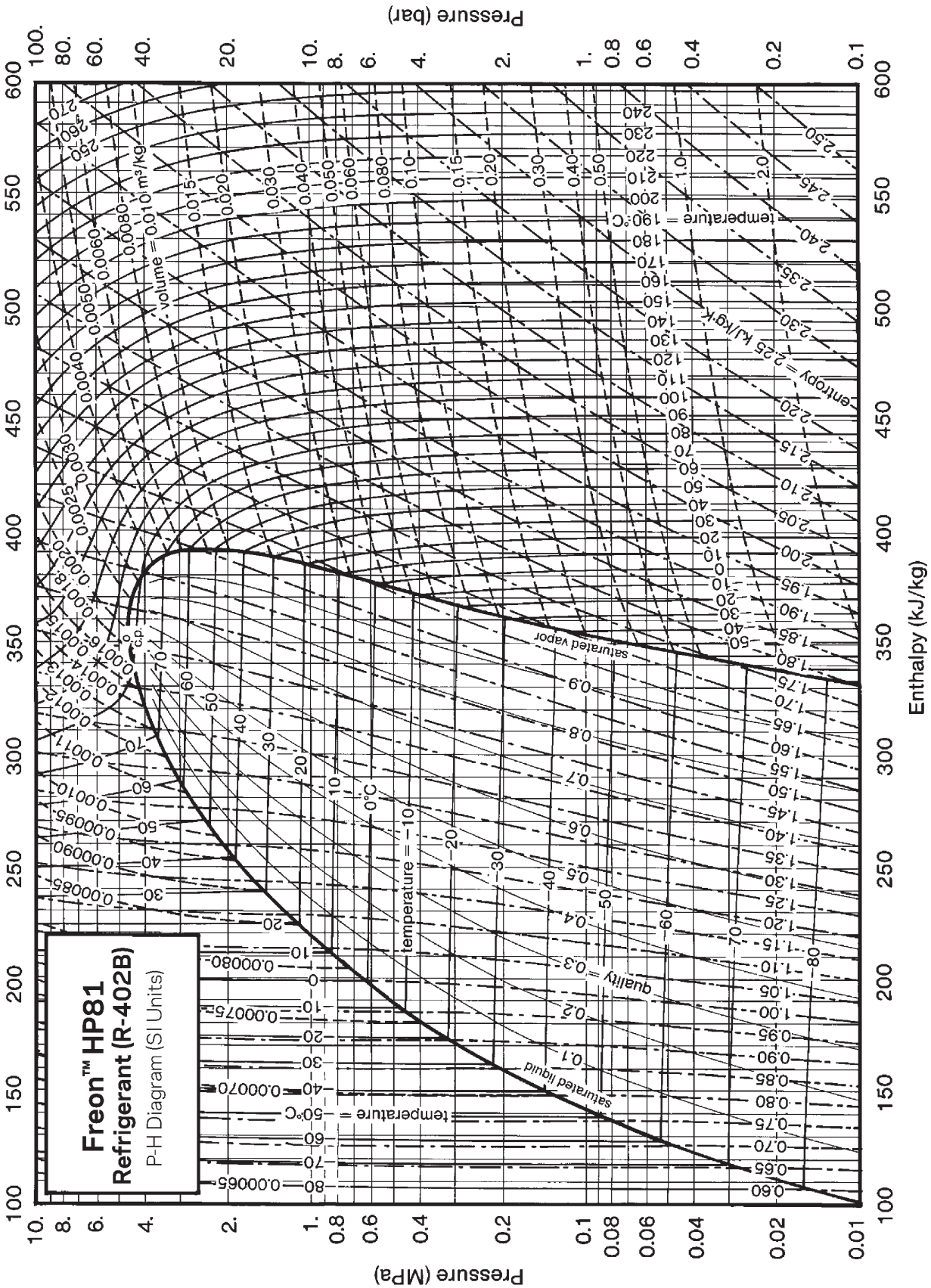
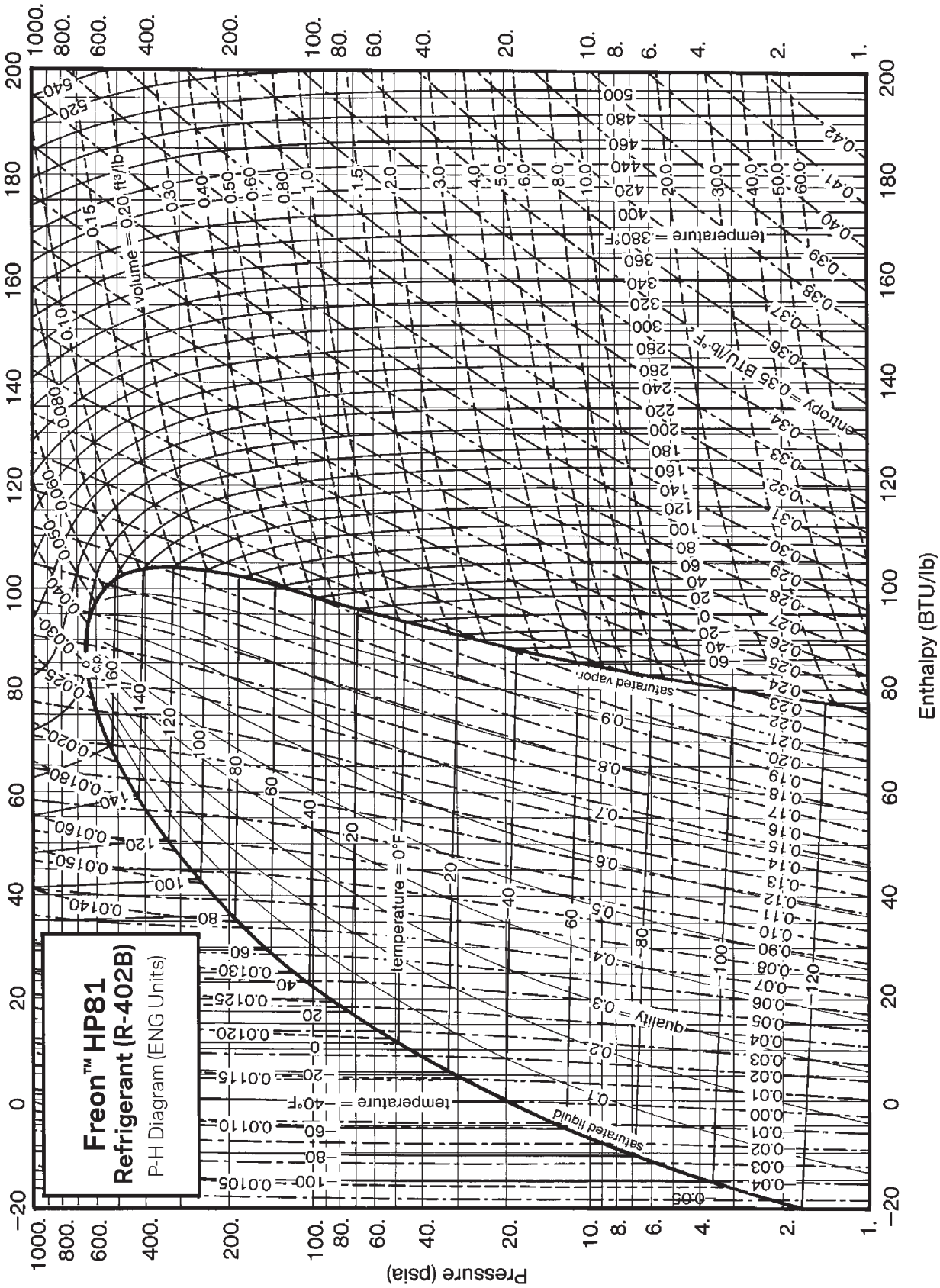


Figure 6. Freon™ HP81 (R-402B) Pressure-Enthalpy Diagram (ENG Units)



Materials Compatibility

Because Freon™ HP 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. Because Freon™ HP products have been designed as refrigerants, the compatibility data summarized here will include materials commonly used in refrigeration applications.

Elastomers

Compatibility results for Freon™ HP81 (R-402B) and Freon™ 404A (R-404A) were developed with five different polymer and lubricant combinations. It was assumed that Freon™ HP80 (R-402A) compatibility would be similar to Freon™ HP81.

Recognize 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, the 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 rankings shown in **Table 5** are based on duplicate samples of each polymer subjected to aging at 150 °C (302 °F) for 30 days in various lubricant/refrigerant combinations. Physical properties of the test samples were determined before and after aging. The resulting ratings are based on 1 being best and 5 being worst for the purposes of comparison. The factors included in the overall assessment of compatibility included:

- Visual observations of material changes due to aging
- Changes in weight and volume of the samples due to aging
- Changes in hardness of the samples due to aging
- Changes in flexural properties of the samples due to aging
- Recovery of weight and flexural properties after refrigerant evaporation

The compounds tested were:

- PTFE (Teflon™, commercial-grade skived sheet, from Tex-O-Lon Mfg. Co.)
- Neoprene W (from Precision Rubber Co.)
- HNBR (hydrogenated nitrile butadiene, N1195 from Parker Seal Co.)
- EPDM (ethylene propylene diene, commercial grade, from Kirkhill Rubber Co.)
- NBR (BUNA N, nitrile butadiene, from Parker Seal Co.)

Lubricants tested:

- Mineral Oil, Suniso 3GS, Witco Corporation
- Alkylbenzene, Zerol 150 TD, Shrieve Chemical Products Inc.
- Polyol Ester, Icematic SW32, Castrol
- Polyol Ester, Arctic EAL22, Mobil Chemical

Motor Materials

In hermetic and semi-hermetic compressors, the compressor motor is normally cooled by direct contact with refrigerant returning from the evaporator. As a result, the motor must be compatible with the refrigerants and lubricants used in the refrigeration system.

Accelerated aging tests were conducted with combinations of refrigerants, lubricants, and motor materials using sealed tube tests prepared according to ANSI/ASHRAE 97-1989. After aging, the materials in the tubes were inspected visually and microscopically and tested physically and chemically to determine property changes.

Materials tested, and a summary of test results, are described below.

Polyethylene Terephthalate (PET), Mylar®
PET film is used as phase and slot insulation in hermetic motors. Visual inspection of sealed tubes after aging in refrigerant environments revealed no extracts with refrigerant alone (R-502, Freon™ HP81, or Freon™ 404A [R-404A]), but varying degrees of cloudiness and light precipitates when lubricants were present.

PET weight change on aging was small (<5%) and occurred with R-502/lubricant and HP81/lubricant combinations. Weight gain with Freon™ 404A (R-404A)/ester lubricants was 2% or less.

PET flexibility after aging was determined by a bend test. The results show excellent retention of flexibility on aging at 135 °C (275 °F). There is definite loss of flexibility when PET is aged in R-502/mineral oil or R-502/alkylbenzene at 150 °C (302 °F). This loss of flexibility does not occur when PET is aged in HP81 or Freon™ 404A (R-404A) with ester lubricants at 150 °C (302 °F).

Table 4. Stability of HP Refrigerants with Metals and Lubricants

Freon™ HP81 with Various Lubricants			
Property	**HP81 with Mineral Oil, Suniso 3GS**	**HP81 with Alkylbenzene, Zerol 150 TD**	**HP81 with Polyol Ester, Castrol Icematic SW32**
Viscosity of Neat Oil at 40 °C (104 °F), $(mm)^2/s$ (cSt)	ND	ND	29.6
Stability Tests/Visual Ratings			
Neat Oil	0	ND	1, H
Oil/Refrig	1, G, H	2, P	0
Copper	0	2, T	0
Iron	0	0	1, T
Aluminum	0	0	0
Viscosity Change			
% Change Neat	ND	ND	5.0
% Change w/Refrig	ND	ND	–13.3
Decomposition Analysis			
(F-), ppm	ND	ND	7
(Cl-), ppm	ND	ND	7

(Values for Freon™ HP80 assumed to be comparable)

Freon™ 404A (R-404A) with Various Lubricants				
Property	**Freon™ 404A (R-404A) with Mineral Oil, Suniso 3GS**	**Freon™ 404A (R-404A) with Alkylbenzene, Zerol 150 TD**	**Freon™ 404A (R-404A) with Polyol Ester, Castrol Icematic SW32**	**Freon™ 404A (R-404A) with Polyol Ester, Mobil Arctic EAL22**
Viscosity of Neat Oil at 40 °C (104 °F), $(mm)^2/s$ (cSt)	ND	ND	29.6	23.7
Stability Tests/Visual Ratings				
Neat Oil	0	0	1, H	0
Oil/Refrig	1, G	2, P, G, H	0, G	1, G
Copper	0	2, T	0	0
Iron	0	1, T	1, T, P	0
Aluminum	0	0	0	0
Viscosity Change				
% Change Neat	ND	ND	5.0	ND
% Change w/Refrig	ND	ND	ND	ND

Visual Ratings:
ND = Not Determined
G = Gel
T = Tarnish
H = Haze
P = Precipitate

Stability Ratings: 0 to 5
0 = Best
3 = Failed
5 = Coked

Table 5. Relative Ranking of Polymer/Refrigerant/Lubricant Compatibility

Refrigerant/Lubricant	Polymer				
	PTFE	HNBR	Neoprene W	EPDM	NBR
R-502 Neat	2	4	2	2	1
R-502/Mineral Oil	2	4	4	5	2
R-502/Alkylbenzene	2	4	2	5	2
HP81 (R-402B) Neat	2	4	2	2	2
HP81 (R-402B)/Mineral Oil	2	4	4	5	2
HP81 (R-402B)/Alkylbenzene	2	4	2	5	2
HP81 (R-402B)/Castrol Ester	2	4	2	2	5
HP81 (R-402B)/Mobil Ester	2	4	2	1	5
404A (R-404A) Neat	2	1	1	2	1
404A (R-404A)/Mineral Oil	2	2	4	5	2
404A (R-404A)/Alkylbenzene	2	2	3	5	2
404A (R-404A)/Castrol Ester	2	4	2	1	5
404A (R-404A)/Mobil Ester	2	4	2	1	5

(1 → 5; best → worst)

Polyesterimide Enameled Motor Wire, Amide-Imide Overcoated (NEMA NW 35C)

No extracts or precipitates were observed on aging the enameled wire in any of the lubricant/refrigerant combinations. No blistering, crazing, or cracking was observed after aging. Retention of flexibility was confirmed by 1x bend tests of the wire after aging.

Dacron®/Mylar®/Dacron® Lead Wire (Belden 14 AWG)

After aging of D-M-D samples in refrigerant/lubricant environments, contents of the tubes were inspected for particulates, the tubes were cooled and opened, and the lead wire samples were subjected to bend tests. Minimal particulates or extracts were observed after aging. PET embrittlement, ranging from slight loss of flexibility to shattering, was observed when specimens were bent 135 degrees. The degree of embrittlement appeared to be a factor of the lubricant, rather than the refrigerant. All D-M-D samples were embrittled in the presence of mineral oil or alkylbenzene lubricants. Good flexibility was seen after aging with polyol esters in the presence of all refrigerants.

Summary

In summary, ester-based lubricants appear to cause much less effect on common motor materials than mineral oils or alkylbenzene lubricants. In all cases, the results appeared to be better than R-502 with lubricants commonly used with R-502.

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. A desiccant used with R-502, UOP's (formerly Union Carbide Molecular Sieve) 4A-XH-5, is not generally compatible with highly fluorinated refrigerants such as Freon™ HP products. However, compatible molecular sieve desiccants, such as XH-9, have been developed. For loose-filled and solid core dryers, new desiccants are available that are also compatible with the new refrigerants and lubricants. Be sure to tell your parts wholesaler what refrigerants you plan to use when specifying the dryer for your system.

Refrigeration Lubricants

Most compressors require a lubricant to protect internal moving parts. The compressor manufacturer usually recommends the type of lubricant(s) and proper viscosity that should be used to ensure acceptable operation and equipment durability. Recommendations are based on several criteria, which can include lubricity, miscibility, compatibility with materials of construction, thermal stability, and compatibility with other lubricants. It is important to follow the manufacturers' recommendations for lubricants to be used with their equipment.

Current lubricants used with R-502 have at least partial miscibility with R-502, which eases the problems of designing systems to allow lubricant return back to the compressor. Many refrigeration systems take advantage of this miscibility when considering lubricant return.

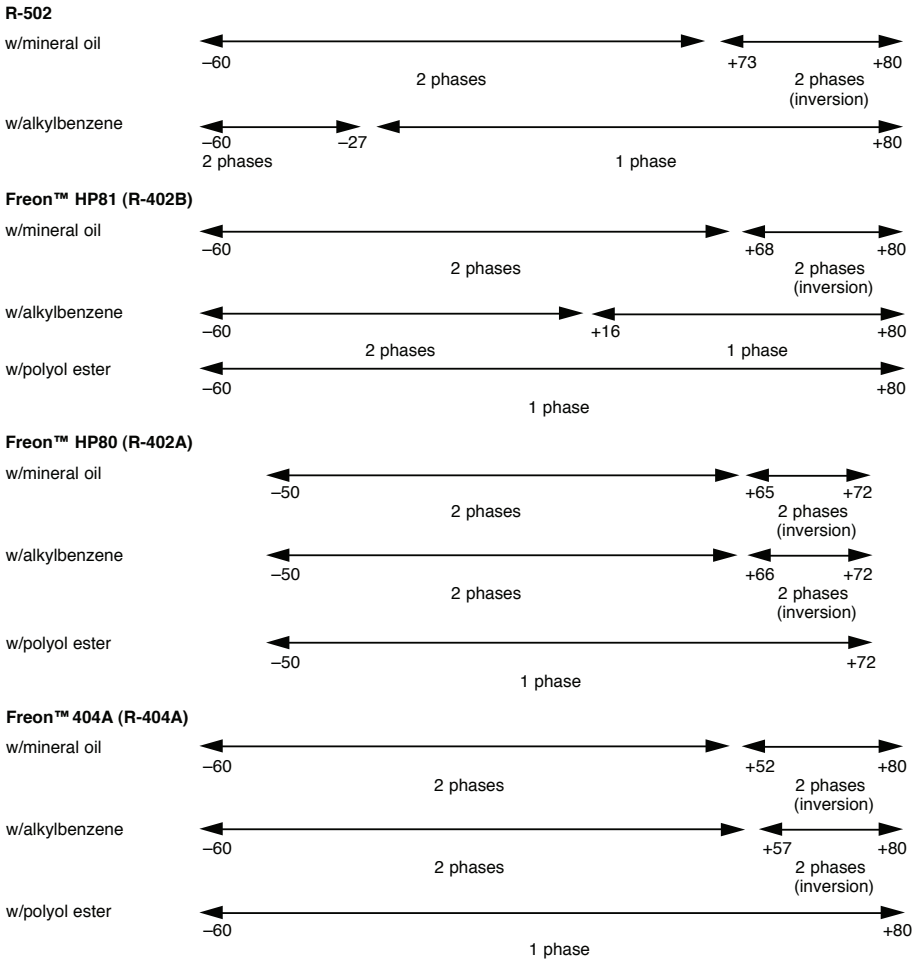
Note: Field experience has shown that Freon™ HP81 works successfully with mineral oil in many small hermetic systems where oil return is not a concern.

Refrigerants such as Freon™ HP products, with little or no chlorine present in them, may exhibit less miscibility with common lubricants used with R-502. Although many R-502 systems operating at low temperatures allow for reduced miscibility with the lubricant, it is important to know that the lubricants used with Freon™ HP refrigerants will return to the compressor using existing equipment designs.

Different compressor and equipment manufacturers will recommend lubricants to use with their equipment and Freon™ HP products. It would be difficult to summarize all possible lubricant candidates that may be screened by various equipment manufacturers. In addition, there will be continuing research and development of new lubricants that we may not have tested because the market for alternative refrigerants continues to stimulate other market areas. Review your system needs with the equipment manufacturer, Chemours distributor, certified refrigeration service contractor, or other qualified party. Never assume the current lubricant in your refrigeration system will be acceptable with the Freon™ HP refrigerant you intend to use. Always review system components for compatibility with the new refrigerant and possibly a new lubricant.

Table 6 shows a summary of miscibility tests done with a 50/50 volume mixture of refrigerant and lubricant over a wide range of temperatures, with visual inspection for phase separation as the tubes are slowly warmed. This table does not show that any refrigerant/lubricant combination is acceptable, only whether the two appear to be miscible at the conditions shown.

Table 6. Miscibility Summary



Note: All temperatures in °C

Safety

Users must have and understand the applicable Freon™ HP refrigerant Safety Data Sheets (SDS).

Inhalation Toxicity

Freon™ HP refrigerants pose no acute or chronic hazard when they are handled in accordance with Chemours recommendations and exposures are maintained below recommended exposure limits, such as the Chemours acceptable exposure limit (AEL) of 1,000 ppm, 8- or 12-hour time-weighted average (TWA).

An AEL is an airborne exposure limit established by Chemours that specifies time-weighted average for airborne concentrations to which nearly all workers may be repeatedly exposed without adverse effects. The AEL for Freon™ HP refrigerants is the same level as the threshold limit value (TLV) established for HCFC-22 and calculated for R-502 based on the TLVs for the components.

However, like R-502, exposure above the recommended exposure limit to the vapors of Freon™ HP refrigerants by inhalation 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. Higher exposures to the vapors may cause temporary alteration of the heart's electrical activity with irregular pulse, palpitations, or inadequate circulation. Death can occur from gross overexposure. Intentional misuse or deliberate inhalation of Freon™ HP refrigerant vapors may cause death without warning. This practice is extremely dangerous.

A person experiencing any of the initial symptoms should be moved to fresh air and kept calm. If breathing is difficult, administer oxygen. If not breathing, administer artificial respiration. Call a physician.

Cardiac Sensitization

As with many other halocarbons and hydrocarbons, inhalation of Freon™ HP refrigerants followed by intravenous injection of epinephrine, to simulate human stress reactions, results in a cardiac sensitization response. In humans, this can lead to cardiac irregularities and even cardiac arrest. The likelihood of these cardiac problems increases if you are under physical or emotional stress. Freon™ HP refrigerants can cause these responses well above the AEL, but the effect level varies with people and has not been fully determined.

If you are exposed to very high concentrations of Freon™ HP refrigerants, move immediately from the area and seek medical attention as a precaution. Do not attempt to remain in the area to fix a leak or perform other duties—the effects of overexposure can be very sudden.

Medical attention must be given immediately if someone is having symptoms of overexposure to Freon™ HP refrigerants. Do not treat the patient with drugs such as epinephrine. These drugs could increase the risk of cardiac problems. If the person is having trouble breathing, administer oxygen. If breathing has stopped, administer artificial respiration. Call a physician.

Skin and Eye Contact

At room temperature, Freon™ HP refrigerant vapors have little or no effect on the skin or eyes. However, in liquid form, they can freeze skin or eyes on contact, causing frostbite. If contact with liquid does occur, soak the exposed areas in lukewarm water, not cold or hot. In all cases, seek medical attention immediately.

Always wear protective clothing when there is a risk of exposure to liquid refrigerants. Where splashing of refrigerant may occur, always wear eye protection and a face shield.

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 elevation areas, which can displace the oxygen needed for life, resulting in suffocation.

Evacuate everyone until the area has been well ventilated. Re-enter the area only while using self-contained breathing apparatus. Use blowers or fans to circulate the air at floor or low levels.

Always use self-contained breathing apparatus or an air-line respirator when entering tanks or other areas where vapors might exist. Use the buddy system (a second employee stationed outside the tank) and a lifeline. Refer to the Safety Data Sheet for the specific Freon™ HP refrigerant you plan to use.

Freon™ HP refrigerants have virtually no odor and, therefore, can be extremely difficult to detect in enclosed areas. Frequent leak checks and the installation of permanent leak detectors may be necessary for enclosed areas or machinery rooms. Refer to ASHRAE Standards 15 and 34 for machinery room requirements.

To ensure safety when using Freon™ HP refrigerants in enclosed areas:

1. Route relief and purge vent piping outdoors, away from air intakes.
2. Make certain the area is well ventilated at all times; use auxiliary ventilation, if necessary, to remove vapors.
3. Make sure the work area is free of vapors prior to beginning any work.
4. Install air monitoring equipment to detect leaks.

Combustibility of Freon™ HP Refrigerants

Freon™ 404A (R-404A), HP80, and HP81 are not flammable in air at temperatures up to 100 °C (212 °F) at atmospheric pressure. However, mixtures of R-404A, HP80 or HP81 with high concentrations of air at elevated pressure and/or temperature can become combustible in the presence of an ignition source. Freon™ 404A (R-404A), HP80, and HP81 can also become combustible in an oxygen enriched environment (oxygen concentrations greater than that in air). Whether a mixture containing Freon™ 404A (R-404A), HP80 or HP81 and air, or Freon™ 404A (R-404A), HP80 or HP81 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, Freon™ 404A (R-404A), HP80 or HP81 should not be allowed to exist with air above atmospheric pressure or at high temperatures, or in an oxygen enriched environment. **For example: R-404A, HP80 or HP81 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 the 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 R-404A, HP80 or HP81 and air. Pressurized mixtures of dry nitrogen and R-404A, HP80 or HP81 can be used for leak testing.
- Bulk Delivery and Storage
  - Tanks should 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 tank manufacturer's maximum allowable working pressure when filling with R-404A, HP80 or HP81. 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 should never be filled while under positive air pressure.
  - Filled cylinders should periodically be analyzed for air (nonabsorbable gas or [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 HCFC-22 (a component of HP80 and HP81) 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. There are several reasons for leak pinpointing or area monitoring, including:

- Conservation of refrigerant
- Protection of employees
- Detection of fugitive or small emissions
- Protection of equipment

Leak detectors can be placed into two broad categories: leak pinpointers and area monitors. Before purchasing a monitor or pinpointer, several criteria should be considered, which include sensitivity, detection limits, and selectivity.

Types of Detectors

Using selectivity as a criterion, 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 will the complexity and cost.

A different technology that can be employed to find leaks is by using a dye or other additive that is placed in the refrigeration system and emitted with the leaking refrigerant and lubricant.

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 rugged, inexpensive, and almost always portable. However, their inability to be calibrated, long-term drift, and lack of selectivity and sensitivity limit their use for area monitoring.

Some nonselective detectors designed for use with R-502 may have a much lower sensitivity when used with Freon™ HP refrigerants. However, newly designed detectors with good sensitivity for HFCs are now available. Be sure to consult with the manufacturer before selecting or using a nonselective detector with Freon™ HP refrigerants.

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 <1.4 g/yr [<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 easily calibrated.

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 compound without interference from other compounds.

With Freon™ HP refrigerants, using compound-specific detectors may be difficult because the different mixtures often contain similar types of compounds. In an area where different refrigerant mixtures are used, these detectors may offer more specificity than is needed for normal leak management. Discuss these issues with the equipment manufacturers before making a purchase decision.

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 or charged. Leaks are detected by using a UV light to search for additive that has escaped from the system.

Recent innovations in dye technology have allowed fluorescent additives to be used with HFCs and new refrigerant mixtures. However, before adding additives to a system, the compatibility of the specific dye with the lubricant and refrigerant should be tested.

Storage and Handling

Shipping Containers in the United States

Freon™ HP refrigerants are liquefied compressed 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 psia at 21 °C (70 °F) and/or an absolute pressure greater than 104 psia at 54 °C (130 °F). See **Table 7** for the appropriate DOT designation.

Table 7. DOT Designations

DOT Proper Shipping Name	(HP80/81)	Compressed Gas N.O.S. (Contains Pentafluoroethane and Chlorodifluoromethane)
	(404A [R-404A])	Compressed Gas N.O.S. (Contains Pentafluoroethane and Trifluoroethane)
Hazard Class	(All)	Nonflammable Gas
DOT/IMO Hazard Class	(HP80/81)	2
	(404A [R-404A])	2.2
UN/NA Number	(All)	UN 3163
DOT Labels	(All)	Nonflammable Gas
DOT Placard	(All)	Nonflammable Gas

A list of the different types of containers that can be used to ship Freon™ HP refrigerants in the United States, along with their water capacities, dimensions, DOT specifications, and net weights, are provided in **Table 8**. All pressure relief devices used on the containers must be in compliance with the corresponding Compressed Gas Association (CGA) Standards for compressed gas cylinders, cargo, and portable tanks.

The 15-lb, 30-lb, and 123-lb cylinders designed for refrigerant applications will be painted the colors shown in **Table 8**, with labels that bear the name of the product in the same color. For clarification, the colors are:

Freon™ HP80	PMS 461	Light Brown
Freon™ HP81	PMS 385	Green Brown
Freon™ 404A (R-404A)	PMS 021	Orange

Disposable cylinders, known as a Dispos-A-Can® (or DAC), fit into a box with the measurements given in **Table 8**. When used to ship Freon™ HP refrigerants to the stationary refrigeration market, the cylinders will have the same outlet fittings as cylinders of R-502.

The 123-lb cylinders are equipped with a nonrefillable liquid vapor CGA-660 valve. With this two-way valve, refrigerant can be removed from the cylinder as either vapor or liquid, without inverting the cylinder. The vapor valve handwheel is located on the top of the valve assembly. The liquid handwheel is on the side of the valve and attached to a dip tube extending to the bottom of the cylinder. Each is clearly identified as vapor or liquid.

The 4,400-gal cylinder is known as an ISO tank. The dimensions referenced in **Table 8** represent the frame in which the container is shipped. The tank itself has the same length of 20 ft and an outside diameter of approximately 86 in. ISO tanks are used for export shipments of refrigerants from the United States.

The general construction of a one-ton returnable container is shown in **Figure 7**. Note that one end of the container is fitted with two valves. When the container is turned so that the valves are lined up vertically, the top valve will discharge vapor and the bottom valve will discharge liquid. The valves are protected by a dome cover. The valves are Superior Type 660-X1-B1.

One-ton containers are equipped with two fusible plugs in each end. The fusible metal in the plugs is designed to start melting at 69 °C (157 °F) and completely melt at 74 °C (165 °F). Containers should never be heated to temperatures higher than 52 °C (125 °F). One spring-loaded pressure relief valve is also located in each end of the container.

Bulk Storage Systems

Chemours sells storage systems, at cost, to their refrigeration 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 Chemours refrigerants. The delivered systems include all components, such as storage tank, pumps, piping, valves, motors, and instrumentation, as an integrated unit. All systems are equipped 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 8**. Your Chemours marketing representative can arrange for guidance on site selection, purchase, installation, start-up, and maintenance.

Table 8. Specifications of Shipping Containers for Freon™ HP Refrigerants

Container	Dimensions	DOT Spec.	Net Weight (lb)		Color Code
15-lb Dispos-A-Can®	7.5" x 7.5" x 14.5"	39	(HP81 Only)	13	PMS 385/Green Brown
30-lb Dispos-A-Can®	10" x 10" x 17"	39	(HP80)	27	PMS 461/Light Brown
			(404A [R-404A])	24	PMS 021/Orange
123-lb Cylinder	55" H x 10" OD	4BA300	(HP81)	110	
			(404A [R-404A])	100	
		4BA400	(HP80)	110	
1,682-lb ton Cylinder	82" L x 30" OD	110A500W			
5,000 gal	Tank Truck	MC-330 or -331	40,000		
4,400 gal ISO	8' x 8.5' x 20' (frame)	51			
170,000 lb	Rail Car	114A340W			

Figure 7. One-Ton Returnable Container

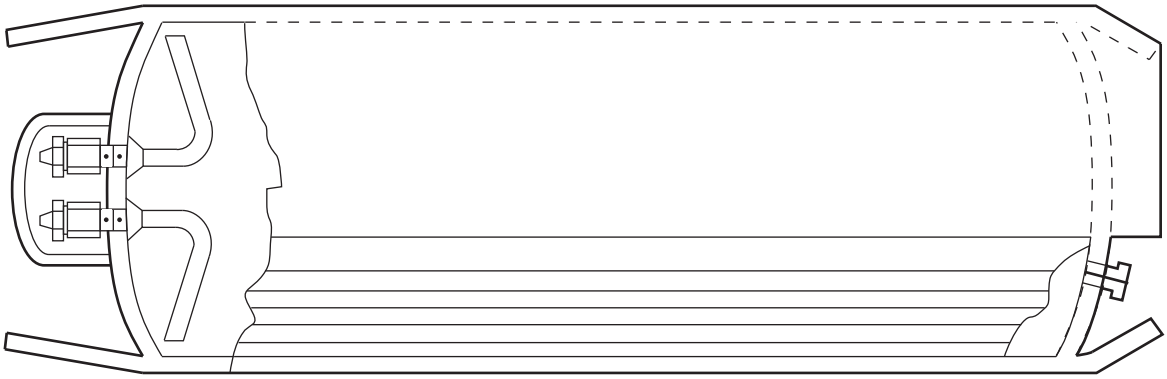
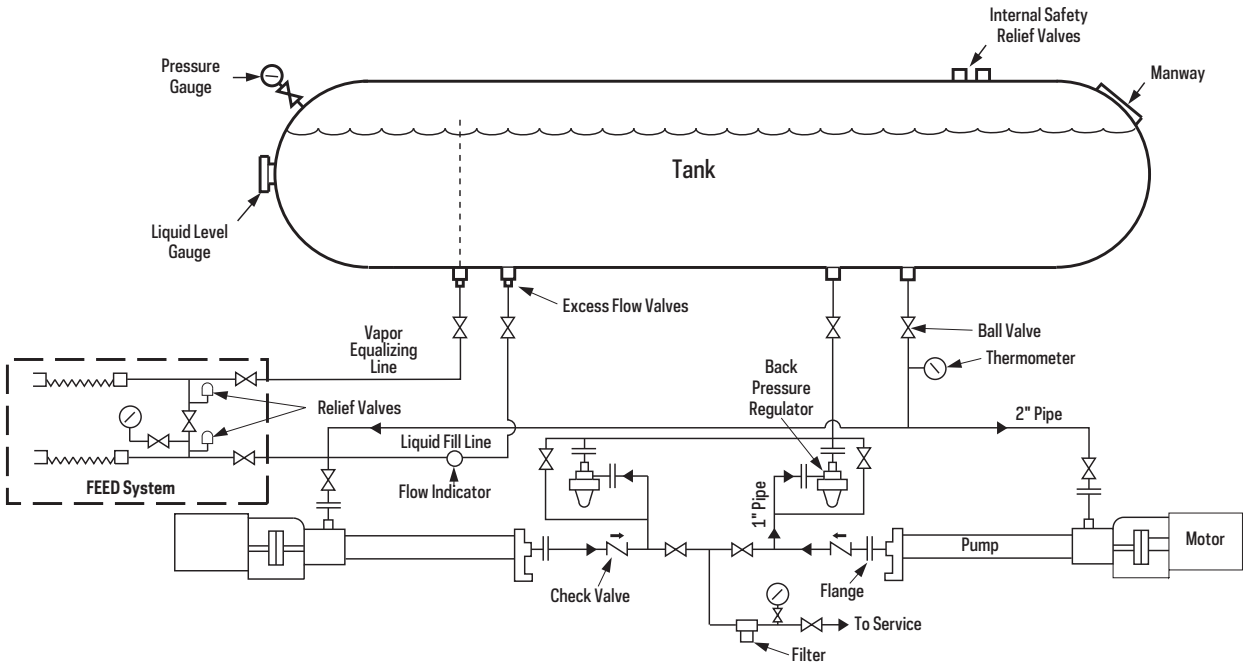


Figure 8. Typical Bulk Storage System



Converting Bulk Storage Tanks from R-502 to Freon™ HP Refrigerants

Before switching any R-502 storage system to Freon™ HP refrigerants, 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). This rating must be 320 psig or higher for use with all Freon™ HP refrigerants. In addition, the set pressure of the tank relief device must also be checked and changed if necessary. This relief setting cannot be higher than the maximum working pressure listed on the nameplate, however.

We recommend that storage tanks be completely emptied of all R-502 liquid and vapor before introducing the HP refrigerant. In general, converting a storage tank to HP refrigerant requires:

1. Removing all R-502 from the storage tank, lines, and equipment.
2. Evacuating the storage tank to 25–29 in of vacuum and purging with compressed dry nitrogen gas.
3. Making necessary repairs to the tank after initial evacuation and purging.
4. Repeating Step 2 until R-502 and moisture levels are within acceptable limits.
5. Refilling the system with Freon™ HP refrigerant.

This 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 R-502 are also compatible with Freon™ HP refrigerants. These include standard grades of carbon steel, aluminum, and copper. Some elastomeric or nonmetallic components suitable for R-502 may not be adequate with the new refrigerants. Therefore, all elastomeric or nonmetallic components throughout the system must be identified and their compatibility with Freon™ HP refrigerants verified. 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-glass gaskets
- Back-pressure regulator diaphragms and O-rings

Handling Precautions for Freon™ HP Refrigerant Shipping Containers

The following rules for handling HP refrigerant containers are strongly recommended:

- Use personal protective equipment such as side shield safety glasses, gloves, and safety shoes when handling refrigerant containers.
- Avoid skin contact with refrigerants, as they may cause frostbite.
- Never heat a container to temperatures 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 containers as rollers, supports, or for any purpose other than to carry refrigerant.
- Protect containers from any object that will result in a 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 outlets.
- 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 refrigerant vapors from lines after unloading.

Recovery, Recycle, Reclamation, and Disposal

Responsible use of Freon™ HP refrigerants requires that the product be recovered for re-use or disposal whenever possible. Chemours purchases used refrigerant for reclamation through its distributor networks in the United States, Canada, and Europe. In the United States, all Freon™ HP products will be accepted as part of this program. Recovery and re-use of refrigerant 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 of refrigeration equipment.

Recovery

Recovery refers to the removal of refrigerant from equipment and collection in an appropriate container. As defined by the Air Conditioning and Refrigeration Institute (ARI), recovery does not involve processing or analysis of the refrigerants. Freon™ HP refrigerants may be recovered from refrigeration equipment using permanent on-site equipment or many of the portable recovery devices now available in the marketplace. The portable devices contain a small compressor, an air-cooled condenser, and may be used for vapor (and in some cases, liquid) recovery. At the end of the recovery cycle, the system is evacuated thoroughly 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 contains proper materials of construction and lubricant for the refrigerants you intend to recover.

Due to the fact that Freon™ HP products are not azeotropes, it is important that all refrigerant is removed from a system during recovery or recycle. It is always recommended that refrigerant transfers be made liquid phase whenever possible to minimize composition changes in the products.

Recycle

Refrigerant recycle refers to reducing the contaminant levels in used refrigerants by passing the refrigerants through devices that separate out or reduce the amount of lubricant, water, acidity and particulates. Recycle is usually a field or shop procedure with no analytical testing of refrigerant. Freon™ HP refrigerants may be recycled using many of the devices now available. In the United States, the EPA sets standards for these devices. Recycle is already standard practice in many portions of the commercial refrigeration industry. Consult with the manufacturer before specifying a recycle device for any refrigerant.

If you routinely recycle Freon™ HP refrigerants through several cycles, we recommend that you have the composition of the refrigerant checked periodically. This will prevent loss of performance in the unlikely event that the composition has shifted.

Reclamation

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

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

Disposal

Disposal refers to the destruction of used refrigerant. Disposal may be necessary when the refrigerant has become badly contaminated with other products and no longer meets the acceptance specifications of Chemours or other reclaimers. Although Chemours does not presently accept severely contaminated refrigerant for disposal, licensed waste disposal firms are available. Be sure to check the qualifications of any firm before sending them used refrigerants.