



Freon™ 123

Refrigerant (R-123)

Properties, Uses,
Storage, and
Handling



Chemours™

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Introduction

Background

Freon™ 123 was introduced by Chemours as an environmentally acceptable, nonflammable replacement for chlorofluorocarbon (CFC) 11 in refrigeration and heat-transfer applications. CFCs, which were developed over 60 years ago, have many unique properties. CFCs are low in toxicity, nonflammable, non-corrosive, 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; as blowing agents in the manufacture of insulation, packaging, and cushioning foams; as cleaning agents for metal and electronic components; and in many other applications.

However, the stability of CFCs, 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 environmentally acceptable alternatives, such as hydrochlorofluorocarbon (HCFC) 123.

Freon™ 123—An Environmentally Acceptable Alternative

Although Freon™ 123 contains chlorine, its hydrogen-containing molecules decompose primarily in the lower atmosphere before they can reach the ozone layer. Because the chlorine is dissipated at lower altitudes, HCFCs have relatively short atmospheric lifetimes and much lower ozone

depletion potentials (ODPs) than CFCs. The ODP of Freon™ 123 is 0.02 compared to 1.00 for CFC-11. The generic and Chemours trade names for Freon™ 123 are:

- Freon™ 123
- Hydrochlorofluorocarbon 123
- HCFC-123

The chemical properties of Freon™ 123 are:

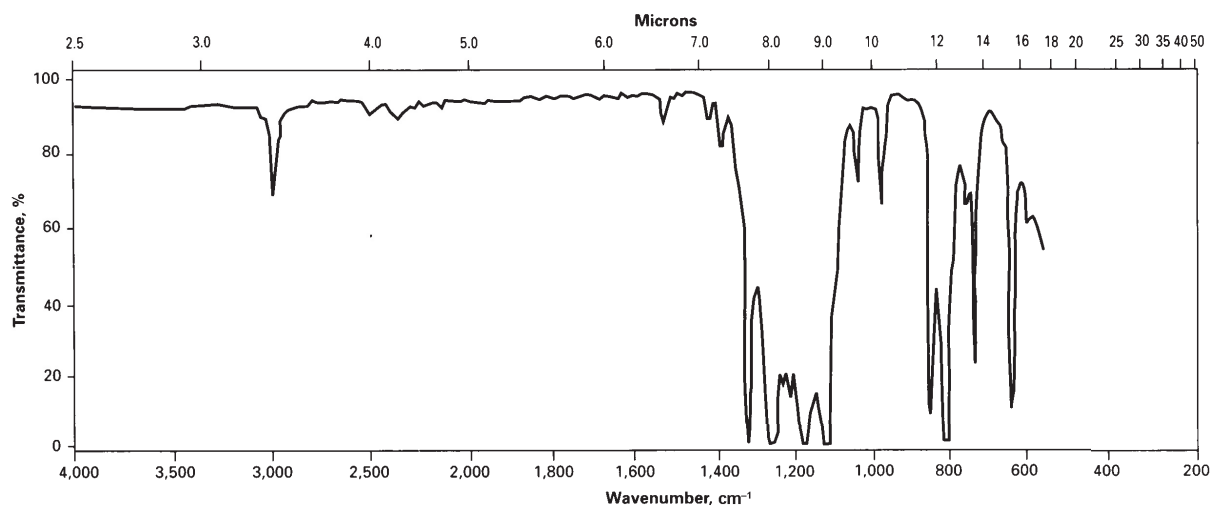
| | |
|---------------------|--|
| Chemical Name | 2,2-dichloro-1,1,1-trifluoroethane |
| Molecular Formula | CF ₃ CHCl ₂ |
| CAS Registry Number | 306-83-2 |
| Molecular Weight | 152.93 |
| Chemical Structure | $ \begin{array}{c} \text{F} \quad \text{Cl} \\ \quad \\ \text{F}-\text{C}-\text{C}-\text{H} \\ \quad \\ \text{F} \quad \text{Cl} \end{array} $ |

The infrared spectrum of Freon™ 123 is shown in **Figure 1**.

Uses

Freon™ 123 is a viable replacement for CFC-11 as a refrigerant and heat-transfer fluid. Because Freon™ 123 has a Workplace Environmental Exposure Level (WEEL) of 50 ppm, its use is limited to applications where it can be effectively contained within the operating equipment. Chemours does not sell Freon™ 123 for use as blowing agents for polymer foams or aerosol propellants. See later sections of this bulletin for discussions of toxicity and recommendations for safe handling.

Figure 1. Infrared Spectrum of Freon™ 123 Liquid



Refrigerant

The thermodynamic and physical properties of Freon™ 123, coupled with its nonflammability, make it an efficient and safe replacement refrigerant for CFC-11 in centrifugal chillers. In fact, Freon™ 123 offers the best theoretical efficiency of the several alternatives for use in chillers. Chemours Freon™ 123 is available to chiller manufacturers for use in new and existing equipment. Chemours is also converting most of its own CFC-11 chillers to Freon™ 123.

Freon™ 123 was selected as a replacement for CFC-11 because the two compounds will produce roughly the same operating pressures and temperatures in a chiller. However, an unmodified chiller will produce less cooling capacity and an equivalent or lower efficiency with Freon™ 123 than it did with CFC-11. The differences in capacity and efficiency will depend on the original system component selection and operating conditions. **Table 1** gives performance ranges to be expected based on actual retrofit experience.

Table 1. Retrofit Experience with Unmodified Chillers
Freon™ 123 vs. CFC-11

| | |
|--------------------------------|-----------------------|
| Capacity, % | -5 to -20 |
| Coefficient of Performance, % | 0 to -5 |
| Evaporator Pressure, kPa (psi) | -14 to -21 (-2 to -3) |
| Condenser Pressure, kPa (psi) | -14 to -21 (-2 to -3) |
| Discharge Temperature, °C (°F) | -1 to -3 (-2 to -6) |

The industry has developed mechanical components optimized for Freon™ 123 that can be installed in existing equipment to maintain full capacity in a retrofit application. In addition, new equipment designed specifically for Freon™ 123 will have equivalent or better capacity and efficiency than the equipment it is designed to replace. When considering whether to retrofit or replace existing systems, one should compare, on a life-cycle basis, the difference in operating and maintenance costs as well as the initial investment and retrofit costs. Newly designed and optimized refrigeration equipment may provide much lower operating costs than existing equipment.

In general, alternative refrigerants cannot be simply “dropped into” systems designed to use CFCs. Alternatives are similar but not the same as the CFCs they are targeted to replace. The differences in physical properties and compatibilities with construction materials must be carefully considered. Application bulletins are available from Chemours giving more details on the use of Freon™ 123 as a refrigerant.

Heat-Transfer Fluid

In many applications, refrigeration equipment is located in a service facility separate from an industrial process. The process heat is transferred to the refrigeration equipment by means of a circulating heat-transfer fluid, known as a “brine” or secondary refrigerant. A typical brine system is shown in **Figure 2**. The most common brines are water-based solutions of salts, glycols, or alcohols. However, for low temperatures or in situations where chemical inertness is important, chlorinated organic solvents (methylene chloride, trichloroethylene) or CFCs (e.g., CFC-11, CFC-113) have been widely used. These compounds are no longer acceptable from an environmental or, in the case of the chlorinated solvents, an occupational health standpoint.

Table 2 compares pertinent physical properties of Freon™ 123 with those of typical brines. When planning to retrofit a brine system to Freon™ 123, it is important to check heat-transfer design calculations for the system. Rates will be similar if the retrofit is being made from CFC-11 or CFC-113. However, Freon™ 123 has a specific heat approximately 15% lower than methylene chloride, requiring higher circulating flow rates and increased pumping power. A bulletin is available from Chemours giving details on the use of Freon™ 123 as a heat-transfer brine.

Physical Properties

Physical properties of Freon™ 123 are given in **Table 3** and **Figures 3-7**. Additional physical property data may be found in other Chemours publications. “Transport Properties of Freon™ Refrigerants” contains viscosity, thermal conductivity, and heat capacity data for saturated liquid and vapor, in addition to heat capacity data and ratios for both saturated and superheated vapors. Thermodynamic tables in English and SI units are also available from Chemours. Liquid and vapor densities are included in the thermodynamic tables.

Figure 2. Schematic Diagram of Typical Brine System

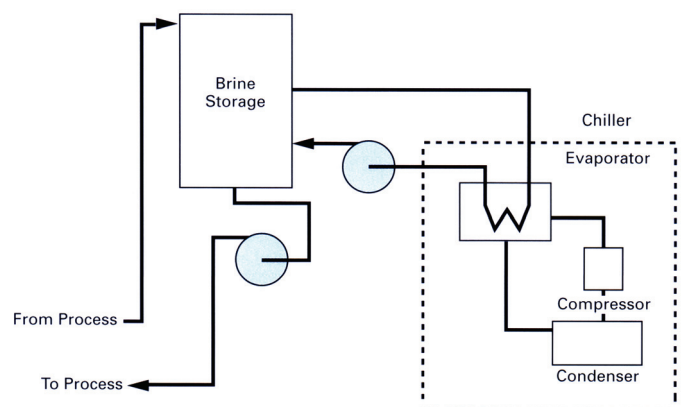


Table 2. Measured Properties of Heat-Transfer Brines

| Property | Aqueous Calcium Chloride (25%) | Methylene Chloride | CFC-11 | CFC-113 | Freon™ 123 |
|--|--------------------------------|--------------------|--------------|---------------|---------------|
| Boiling Point, °C (°F) | >100 (>212) | 40 (104) | 24 (75) | 48 (118) | 28 (82) |
| Freezing Point, °C (°F) | -29 (-20) | -97 (-143) | -111 (-168) | -35 (-31) | -107 (-161) |
| Vapor Pressure at 25 °C (77 °F), kPa (psig) | NA | 57 (-6.4) | 106 (0.7) | 45 (-8.2) | 91 (-1.5) |
| Viscosity, MPa·sec (cP) | 12 | 0.70 | 0.73 | 1.49 | 0.82 |
| Specific Heat, kJ/kg·°K (Btu/lb·°F) | 2.81 (0.67) | 1.13 (0.26) | 0.84 (0.20) | 0.88 (0.21) | 0.90 (0.22) |
| Thermal Conductivity, W/m·°K (Btu/hr-ft·°F) | 0.50 (0.29) | 0.19 (0.11) | 0.10 (0.06) | 0.08 (0.05) | 0.096 (0.056) |
| Density, kg/m ³ (lb/ft ³) | 1,260 (78.8) | 1,400 (87.5) | 1,560 (97.5) | 1,650 (103.0) | 1,578 (98.5) |

Note: Properties other than vapor pressure are given at -24 °C (-11 °F).

NA = Not Available

Figure 3. Solubility of Water in Freon™ 123

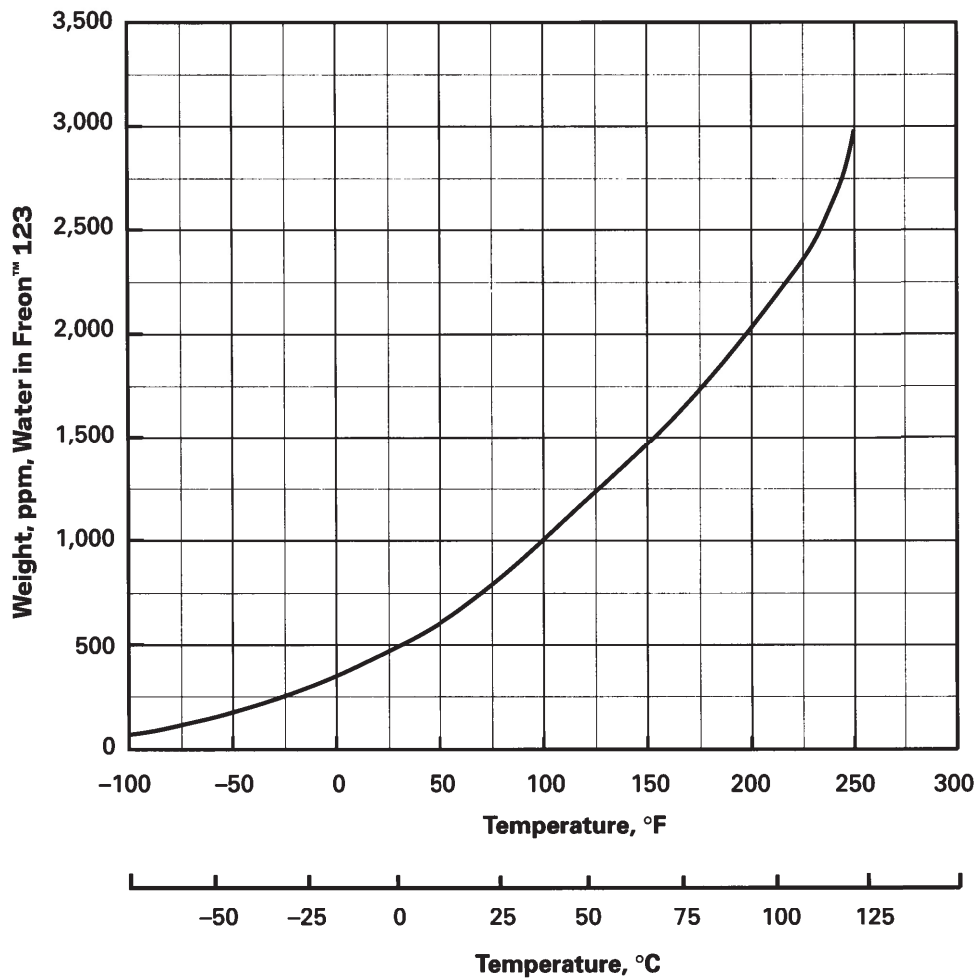


Table 3. Physical Properties of Freon™ 123

| Physical Property | Unit | Freon™ 123 |
|--|---|------------------------------------|
| Chemical Name | — | 2,2-dichloro-1,1,1-trifluoroethane |
| Chemical Formula | — | CF ₃ -CHCl ₂ |
| Molecular Weight | g/mol | 152.93 |
| Boiling Point at 1 atm (101.3 kPa or 1.013 bar) | °C °F | 27.85 82.0 |
| Freezing Point | °C °F | -107.0 -161.0 |
| Critical Temperature | °C °F | 183.68 362.63 |
| Critical Pressure | kPa lb/in ² abs | 3,668 532.0 |
| Critical Volume | m ³ /kg ft ³ /lb | 1.82 x 10 ⁻³ 0.0291 |
| Critical Density | kg/m ³ lb/ft ³ | 550.0 34.34 |
| Density (Liquid) at 25 °C (77 °F) | kg/m ³ lb/ft ³ | 1,463 91.3 |
| Density (Saturated Vapor) at Boiling Point | kg/m ³ lb/ft ³ | 6.47 0.403 |
| Heat Capacity (Liquid) at 25 °C (77 °F) | kJ/kg-K Btu/lb-(°F) | 0.965 0.235 |
| Heat Capacity (Vapor at Constant Pressure) at 25 °C (77 °F) (1 atm) (101.3 kPa or 1.013 bar) | kJ/kg-K Btu/lb-(°F) | 0.721 0.172 |
| Vapor Pressure at 25 °C (77 °F) | kPa bar psia | 91.29 0.9129 13.241 |
| Heat of Vaporization at Boiling Point | kJ/kg Btu/lb | 170 73.3 |
| Thermal Conductivity at 25 °C (77 °F) Liquid | W/m-K Btu/hr-ft-(°F) | 0.0810 0.0471 |
| Vapor at 1 atm (101.3 kPa or 1.013 bar) | W/m-K Btu/hr-ft-(°F) | 0.0112 0.0064 |
| Viscosity at 25 °C (77 °F) Liquid | MPa-sec (cP) | 0.456 |
| Vapor at 1 atm (101.3 kPa or 1.013 bar) | MPa-sec (cP) | 0.0110 |
| Solubility of Freon™ 123 in Water at 25 °C (77 °F) and 1 atm (101.3 kPa or 1.013 bar) | wt% | 0.39 |
| Solubility of Water in Freon™ 123 at 25 °C (77 °F) | wt% | 0.08 |
| Flammability Limits in Air at 1 atm (101.3 kPa or 1.013 bar) | vol % | None |
| Ozone Depletion Potential (ODP) (For CFC-11, ODP = 1) | — | 0.02 |
| Halocarbon Global Warming Potential (HGWP) (For CFC-11, HGWP = 1) | — | 0.02 |
| Global Warming Potential (GWP) (100 yr ITH.) (For CO ₂ , GWP = 1) | — | 93 |
| TSCA Inventory Status | — | Listed |
| Workplace Environmental Exposure Level (WEEL)* | ppm (v/v) 8- and 12-hr TWA | 50 |

*Workplace Environmental Exposure Level (WEEL) established by Occupational Alliance for Risk Science (OARS).

Note: kPa is absolute pressure.

Figure 4. Vapor Pressure of Freon™ 123 vs. Temperature (English Units)

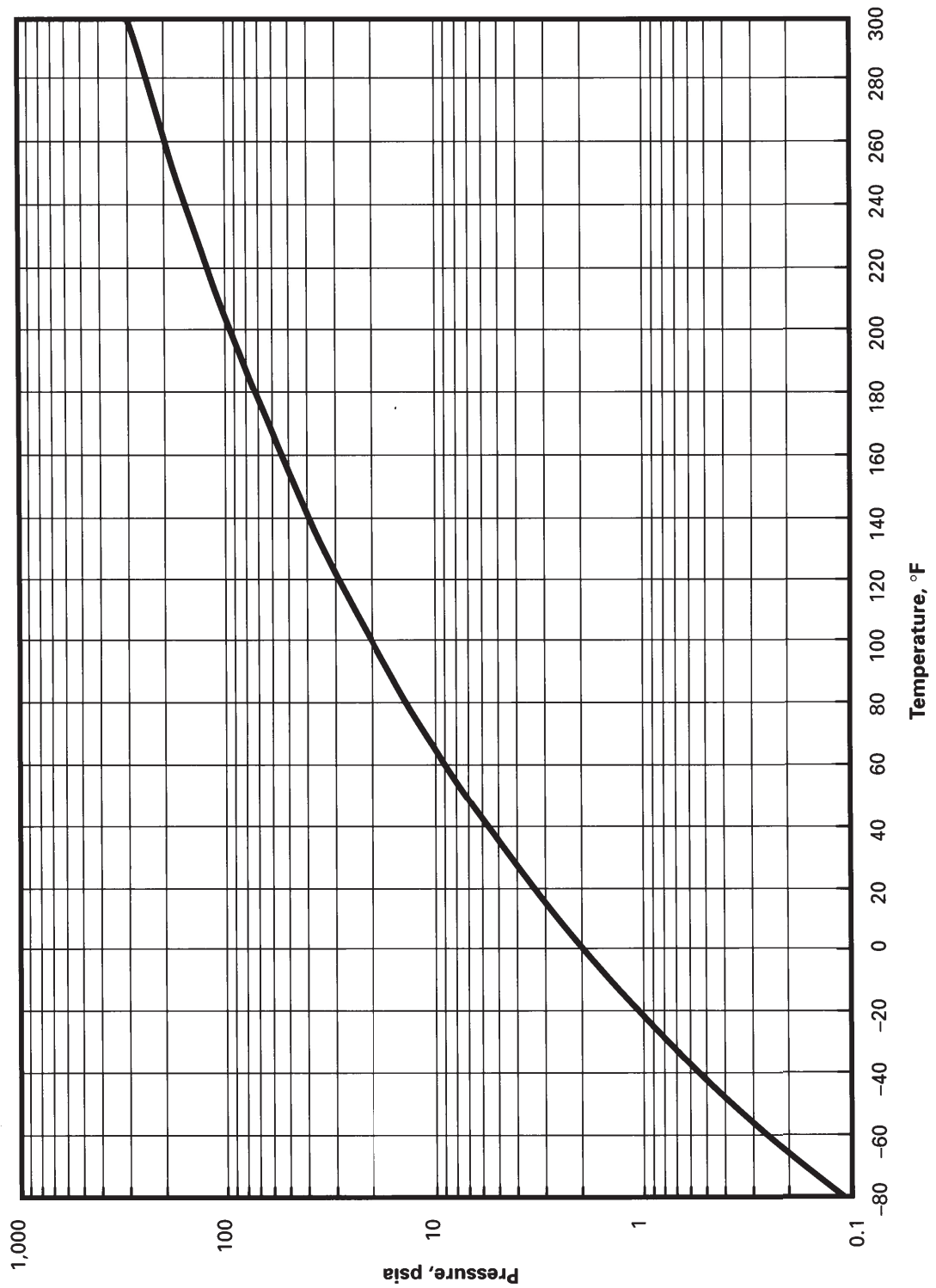


Figure 5. Vapor Pressure of Freon™ 123 vs. Temperature (SI Units)

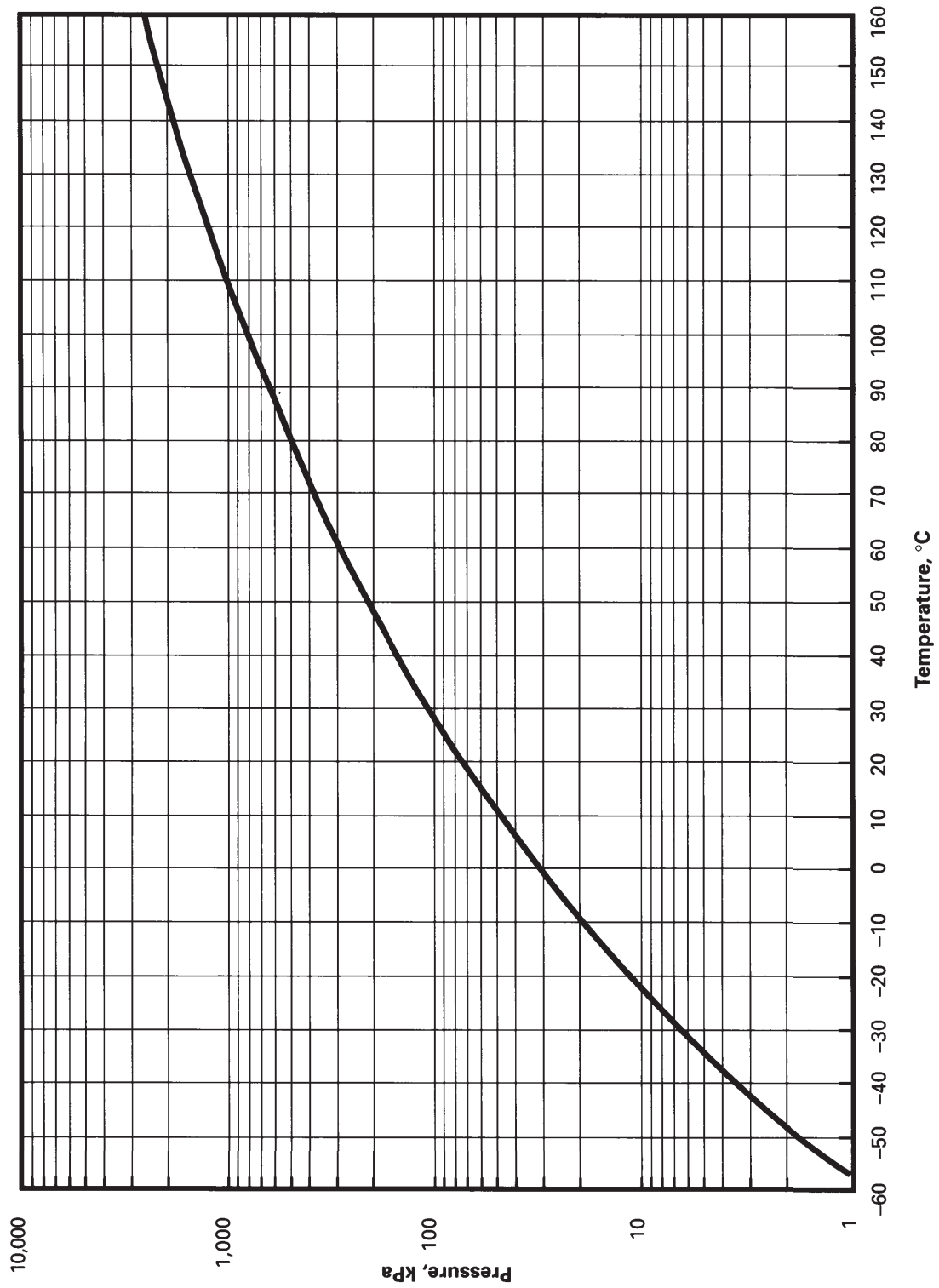


Figure 6. Pressure-Enthalpy Diagram for Freon™ 123 (English Units)

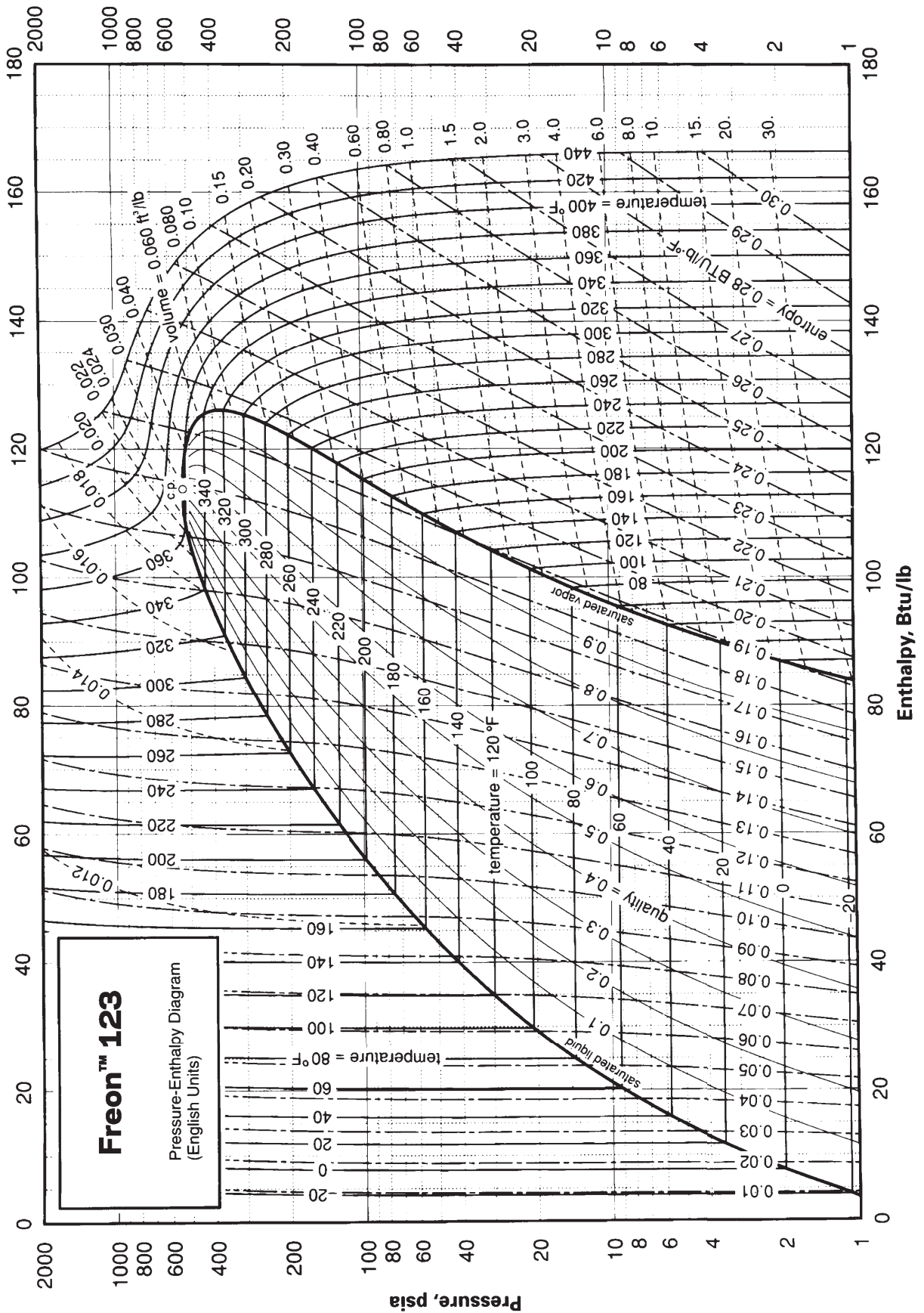
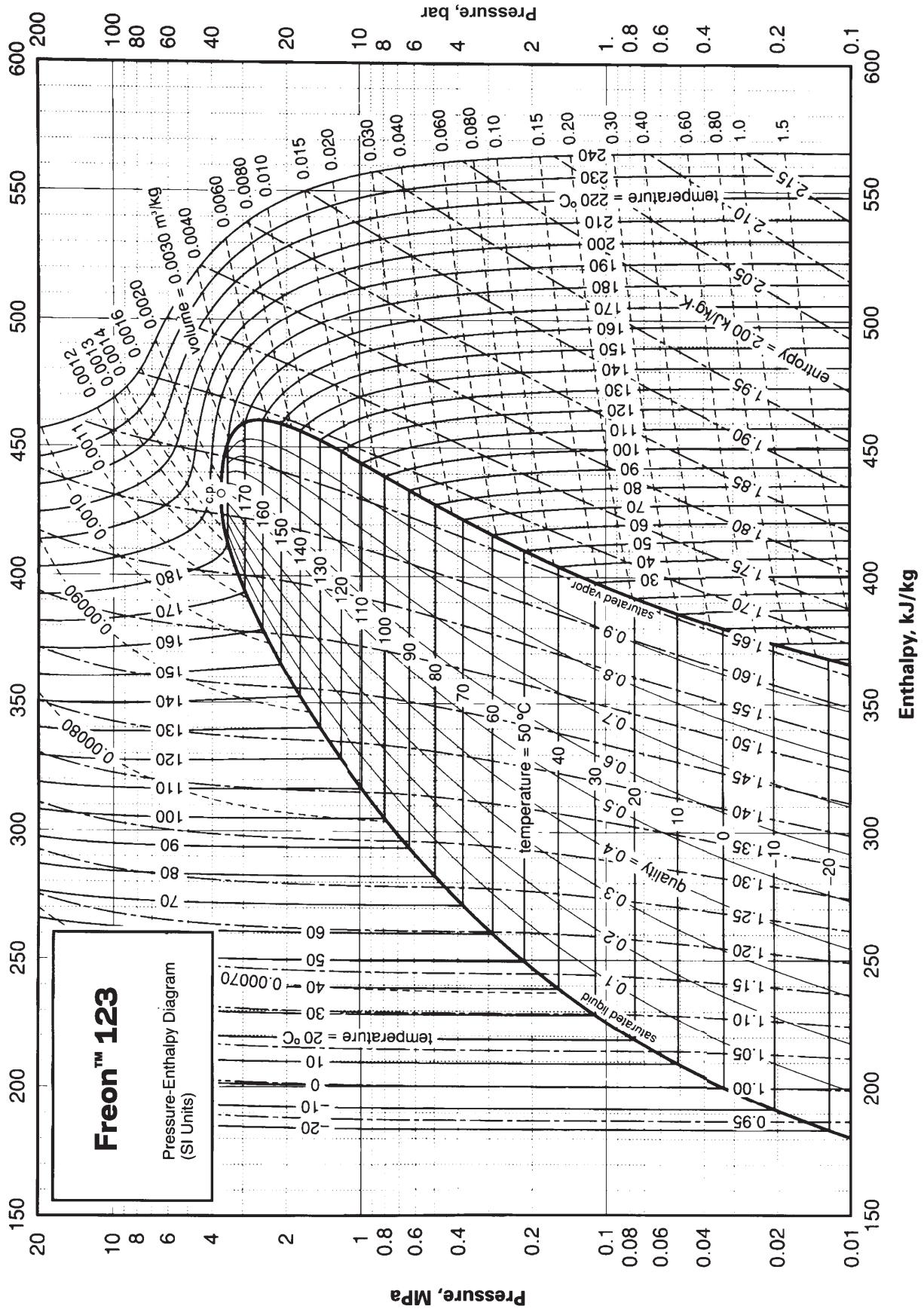


Figure 7. Pressure-Enthalpy Diagram for Freon™ 123 (SI Units)



Chemical/Thermal Stability

Thermal Decomposition

Freon™ 123 vapors will decompose when exposed to high temperatures from flames or electric resistance heaters. Decomposition may produce toxic and irritating compounds, such as hydrogen fluoride and hydrogen chloride. The pungent odors released will irritate the nose and throat and generally force people to evacuate the area. Therefore, it is important to prevent decomposition by avoiding exposure to high temperatures.

Stability with Metals and Refrigeration Lubricants

Stability tests for refrigerants with metals are typically performed in sealed glass tubes in the presence of refrigeration lubricants. Because existing refrigeration oils are used with Freon™ 123, stability tests were performed in the presence of several mineral oils. Results are presented here for two series of tests in which the stability of Freon™ 123 was compared to CFC-11 under identical test conditions.

In the first test series, 1.0 mL (0.03 oz) of refrigerant and an equal weight of lubricant were added to glass tubes in the presence of strips of Sandvik valve steel. The tubes were frozen, evacuated, sealed, and then heated for 14 days at temperatures of 105 °C (221 °F) and 150 °C (302 °F). Aged tubes were inspected visually for insoluble reaction products and appearance of the metal surfaces. Exposed tubes were opened, and the chloride contents determined by analysis. The amount of refrigerant reacted during each test was then calculated from the amount of chloride formed.

The results from the first test series are summarized in **Table 4**. Freon™ 123 appeared approximately ten times more stable than CFC-11 in these tests.

In the second test series, 3.0 mL (0.1 oz) of refrigerant and 0.52 mL (0.02 oz) of lubricant were added to glass tubes in the presence of steel, copper, and aluminum coupons. The tubes were frozen, evacuated, sealed, and then heated for 2.95 days at 151 °C (304 °F). After exposure, visual ratings were obtained on both the liquid and metal coupons. Visual ratings ranged from 0 to 5, with 0 being the best. The sample tubes were then opened, and the lubricant/refrigerant solutions analyzed for chloride and fluoride ions to indicate the extent of refrigerant decomposition.

The results of the second test series are in **Table 5**. The Freon™ 123 again exhibited improved stability versus CFC-11.

Because CFC-11/metal/mineral oil combinations have given good results in actual refrigeration service, these tests indicate that replacement of CFC-11 by Freon™ 123 will give satisfactory performance from a compatibility standpoint.

Note that the tests described here were accelerated tests. Freon™ 123 and CFC-11 are low-pressure refrigerants and would seldom be exposed to temperatures as high as the upper test temperature (150 °C [302 °F]).

Materials Compatibility

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™ 123 will be used primarily as a refrigerant or heat-transfer fluid, the compatibility data summarized below includes materials commonly used in refrigeration applications.

Plastics

Compatibility results for Freon™ 123 and CFC-11 are compared for ten typical plastic materials in **Table 6**. The table summarizes screening tests in which these materials were exposed to liquid refrigerant in sealed glass tubes at two temperatures. The ratings given are based on observations of length, weight, and appearance changes. The presence of a hydrogen atom on the Freon™ 123 molecule makes it a stronger solvent than CFC-11 and, therefore, more aggressive toward plastics. Several plastics used with CFC-11 are also compatible with Freon™ 123. As its use becomes more common, other materials will be approved for use with Freon™ 123.

Because the performance of plastic materials is affected by polymer variations, compounding agents, fillers, and molding processes, verifying compatibility using actual fabricated parts under end-use conditions is advised.

Refrigerant contacts the motor windings in a hermetic compressor. Equipment manufacturers have developed specially cured epoxy wire insulation that has performed well in hermetic compressors handling Freon™ 123. Be sure to check with the manufacturer before using any hermetic compressor with Freon™ 123.

Table 4. Stability of Freon™ 123 with Steel and Lubricating Oils

| Oil | Mineral Oil ISO VG32 | | | | White Naphthenic Oil ISO VG46 | | | |
|---|-------------------------|----------------|------------------|--------------|----------------------------------|-----------|------------------|----------------|
| | 105 °C 221 °F | | 150 °C 302 °F | | 105 °C 221 °F | | 150 °C 302 °F | |
| Temperature | | | | | | | | |
| Refrigerant | R-11 | R-123 | R-11 | R-123 | R-11 | R-123 | R-11 | R-123 |
| Chloride, mg | 1.06 | 0.099 0.066 | 225 | 3.26 5.66 | 0.033 | 0.048 | 94.5 | 12.2 |
| Percent Refrigerant Reacted from Chloride | 0.46 | 0.045 0.032 | 72.0 | 1.56 2.71 | 0.014 | 0.002 | 45.2 | 5.84 |
| Appearance of Steel | Light Stains | Brown Stain | Heavy Sludge | Light Sludge | Slight Color | No Change | Etched | Light Deposits |

Source of Data: D. F. Huttenlocher (Spauchus Associates), "Chemical and Thermal Stability of Refrigerant-Lubricant Mixtures with Metals," Report DOE/CE/23810-3B, Air Conditioning and Refrigeration Technology Institute, Arlington, VA, July 10, 1992.

Test Conditions

Sealed tubes containing 0.9 g (0.03 oz) refrigerant + 0.9 g (0.03 oz) lubricant

Metal specimen: 1/4 in (6.4 mm) x 1-1/4 in (3.18 cm) strip of valve steel (Sandvik Steel Company)

Exposure: 14 days at indicated temperature

Table 5. Stability of Freon™ 123 with Steel, Copper, Aluminum, and Heavy Naphthenic Oil

| Refrigerant | R-11 | Freon™ 123 | |
|-------------------------------|------|------------|----------|
| | | Sample 1 | Sample 2 |
| Visual Ratings | | | |
| Liquid | 3 | 0+ | 2 |
| Steel | 1 | 1+ | 2 |
| Copper | 3 | 2 | 2 |
| Aluminum | 1 | 0 | 0 |
| Decomposition Analyses | | | |
| Chloride, wt% | 1.7 | 0.08 | 0.13 |
| Fluoride, wt% | 0.42 | 0.003 | 0.004 |

Metals

Steel 1010

Copper

Aluminum 1100

Oil: Witco Freezene, heavy white naphthenic mineral oil, 255 SUS (approx. 55 cSt at 38 °C [100 °F])

Source of Data: Chemours Tests

Test Conditions

Sealed tubes containing 3.0 mL (0.1 oz) refrigerant + 0.52 mL (0.02 oz) lubricant

Metal specimens: 2-3/8 in (6.0 cm) x 1/4 in (6.4 mm) x 1/16 in (1.6 mm)

Exposure: 2.95 days at 151 °C (304 °F)

Visual Ratings: 0 to 5

| Rating | Metal | Liquid |
|--------|-----------------|---------------------|
| 0 | Bright, shiny | Clear, colorless |
| 3 | Darkening | Clear, brown |
| 5 | Severe deposits | Black, coke present |

(Ratings of 3 and higher considered unacceptable)

Table 6. Plastics Compatibility of CFC-11 vs. Freon™ 123

Screening Test Conditions: Plastic specimens exposed to liquid in sealed glass tubes at temperatures and exposure times given below.

| Plastic | | Compatibility Ratings | | | |
|---------------------|------------------------------|-----------------------|------------|--------------------------|------------|
| | | 4 hr at 24 °C (75 °F) | | 100 hr at 54 °C (130 °F) | |
| Chemical Type | Trade Name | CFC-11 | Freon™ 123 | CFC-11 | Freon™ 123 |
| ABS | Kralastic (Uniroyal Chem.) | 0 | 4 | 0 | 4 |
| Acetal | Delrin | 0 | 0 | 0 | 1 |
| Acrylic | Lucite | 0 | 4 | 0 | 4 |
| Fluorocarbon PTFE | Teflon™ | 0 | 0 | 0 | 1 |
| Polyamide 6/6 nylon | Zytel | 0 | 0 | 0 | 0 |
| Polycarbonate | Lexan (General Electric Co.) | 0 | 4 | 0 | 4 |
| Polyethylene-HD | Alathon (Cain Chem. Co.) | 0 | 0 | 1 | 1 |
| Polypropylene | Alathon | 0 | 0 | 2 | 2 |
| Polystyrene | Styron (Dow Chem. Co.) | 0 | 4 | 4 | 4 |
| Polyvinyl Chloride | | 0 | 0 | 1 | 1 |

Ratings: 0 = Suitable for use
 1 = Probably suitable for use
 2 = Probably not suitable for use
 3 = Not suitable
 4 = Plastic disintegrated or dissolved in liquid

Ratings Based on: Specimen dimensional, weight, and surface changes.

Table 7. Elastomer Compatibility of CFC-11 vs. Freon™ 123

Test Conditions: Exposure to liquid in sealed tubes for 7 days at 54 °C (130 °F), then ambient air drying for 21 days

| Elastomer | | Length Change at End of Exposure, % | | Weight Change After Drying, % | |
|--|----------------------------|-------------------------------------|------------|-------------------------------|------------|
| Chemical Type | Trade Name | CFC-11 | Freon™ 123 | CFC-11 | Freon™ 123 |
| Butyl Rubber | | 16 | 11 | -4 | -2 |
| Chlorosulfonated Polyethylene (CSM) | Hypalon | 2 | 12 | -2 | -5 |
| Fluoroelastomer | Viton™ A | 2 | 23 | 0 | 5 |
| Hydrocarbon Rubber (EPDM) | Nordel | 12 | 13 | -9 | -6 |
| Natural Rubber | | 31 | 39 | -4 | -4 |
| Neoprene | | 2 | 10 | -8 | -9 |
| Nitrile Rubber Buna N (NBR) Buna S (SBR) | | 1 13 | 50 26 | 0 -8 | -4 -9 |
| Polysulfide | Thiokol FA (Thiokol Corp.) | 0 | 7 | -1 | -2 |
| Silicone | | 33 | 28 | -2 | -2 |
| Urethane | Adiprene C | 7 | 56 | -3 | -5 |

Elastomers

Compatibility results for Freon™ 123 and CFC-11 are compared for 11 typical elastomers in **Table 7**. The table lists linear swell immediately after exposure and weight change measured after drying. As in the case of plastics, Freon™ 123 may affect some elastomers more than CFC-11. Low swelling and extraction are not sufficient by themselves to qualify an elastomer. Elastomers that show limited effects must still be tested for changes in mechanical properties, such as hardness, tensile strength, and compression set. Some of the elastomers listed here, such as polysulfide, show limited swelling and weight

change, but significant differences in properties after exposure to Freon™ 123.

Although they contain elastomeric binders, compressed sheet gasketing can be used with Freon™ 123 because elastomers are not the major components of these materials. Manufacturers have successfully formulated sheet gasketing based on neoprene and other elastomers. Chiller manufacturers consider many of these formulations to be proprietary. Garlock, Inc. recommends their Style 3300 compressed sheet gasketing, which uses a neoprene binder, for Freon™ 123 service. Filled PTFE gasketing should also be satisfactory.

The original equipment manufacturer should always be consulted before specifying gasketing material to be used in a chiller with Freon™ 123.

Effects on specific elastomers depend on the nature of the polymer, the compounding formulation, and the curing or vulcanizing conditions. Actual samples should be tested under end-use conditions before specifying elastomers for critical components.

Desiccants

Driers with desiccant are typically used in refrigeration systems and bulk storage facilities. Actual field experience has shown that Freon™ 123 is compatible with solid-core driers used with established refrigerants, such as R-11, R-12, and R-22.

Refrigeration Lubricants

Most compressors require a lubricant to protect internal moving parts. The compressor manufacturer usually recommends the type of lubricant and viscosity that should be used to ensure proper operation and equipment durability. Recommendations are based on several criteria, such as lubricity, compatibility with materials of construction, thermal stability, and refrigerant/oil miscibility. To ensure efficient operation and long equipment life, it is important to follow the manufacturer's recommendations.

In refrigeration and air conditioning systems, some lubricant escapes from the compressor discharge area and circulates through the system with the refrigerant. Current lubricants used with CFC-11 are fully miscible over the range of expected operating conditions, easing the problem of getting the lubricant to flow back to the compressor. Refrigeration systems using CFC-11 take advantage of this full miscibility when considering lubricant return.

Several families of lubricants that have acceptable miscibility with Freon™ 123 have been identified. Although most applications for Freon™ 123 will not involve high discharge temperatures or evaporator temperatures below 0 °C (32 °F), the candidate lubricants were tested over the broad temperature range shown in **Table 8**. All of the lubricants listed in the table were miscible over the entire temperature range in the proportions listed.

In summary, lubricants used with CFC-11 are giving satisfactory performance with Freon™ 123 in operating systems.

Table 8. Mutual Solubility Tests with Freon™ 123 and Lubricants

Refrigeration oils determined to be miscible from -10 to 93 °C (14 to 199 °F) in mixtures containing 30, 60, and 90 wt% Freon™ 123:

| |
|--------------------------------|
| 500 SUS Alkylbenzene Lubricant |
| 500 SUS Paraffinic Lubricant |
| 500 SUS Naphthenic Lubricant |
| 125 SUS Alkylbenzene Lubricant |

Note: 500 SUS (Saybolt Universal Seconds) viscosity is equivalent to approximately 110 cSt at 38 °C (100 °F); 125 SUS viscosity is equivalent to approximately 27 cSt at 38 °C (100 °F).

Safety

Users must implement a program to inform employees of the hazards of Freon™ 123 and protective measures to be taken to protect against overexposure during routine operations and emergencies. Users must read and understand the Freon™ 123 Safety Data Sheet (SDS).

Inhalation Toxicity

Chemours has concluded that Freon™ 123 poses no acute or chronic hazard, when it is handled in accordance with recommendations and exposures are maintained at or below the Workplace Environmental Exposure Level (WEEL) of 50 ppm (8- and 12-hr time-weighted average [TWA]).

A WEEL is an environmental exposure level established by the Occupational Alliance for Risk Science (OARS) that specifies TWA airborne concentrations to which nearly all workers may be repeatedly exposed without adverse effects during an 8- or 12-hr workday or 40-hr workweek.

Prolonged inhalation of high concentrations of Freon™ 123 vapor may cause temporary nervous system depression with anesthetic effects, such as dizziness, headache, confusion, incoordination, and loss of consciousness. With gross overexposure (greater than 20% concentration), a temporary alteration of the heart's electrical activity with irregular pulse, palpitations, or inadequate circulation may occur. Similar effects are observed in overexposure to CFC-11. Inhalation may cause liver effects with extended high-level exposures. Intentional misuse or deliberate inhalation of Freon™ 123 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 not breathing, give artificial respiration. If breathing is difficult, give oxygen. Call a physician.

Cardiac Sensitization

If Freon™ 123 vapors are inhaled at a concentration of 20,000 ppm or greater, the heart may become sensitized to adrenaline, leading to cardiac irregularities and, possibly, cardiac arrest. Similar effects are observed with CFC-11 at concentrations in air of 3,500 ppm or greater. The likelihood of these cardiac problems increases if you are under physical or emotional stress.

Because of possible disturbances of cardiac rhythm, catecholamine drugs, such as epinephrine, should be considered only as a last resort in life-threatening emergencies.

Skin and Eye Contact

Freon™ 123 is not a skin irritant or sensitizer, but is a mild to moderate eye irritant. Overexposure by eye contact may include eye irritation with discomfort, tearing, or blurring of vision.

In case of skin contact, flush with water for 15 min. Get medical attention if irritation is present. In case of eye contact, immediately flush eyes with plenty of water for 15 min. Call a physician.

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 refrigerants, protection of valuable equipment, reduction of fugitive emissions, and protection of employees. American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) Standard 15 requires area monitors in refrigeration machinery rooms as defined in the standard. In conformance with the standard, an air monitor capable of measuring 0-150 ppm of Freon™ 123 is required for indoor applications.

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

Types of Detectors

Using selectivity as a criterion, leak detectors can be placed into one of three categories: non-selective, halogen-selective, or compound-specific. In general, as the specificity of the monitor increases, so does the complexity and cost.

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

Non-Selective Detectors

Non-selective 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.

Non-selective detectors will respond to chlorine-containing soaps commonly used in leak testing.

Although non-selective detectors designed for use with CFCs will respond well to Freon™ 123, the low WEEL of Freon™ 123 requires detection of very small leaks. Recently, new detectors with greatly improved sensitivity to Freon™ 123 have become available. Be sure to consult with the manufacturer before selecting or using a non-selective detector with Freon™ 123.

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 non-selective 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 calibrated easily.

Halogen-selective detectors should not be used as area monitors for Freon™ 123, unless it is extremely unlikely that other halogen compounds will be present in the area.

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. Compound-specific detectors are preferred for monitoring Freon™ 123.

Storage and Handling

Shipping Containers in the United States

Freon™ 123 is a nonflammable liquid. It is not regulated by the U.S. Department of Transportation (DOT) and, therefore, does not have a proper shipping name or hazard class.

A list of the different types of containers that can be used to ship Freon™ 123 in the U.S., along with their water capacities, dimensions, DOT specifications, and net weights of Freon™ 123, are provided in **Table 9**. Any pressure relief devices used on the containers must be in compliance with the corresponding Compressed Gas Association (CGA) standards for cargo and portable tanks.

The drums used for Freon™ 123 are painted "light gray," PMS 428. Drums have 5.1-cm (2-in) and 1.9-cm (3/4-in) openings diametrically opposite on the top heads. The 5.1-cm (2-in) opening is fitted with a 5.1-cm (2-in) steel-plated flange with white neoprene gasket and containing 5.1-cm (2-in) and 1.9-cm (3/4-in) zinc die cast combination plugs with bottle cap and irradiated polyethylene gasket beneath the 1.9-cm (3/4-in) plug. The bottle cap provides a seal and

is ruptured upon initial opening of the drum as described in the Storage, Handling, and Use Recommendations section.

Bulk Storage Systems

Chemours sells storage systems, at cost, to its refrigerant customers. The systems are prefabricated, tested, and ready to install on site. Although most Freon™ 123 customers receive product in drums and do not require storage facilities on site, bulk tanks can be provided if desired.

The delivered systems include all components, such as storage tanks, pumps, piping, valves, motors, and gauges, as an integrated unit. Units are skid-mounted and require only placement on a concrete pad and connection to electrical and process systems. Your Chemours marketing representative can arrange for guidance on site selection, purchase, installation, start-up, and maintenance.

Storage, Handling, and Use Recommendations

A Freon™ 123 specific air monitor with 0-150 ppm range is required for all indoor applications. Sensors should be located so that samples are representative of worker exposure. Appropriate respiratory protection should be available for immediate use in the event of a large release or leak. ASHRAE Standard 15, "Safety Code for Mechanical Refrigeration," provides additional guidance on system and room design.

Prohibited Uses

Freon™ 123, or mixtures containing Freon™ 123, should not be used as an uncontained flushing fluid in refrigeration work or as a general cleaning solvent.

Table 9. Specifications of Shipping Containers for Freon™ 123

| Nominal Size | Dimensions | DOT Specification | Color Code | Net Weight (lb) Freon™ 123 |
|------------------------|-------------------------|----------------------------|------------|----------------------------|
| 10-gal tight head drum | 14-5/8" OD x 17-3/4" H | 17E | PMS 428 | 100 |
| 20-gal tight head drum | 16-1/4" OD x 28-5/16" H | 17E | PMS 428 | 200 |
| 55-gal tight head drum | 23-1/2" OD x 34" H | 17C | PMS 428 | 625 |
| 5,000 gal | Tank Truck | MC-307 MC-330 MC-331 | | 40,000 maximum |
| 20,000 gal | Tank Rail Car | 105A100W | | - |

Table 10. Minimum Respirator Protection

| Concentration of Freon™ 123 in Air, ppm | Exposure Time | Minimum Respirator Protection |
|---|---------------------------------|-------------------------------|
| Less than 50, as a time weighted average (TWA)* | 8–12 hr per workday | None |
| 50–150* | Less than 30 min per work shift | None |

*Instantaneous spikes may occur during operations, such as disconnecting charging lines or tapping drums. When factored into the time-weighted average, existing monitoring data on excursions have not resulted in exceeding the WEEL during typical routine servicing.

When performing tasks that monitoring data indicate may result in concentrations exceeding the above or when performing non-routine or unusual tasks, the following protection is recommended:

| Concentration of Freon™ 123 in Air, ppm | Minimum Respirator Protection |
|---|--|
| 50–300 | Half Mask, Organic Vapor Cartridge, or Canister OR Full Mask, Organic Vapor Cartridge, or Canister |
| 300 or greater | Full Face Air Line or Self-Contained Breathing Apparatus (SCBA) |

Personal Protective Equipment

Respiratory protection should be worn when performing all operations during which there is potential for exposure in excess of an average of 50 ppm for an entire 8- or 12-hr workday. Chemours recommends the use of NIOSH-approved respiratory protection as shown in **Table 10**.

Note: Cartridge performance is affected by humidity. Cartridges should be changed after 2 hr of continuous use, unless it is determined that the humidity is less than 75%; in which case, cartridges can be used for 4 hr. Used cartridges should be discarded daily, regardless of the length of time used.

People who will work with Freon™ 123 should be trained on the proper use of respirators and fit-tested annually to ensure respirator fit is adequate.

Industrial hygiene evaluations of workplace conditions may justify less stringent respirator program recommendations.

Eye protection, gloves of butyl rubber or other impervious material, and safety shoes should be used when filling and handling drums. Nitrile, polyvinyl chloride (PVC)-coated nitrile, and PVC protective equipment are not recommended. Directed mechanical ventilation or localized exhaust may facilitate controlling airborne Freon™ 123 concentrations.

Coverall chemical goggles and a face shield should be used when making first breaks into a system if liquid splash is a potential problem and full-face respiratory protection is not worn. Eyewash fountains or water hoses with quick-opening valves should be accessible to Freon™ 123 work areas.

Storage

Drums of Freon™ 123 should be stored upright, at a temperature below 52 °C (125 °F), and out of direct sunlight. All drum bungs should be leak-tight (at a minimum sealed with tetrafluoroethylene [TFE] tape). Storage of factory-sealed drums does not require a continuously operating air monitor. A monitor is, however, required if liquid transfer or drumming operations are being performed at an indoor storage location. Quantities stored should be limited to that needed for reasonable maintenance requirements. Empty drums should be stored outside.

No storage of Freon™ 123 should be permitted in areas containing alkali or alkaline earth metals, such as powdered aluminum, zinc, or beryllium.

Handling

When moving drums of Freon™ 123, the use of gloves, safety glasses with side shields, and steel-toe shoes is recommended. Use either a hand truck or forklift when moving drums, because filled units can weigh as much as 309 kg (680 lb). When using a forklift truck, always follow the manufacturer's recommended weight capacity.

The larger bung on Freon™ 123 drums loaded in the United States contains a smaller built-in opening for hose/piping connections. This smaller opening has a metal seal to minimize vapors released to the atmosphere on initial opening of the drum. **On initial opening of a drum, it is recommended that a combination 3/4-in screwed brass ball valve with Teflon™ packing and seat and a 3/4 x 2-in pipe nipple be screwed into the threaded bung.** This will rupture the seal and allow for fluid transfer.

This operation should be performed outdoors; if indoors, use directed mechanical ventilation or localized exhaust equipment. Appropriate refrigeration fittings can be connected to the valve for transfer into the machine. This procedure minimizes emissions of refrigerant during drum opening.

Charging, Maintenance, and Sampling

When making first breaks into the system, wear appropriate respiratory protection (unless the room air monitoring data indicates that the Freon™ 123 concentration in air can reasonably be expected to remain below 50 ppm WEEL during the work in progress (see **Table 10**). Directed mechanical ventilation or localized exhaust may facilitate controlling airborne concentrations.

When charging refrigerant into or drawing it out of a chiller, connect the drum to the chiller with both a liquid transfer line and a vent line to avoid a vacuum or overpressure condition in the drum and to minimize venting of Freon™ 123 vapor into the workspace during liquid transfer. The transfer and vent lines should be compatible with Freon™ 123. Minimize Freon™ 123 emission to atmosphere from transfer lines during connection and disconnection. If possible, use the previously recommended drum connection device (valve and nipple), and charge refrigerant under cool ambient conditions.

Good workplace practices should be used to avoid spills, drippage, exposed contaminated equipment, or open containers of Freon™ 123.

When working on a chiller, de-inventory into drums through a recovery device or into a receiver (if provided) and evacuate the system to 29 in Hg (absolute pressure of 3.4 kPa [0.5 psia]). Break the vacuum with nitrogen, re-evacuate, and break vacuum again with nitrogen. Waste oil should be disposed of in accordance with appropriate regulatory requirements. Waste oil will contain significant quantities of dissolved Freon™ 123.

Leaks and Spills

Major leaks or spills will not evaporate readily due to the high boiling point of Freon™ 123, forcing recovery as a liquid. SCBA is required until levels are reduced sufficiently to permit other or no respiratory protection. Spill control measures should be preplanned, and all washes should be disposed of in accordance with applicable government regulations. If splash potential exists, wear protective equipment fabricated from an impervious material, such as butyl rubber.

Recovery, Reclamation, Recycle, and Disposal

Responsible use of Freon™ 123 requires that the product be recovered for reuse or disposal. Chemours purchases used refrigerants for reclamation through its distributor networks in the United States, Canada, and Europe. In the United States, used Freon™ 123 is accepted as part of this program. Recovery and reuse of Freon™ 123 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 Freon™ 123 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™ 123 may be recovered from refrigeration equipment using recovery equipment available from chiller manufacturers and refrigeration contractors. These recovery units are often mounted on a base with casters and have provision for storage of a limited amount of refrigerant during chiller maintenance. Recovery units may be purchased or leased. These devices contain a vacuum pump and water-cooled condenser and may be used for liquid and vapor recovery. At the end of the recovery cycle, the system must be evacuated to remove vapors. In the U.S., the EPA sets standards for recovery equipment. Before purchasing a specific recovery unit, check with the manufacturer to be sure that it is compatible with Freon™ 123.

Reclamation

Reclamation refers to the reprocessing of used Freon™ 123 to new product specifications. Quality of reclaimed product is verified by chemical analysis. In the U.S., Freon™ 123 is included in 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.

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 procedure with no analytical testing of refrigerant. Freon™ 123 may be recycled using recycle/recovery systems now on the market. In the U.S., the EPA sets standards for these devices. Consult with the manufacturer before specifying a recycle device for Freon™ 123.

Disposal

Disposal refers to the destruction of used Freon™ 123. Disposal may be necessary when Freon™ 123 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 refrigerants for disposal, licensed waste disposal firms are available. Be sure to check the qualifications of any firm before sending them used Freon™ 123.

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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