FE-13™

Fire Extinguishing Agent

Properties, Uses, Storage, and Handling

Chemours™

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Introduction

Chemours has developed accepted halon alternatives, such as hydrofluorocarbon (HFC) 23, to protect critical facilities against fires, as HFCs offer unique properties. They are low in toxicity, nonflammable, non-corrosive, and compatible with other materials. In addition, they have thermodynamic and physical properties that make them ideal for a variety of uses. One high value use of these compounds is as fire extinguishants and explosion suppressants. They are used in hand-held portable extinguishers, total flooding systems, and local application systems. The bromofluorocarbons and bromochlorofluorocarbons (halons), which were developed in the 1930s, were linked to depletion of the earth's protective ozone layer. As a result, these halon compounds have been phased out of production, and fire extinguishing agents, such as HFC-23 (FE-13), have stepped in to take their place.

HFC-23

Because HFC-23 does not contain chlorine or bromine, it has an ozone depletion potential (ODP) of zero. Uses are as a fire extinguishant and a refrigerant. It is used as a pure refrigerant and as a blend component for special applications. HFC-23 is nonflammable, has low toxicity, and is non-ozone depleting.

It may be identified by any of the following names:

- Trifluoromethane
- Hydrofluorocarbon (HFC) 23
- Hydrofluoroalkane (HFA) 23
- FE-13™ fire extinguishant

FE-13™ Fire Extinguishing Agent

As a fire extinguishing agent, HFC-23 is referred to as FE-13™, a trademark of Chemours. It is intended to replace Halon 1301 in total flooding and inerting applications. FE-13™ is a safe, clean, and electrically nonconductive agent and is suited for use in applications requiring clean, environmentally acceptable and humanly compatible conditions.

The physical properties of FE-13™ are listed in **Table 1**.

Applications

Total Flooding of Class-B Hazards

FE-13™ is an ideal clean agent for the total flooding applications where people occupy the protected space during discharge of the system and for Class-B fire assets. Class-B fire hazards may involve hard-to-extinguish fuels like methanol, as well as spaces where the volume will vary with contents. Examples of applications where FE-13™ would be an excellent choice for a total flood fire suppression system where people are present such as: oil rig platforms, flammable liquid processing areas, railroad locomotives, and surface mining equipment.

FE-13™ can also be used to suppress Class-A fire hazards. Examples of these applications would include: computer rooms, data collection/storage facilities, electrical control rooms, mobile communication facilities, bank vaults, and storage areas of precious documents.

Protection of Assets in Cold Climates

FE-13™ is an ideal clean agent for total flooding applications where ambient temperatures can vary greatly or in low temperature areas. FE-13™ is ideally suited for cold environments. Its low boiling point permits use in temperature extremes ranging from –40 °C (–40 °F) to 54.4 °C (130 °F). Therefore system containers need not be stored in temperature protected areas.

Protection of Assets in Large Areas or with High Ceiling Enclosures

FE-13™ is an ideal clean agent for total flooding applications where there is a high ceiling or a large space. The vapor density of FE-13™ is lower than other halocarbons. This high pressure and low vapor density allows it to mix throughout the enclosure quicker and stay mixed longer. The normal nozzle coverage area is 9.1 m x 9.1 m (30 ft x 30 ft). In the application where high ceiling are present other halocarbon systems require a double layer of nozzles because their maximum nozzle height is 4.2–4.9 m (14–16 ft). FE-13™ has a maximum nozzle height of 7.6 m (25 ft), so in many applications a single layer of nozzles is required.

Safe for People

FE-13™ is an ideal clean agent for the total flooding and inerting applications where people could be present. This agent offers the widest safety margin between use concentration and onset of exposure restrictions. FE-13™ is safe for use in occupied spaces up to a concentration of 30-vol% in air. Design planners can rely on FE-13™ to provide effective protection at low temperatures, without human exposure issues when the hazard is at high temperatures. Likewise, hazards with changeable contents can be protected with FE- 13™. Concentration for both the empty volume and the filled volume can be safe for people, with no exposure restrictions. If the hazard is a difficult one, requiring more than a minimum extinguishing concentration, the safety margin of FE-13™ allows a comfortable cushion of concentration, insuring fire suppression that is safe and effective.

Even though the toxicity of this clean agent is low, Precautions should always be made to limit the exposure. All persons shall exit the affected area and no one should reenter the area until it has been ventilated.

Physical Properties

Physical properties of FE-13™ are shown in **Table 1.**

Saturated vapor pressures and densities are given in **Tables 2a** and **2b**.

Saturated vapor pressure diagrams are shown in **Figures 1** and **2**.

Thermodynamic tables in ENG and SI units are available from Chemours.

Table 1. Physical Properties of FE-13™

Properties	
Chemical Name	Trifluoromethane
Chemical Formula	CHF_3
CAS Number	75-46-7
Molecular Weight	70.02
Boiling Point, 1 atm, °C (°F)	−82.0 (−115.7)
Freezing Point, °C (°F)	−155 (−247)
Flammable Limits in Air (1 atm)	None
Critical Temperature, °C (°F)	25.9 (78.6)
Critical Pressure, kPa (psia)	4836 (701.4)
Critical Density, kg/m^3 (lb/ft^3)	525.02 (32.78
Liquid Density at 25 °C (77 °F), kg/m^3 (lb/ft^3)	0.6799 (42.45)
Specific Heat, Liquid (cP) at 25 °C (77 °F), kJ/kg-°C (Btu/lb°F)	18.83 (4.502)
Specific Heat, Vapor (cP) at 25 °C (77 °F), kJ/kg-°C (Btu/lb°F) and 1 atm	0.7368 (0.1761)
Vapor Pressure, Saturated at 25 °C (77 °F), kPa (psia)	4699 (681.5)
Heat of Vaporization at BP, kJ/kg (Btu/lb)	239.3 (103.0)
Thermal Conductivity, Liquid at 25 °C (77 °F), W/m-°C (Btu/hr-ft°F)	0.0534 (0.0309)
Thermal Conductivity, Vapor at 25 °C (77 °F), W/m-°C (Btu/hr-ft°F)	0.0352 (0.0203)
Viscosity, Liquid at 25 °C (77 °F), cP (lb/ft-hr)	0.0443 (0.1071)
Viscosity, Vapor at 25 °C (77 °F), cP (lb/ft-hr)	0.0248 (0.0599)
Relative Dielectric Strength at 1 atm, 25 °C (77 °F) (N_2 =1)	1.02
Solubility of Water in FE-13™ at 25 °C (77 °F), ppm	500
Ozone Depletion Potential, ODP	0.0
Global Warming Potential, GWP (100 yr ITH. For CO_2, GWP = 1)*	11700
Atmospheric Lifetime, yr*	264
TSCA Inventory Status	Included
European Classification Number	EC No.: 200-872-4
SNAP Status	Included
Inhalation Exposure Limit (AEL, 8- and 12-hr TWA), ppm**	1000

*The acceptable exposure limit (AEL) is the 8-hr time weighted average (TWA) workplace exposure limit established by Chemours.

**Second Assessment Report (1995) – Intergovernmental Panel on Climate Change (IPCC).

Table 2a. Vapor Pressure and Density of FE-13™ (ENG Units)

Temperature, °F	Saturated Vapor Pressure, psia	Liquid Density at Saturation, lb/ft³	Vapor Density at 1 atm, lb/ft³
–60	66.37	82.42	0.245
–50	82.95	80.88	0.239
–40	102.49	79.27	0.233
–30	125.30	77.60	0.227
–20	151.73	75.84	0.222
–10	182.12	73.99	0.216
0	216.85	72.03	0.211
10	256.31	69.93	0.207
20	300.93	67.65	0.202
30	351.15	65.15	0.198
40	407.50	62.35	0.194
50	470.58	59.10	0.190
60	541.10	55.14	0.186
70	620.11	49.65	0.182
79	700.23	34.82	0.179

Table 2b. Vapor Pressure and Density of FE-13™ (SI Units)

Temperature, °C	Saturated Vapor Pressure, kPa	Liquid Density at Saturation, kg/m³	Vapor Density at 1 atm, kg/m³
–50	478.97	1315	3.909
–45	584.45	1293	3.817
–40	706.63	1270	3.729
–35	847.11	1246	3.645
–30	1007.60	1221	3.566
–25	1189.80	1194	3.490
–20	1395.60	1167	3.417
–15	1626.90	1137	3.348
–10	1885.80	1106	3.282
–5	2174.50	1072	3.218
0	2495.30	1035	3.157
5	2851.00	994	3.098
10	3244.50	947	3.042
15	3679.60	890	2.987
20	4161.40	816	2.935
25	4698.60	680	2.884
26	4814.70	590	2.874

Figure 1. Vapor Pressure of FE-13™ (ENG Units)

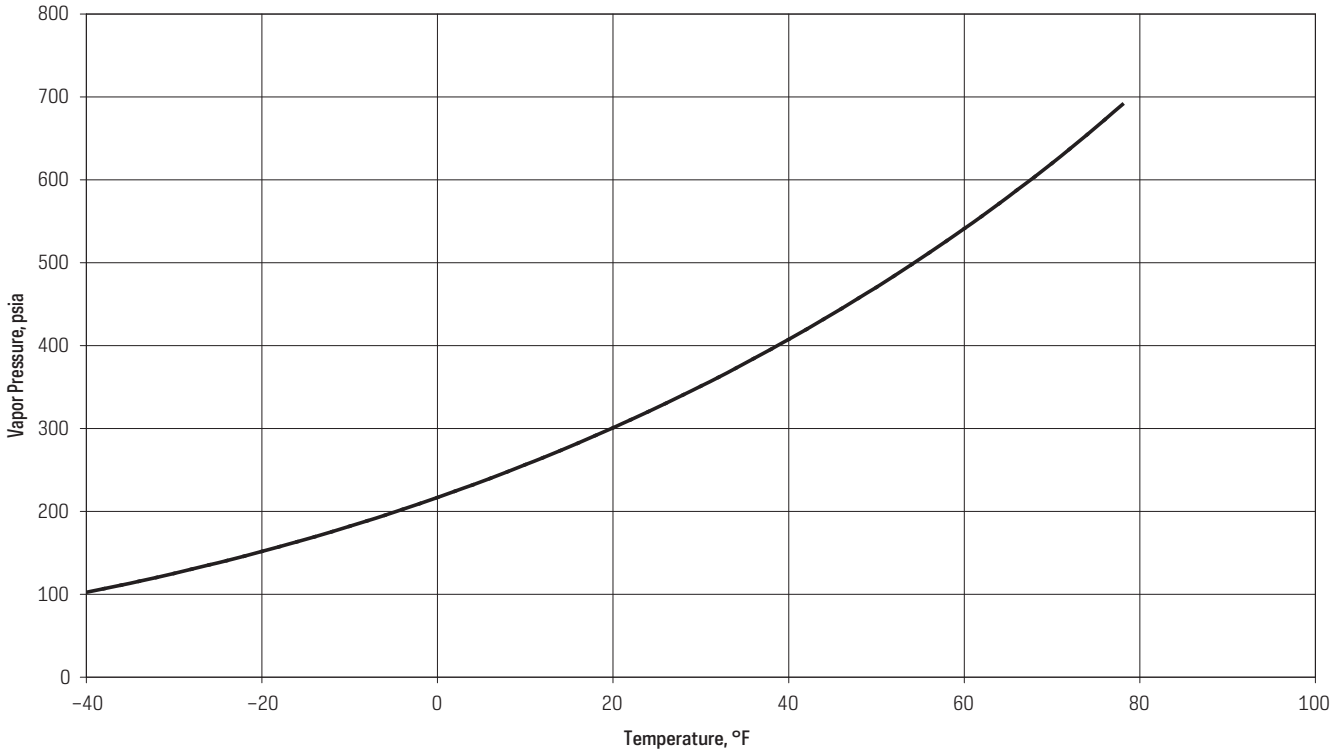
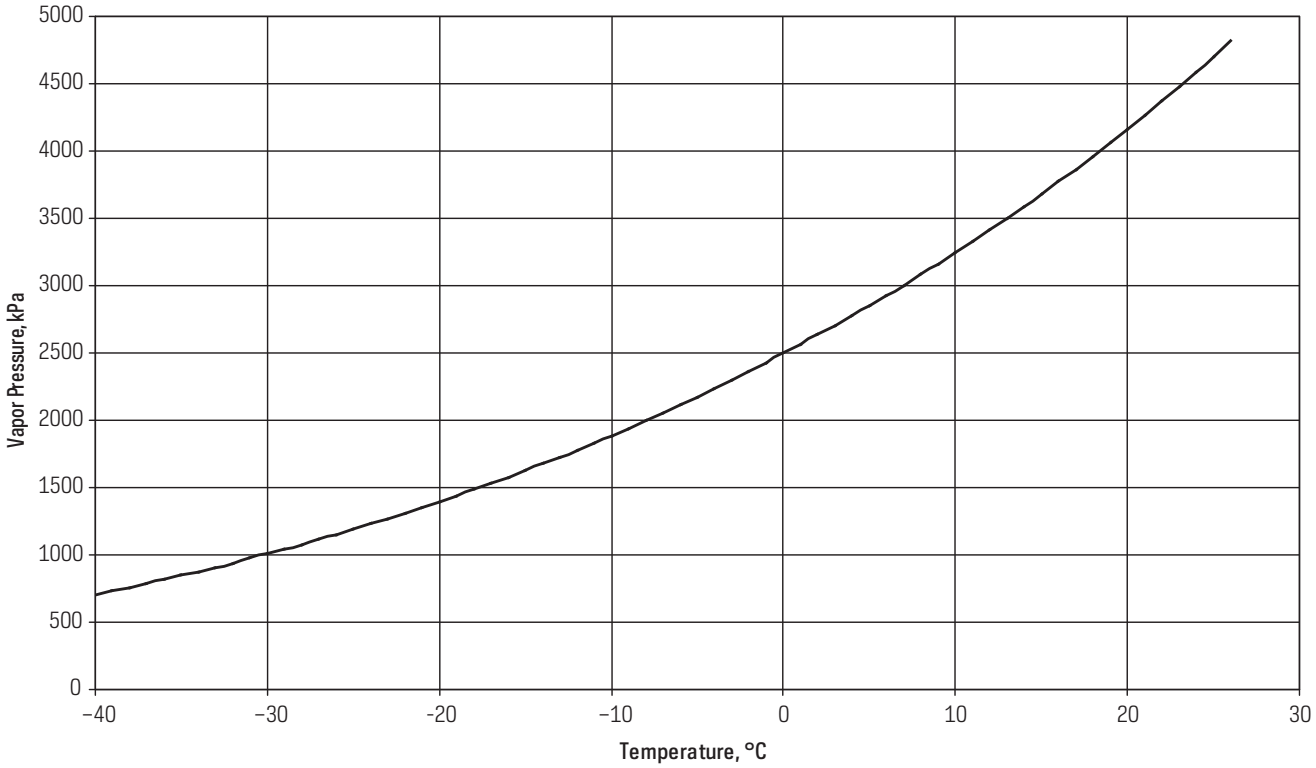


Figure 2. Vapor Pressure of FE-13™ (SI Units)



Performance

The accepted Minimum Extinguishing Concentration (MEC) for FE-13™ for Class-A fires is 12.6% (volume) based on the Class-A fire test requirements found in the Underwriters Laboratories' (UL) Standard 2166. For Class-B fires, the MEC is 12.9% (volume) based on full scale testing by UL 2166 tests with n-heptane fuel. The MEC for other flammable gases and combustible liquids are determined by the cup burner method as described in NFPA 2001 Annex B. Chemours FE Technical Service maintains a NFPA and ISO compliant Cup Burner Apparatus and can assist customers with determining this value. Minimum Design Concentrations (MDC) should be based on the specific hardware manufacturer's MEC plus a safety factor of 20–30% depending on the requirements of the local Authority Having Jurisdiction (AHJ).

The concentration of FE-13™ required to inert an atmosphere containing a flammable concentration of methane has been measured at 20.2% (volume). The inerting concentration is defined as the percentage of agent in air that inhibits the propagation of a flame. It is typically measured using the specific fuel and an ignition spark energy of 68 joules. The inerting concentration is always greater than an agent's extinguishing concentration.

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.

Plastics and Elastomers

See **Tables 3a** and **3b** for compatibility data on commonly used plastics and elastomers.

It should be recognized that these data reflect compatibility in sealed tube tests, and that compatibility in real systems can be influenced by the actual system conditions, the nature of the polymers used, compounding formulations of the polymers, and the curing or vulcanization processes used to create the polymer. Polymers should always be tested under actual operating conditions before reaching final conclusions about their suitability. The results shown in **Table 3a** are based on samples of each plastic subjected to aging at room temperature for two weeks in agent alone. The plastic coupons were 50% immersed in liquid FE-13™. **Table 3b** shows compatibility of FE-13™ with various elastomers using the same aging conditions as used for the plastics. Physical properties of the test samples were determined before and after aging.

Metals

Most commonly used metals such as steel, cast iron, brass, copper, tin, lead, and aluminum can be used satisfactorily with FE-13™ under normal conditions of use. High temperature stability tests were conducted with FE-13™ and commonly used metals at 175 °C (347 °F) for two weeks, and FE-13™ was found to be stable. At temperatures above 175 °C (347 °F), depending on specific conditions, some metals may act as catalysts and break down the FE-13™. These conditions include: presence of moisture or other contaminant, type of metal, metal surface area, contact with liquid or vapor agent, as well as time and temperature of contact.

FE-13™ like other halocarbons may react violently with highly reactive metals such as the alkali and alkaline earth metals, sodium, potassium, and barium, in their free metallic form. Some metals become more reactive when finely ground or powdered, and in this state magnesium and aluminum may react, especially at higher temperatures. Highly reactive materials should not be brought into contact with FE-13™ until a careful study is made and appropriate safety precautions are taken.

Table 3a. Plastic Compatibility with FE-13™ at Room Temperature for 2 Weeks

Plastic	Weight Gain, %	Surface Condition
High-density polyethylene (HDPE)	0.4	No Change
Polypropylene (PP)	0.7	No Change
Polystyrene (PS)	2.9	No Change
Acrylonitrile-butadiene-styrene (ABS)	0.7	No Change
Nylon 6/6	0.3	No Change
Polymethyl methacrylate (PMMA)	1.8	No Change

Table 3b. Elastomer Compatibility with FE-13™ at Room Temperature for 2 Weeks

Elastomer	Linear Swell, %	Weight Gain, %	Hardness Change, units
Butyl	−0.1	1.1	−2
Nordel EPDM	−0.4	2.5	−2
Neoprene W	0.9	1.1	−2
NBR	0.6	4.1	−2
Hypalon CSM	0.5	1.7	−4
Viton™ A	3.3	4.4	−3
Epichlorohydrin homopolymer	0.5	1.6	−1
FA polysulfide	0.1	0.8	2
Hytrel TPE	1.3	3.8	1

Safety

Users of FE-13™ should read and understand the Chemours Safety Data Sheet (SDS). Copies of the FE-13™ SDS can be obtained from Chemours Customer Service or International Offices.

Inhalation Toxicity

FE-13™ poses no acute or chronic hazard when handled in accordance with Chemours recommendations and when exposure is maintained below the recommended exposure limits. Chemours has established the Allowable Exposure Limit (AEL) for HFC-23 at 1000 ppm, 8-hr and 12-hr TWA.

Short-term and extended inhalation studies on animals, including histologic examination, indicate that HFC-23 is chemically and biologically unreactive. HFC-23 is not a mutagen in the Ames Test.

As with many halocarbon materials used safely in fire protection applications, inhalation abuse or intentional inhalation of concentrated HFC-23 vapors may result in suffocation by oxygen displacement, central nervous system anesthesia-like effects, or cardiac sensitization effects that may cause death without warning. If a person is experiencing any of the noted symptoms, they should be moved to fresh air and kept calm. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Seek medical attention.

When exposed to open flames, FE-13™ will decompose and produce hydrofluoric acid (HF). The amount of HF will depend upon the size of the fire and the speed of the extinguishment. Even at low levels, these decomposition products have a very acrid odor and are easily detected by the human senses. The natural tendency to escape exposure should be heeded.

Cardiac Sensitization

Under misuse or intentional abuse conditions, many hydrocarbons and halocarbons can potentially sensitize the heart to adrenaline, especially under conditions of physical or emotional stress. In studies designed to determine the potential for cardiac sensitization, laboratory animals are given large doses of adrenaline to predispose them to cardiac sensitization during inhalation of the test material. In these studies with HFC-23, no cardiac sensitization was produced during exposure to 300,000 ppm (30% by volume) in air.

When treating patients who have been exposed to a high concentration of HFC-23, the use of catecholamine drugs, such as epinephrine, should be considered only as a last resort in life-threatening emergencies because of possible disturbances of cardiac rhythm.

Fire Extinguishing Concentrations

Minimum requirements for the installation and use of clean agent fire extinguishing systems are given in National Fire Protection Association (NFPA) 2001 Standard. Included is guidance for human exposure limits for HFC-23 (FE-13™) based on the Environmental Protection Agency's (EPA) recommended guidelines. The Standard lists HFC-23 acceptable for use in normally occupied spaces. For design concentrations up to 30%, the EPA recommended method allow an exposure time limited to a duration of five minutes.

Skin and Eye Contact

At room temperature, FE-13™ 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 as soon as possible.

Always wear protective clothing when there is a risk of exposure to liquid FE-13™. Where splashing of agent may occur, always wear eye protection and a face shield.

Spills or Leaks

If a large release of vapors occurs, such as from a large leak or spill, the vapors may concentrate near the floor or in subfloor areas and displace the oxygen available for breathing, causing suffocation.

Evacuate everyone until the area has been well ventilated. Use blowers or fans to circulate the air at floor level. Do not re-enter the affected area without self-contained breathing apparatus or unless the area has been monitored to indicate that the concentration of HFC-23 vapors in the area is below the AEL of 1000 ppm.

Always use self-contained breathing apparatus or a supplied air mask when entering tanks or other enclosures where vapors might exist. Use the buddy system and a lifeline. Refer to the FE-13™ SDS for more information.

HFC-23 vapors have virtually no odor. Therefore, frequent leak checks or the installation of area monitors are necessary in enclosed areas where leaks can occur.

To ensure safety when working with halocarbons in confined areas:

1. Route relief and purge vent piping (if used) outdoors, away from air intakes.
2. Make certain the area is well ventilated, using auxiliary ventilation, if necessary, to move vapors.
3. Make sure the area is clear of vapors prior to beginning work.
4. Utilize monitoring equipment to detect leaks.

Refer to the FE-13™ SDS for more information.

Storage and Handling

Shipping Containers in the United States

FE-13™ is a liquefied compressed gas. 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.)

The appropriate DOT designations are as follows:

DOT Proper Shipping Name	Trifluoromethane
Hazard Class	2.2
UN Number	1984
DOT/IMO Labels	Nonflammable Gas

A list of the different types of containers that can be used to ship FE-13™ in the United States, along with their water capacities, dimensions, DOT specifications, and net weights, are provided in **Table 4**. 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 31.8-kg (70-lb) size cylinder of FE-13™ is a free standing, upright returnable container. It is equipped with a single valve. The outlet is designed for CGA-660 connection. With this valve, agent can be removed from the cylinder as vapor. To remove liquid, the cylinder must be inverted.

The 431-kg (950-lb) size cylinder is a returnable container fitted with two valves designed for CGA-660 connection. The general construction of a one-ton returnable container is shown in **Figure 5**. 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.

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.

FE-13™ is also deliverable by tube trailer in quantities of approximately 20,000 lb (9,071 kg). For export shipments, ISO containers are used.

Bulk Storage Systems

Chemours sells storage systems to their 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 material. The delivered systems include all components, such as storage tanks, pumps, piping, valves, motors, and gauges, as an integrated unit. All systems are equipped with 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.

Table 4. Specifications of Shipping Containers for FE-13™, United States

Container	Dimensions	DOT Spec.	Net Weight, kg/lb
84 lb WC Cylinder	50" H x 8.5" OD	3AA1800	31.8/70
1585 lb WC Ton Cylinder	82" H x 30" OD	110A2000W	431/950
ISO	8' x 8' x 20' (frame)	51	9072/20000

Transfer of FE-13™ from the Container

The preferred method to transfer FE-13™ is with a pumping system that has been designed for that purpose. A supplier with experience in building fluorocarbon type systems should be contacted.

If a pump is not available, the chilled transfer line method will facilitate transfer of FE-13™ to the receiving container. This method chills the FE-13™ as it passes through the transfer line, reducing the pressure in the receiver to induce transfer by pressure differential. A coil of compatible metal tubing of sufficient pressure rating is positioned in the transfer line between the supply and the receiver. The coil is placed in a cold bath, such as water ice or carbon ice.

The receiving container should be evacuated to eliminate contamination by air and to facilitate transfer of FE-13™.

Before returning empty Chemours cylinders, the vapor heel should be recovered. This may be done by the chilled transfer method or with a recovery system consisting of a compressor, desiccant dryer, oil separator (or oil-less compressor), and condenser.

Leak Detection

Whenever a system is assembled or serviced, it should be checked for leaks. There are many commercially available leak detectors. These devices are readily available through a refrigeration supply house.

A detailed discussion of leak detection is available from Chemours.

Figure 3. Isometric Diagram of FE-13™, °F

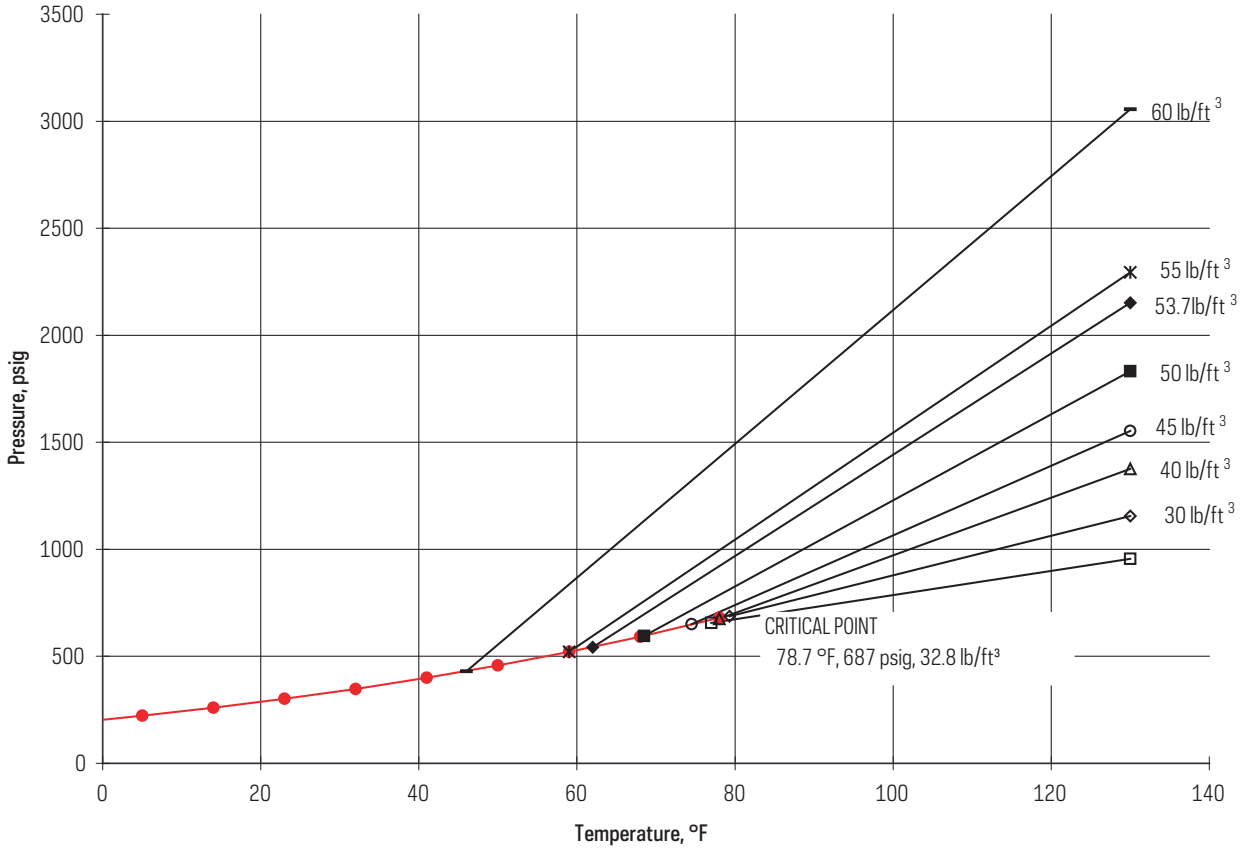


Figure 4. Isometric Diagram of FE-13™, °C

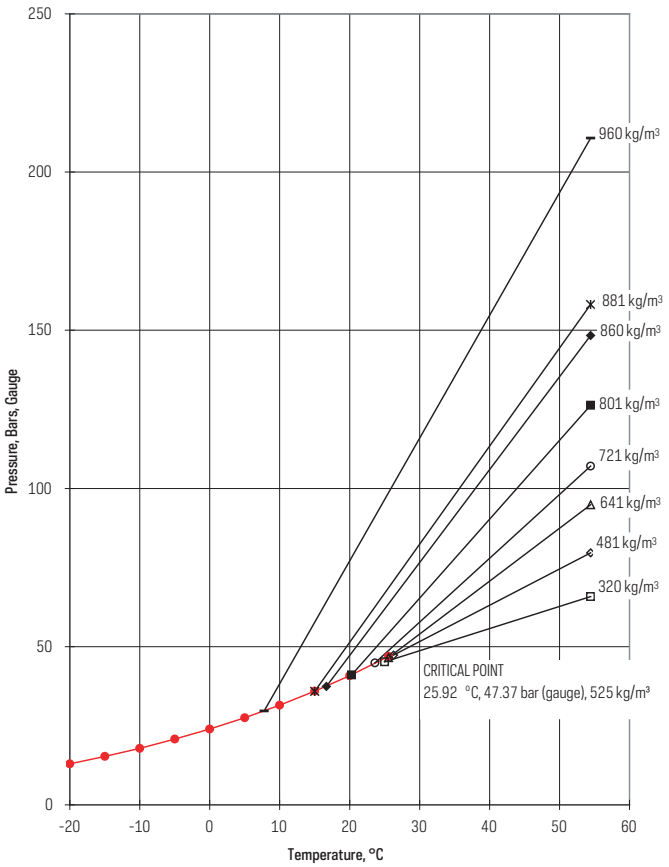
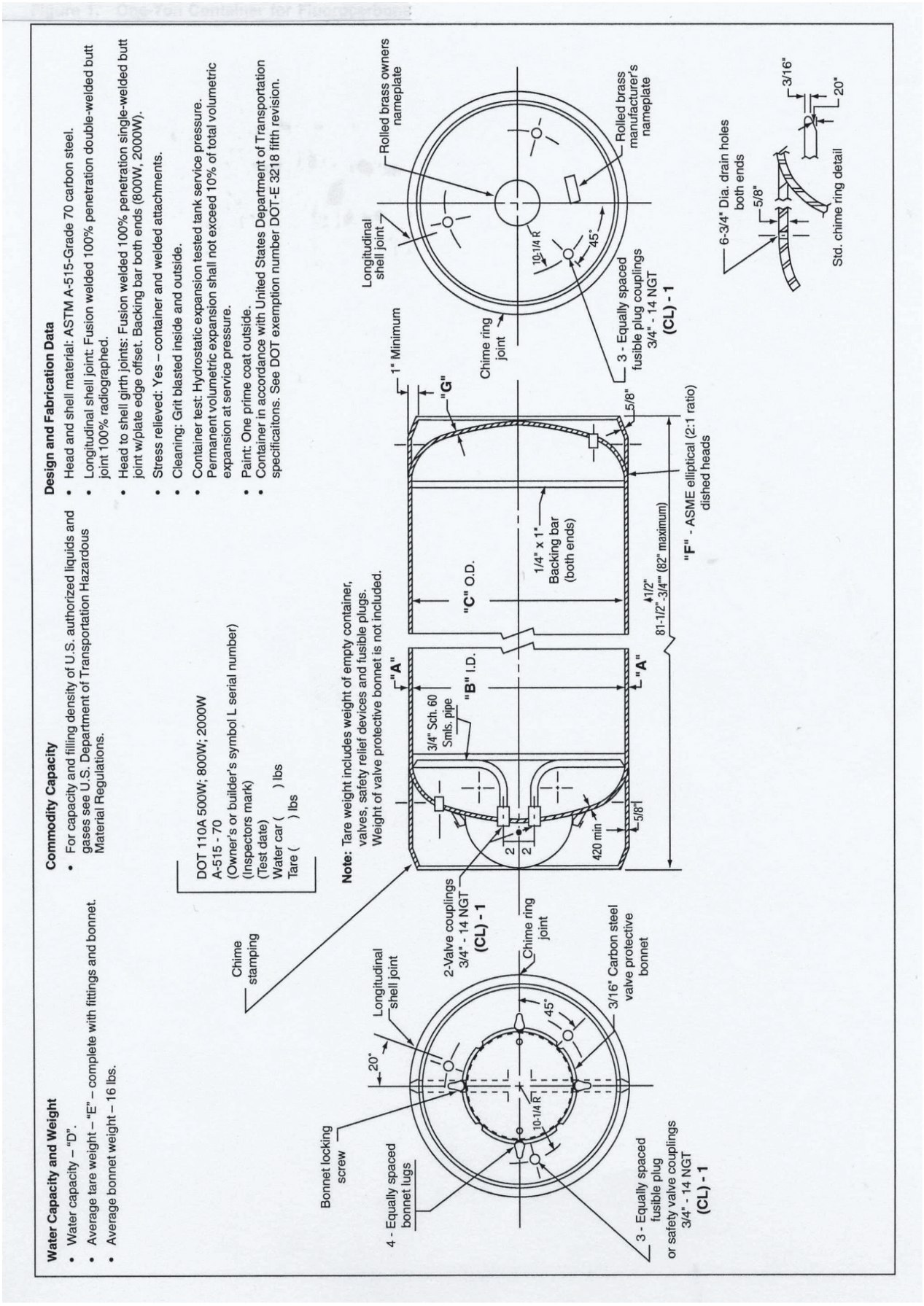


Figure 5. Water Capacity and Weight; Commodity Capacity; Design and Fabrication Data



Handling Precautions for FE-13™ Shipping Containers

A detailed discussion of ton containers is available in Chemours technical bulletin "Handling of One-Ton Containers Containing Fluorocarbon Compounds".

The following rules for handling FE-13™ containers are strongly recommended:

- Use personal protective equipment, such as side-shield glasses, gloves, and safety shoes, when handling containers.
- Avoid skin contact with liquid FE-13™; it can cause frostbite.
- Never heat a container to a temperature higher than 52 °C (125 °F).
- Never refill returnable cylinders without Chemours consent. DOT regulations forbid transportation of returnable cylinders refilled without Chemours authorization.
- Never use a magnet or sling (rope or chain) to lift containers. Lifting may be accomplished by the use of a safe cradle or platform basket that holds the container.
- Never use containers as rollers, supports, or any other purpose than to contain FE-13™.
- Protect containers from any objects 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 container.
- Never attempt to repair or alter containers or valves.
- Never force connections that do not fit. Make sure the threads on the regulator or other auxiliary equipment are the same as those on the valve outlets.
- Keep valves tightly closed, with valve caps and hoods in place when the container is not in use.
- When storing containers outside, store under a roof and protect from weather extremes.

Nitrogen Superpressurization of FE-13™

FE-13™ is shipped in cylinders that contain essentially pure agent. The pressure in these cylinders is therefore due to the vapor pressure of FE-13™ alone. In fire suppression applications, it is often desirable to increase the available pressure above the vapor pressure of the agent. In these cases, nitrogen is added to the agent after transfer to accomplish this pressure increase and is called "superpressurization." Chemours FE-13™ does not require superpressurization. The agent's vapor pressure is sufficient for distribution through piping and dispersion from discharge nozzles.

Recovery, Recycle, Reclamation, and Disposal

Responsible use of FE-13™ requires that the product be recovered for reuse or disposal whenever possible. Recovery and reuse makes sense from an environmental and economic standpoint.

Recovery

Recovery refers to the removal of FE-13™ from equipment and collection in an appropriate external container. Recovery does not involve processing or analytical testing. But if the system contains nitrogen or other pressurizing gas, it must be identified on the label. Recovery is normally performed when a system must undergo maintenance and the FE-13™ is then returned to the system after completion.

Reclamation

Reclamation refers to the reprocessing of FE-13™ recovered from a system to new product specifications. Quality of the reclaimed product is verified by chemical analysis. In the United States, FE-13™ is included in Chemours reclamation program. Contact Chemours for further information.

Disposal

Disposal refers to the destruction of used FE-13™. Disposal may be necessary when FE-13™ has become contaminated with other materials and no longer meets the acceptable specifications of Chemours or other reclaimers. Chemours does not presently accept severely contaminated FE-13™ for disposal; licensed waste disposal firms are available. Be sure to check the qualifications of any firm before sending them used HFC-23.

For more information on FE-13™, please visit cleanagents.chemours.com or call (800) 473-7790

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