ATMOSPHERIC PRODUCTS AND SERVICES (APS)

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SafetyAlert-28

Nitrogen Trifluoride (NF_3)

General

Nitrogen trifluoride (NF_3) is a colorless, odorless nonflammable, oxidizing gas. NF_3 offers the advantages of relative ease of use at ambient conditions and the ability to act as a fluorinating agent. Because of these factors, it has gained commercial acceptance in a number of applications. The electronics industry uses it in plasma and thermal cleaning applications for its advantages, such as high etch rates, high selectivity, carbon-free etching, and minimal residual contamination. NF_3 is also used as a fluorine source in high-energy chemical lasers, owing to its ease of use relative to fluorine gas. NF_3 is also used as an intermediate in the production of specialized chemicals. NF_3 is available in a variety of grades and at purity levels in excess of 99.999% due to advanced purification techniques developed by Air Products.

Table 1 lists the physical and chemical properties of NF_3.

Health Effects

NF_3 is not hazardous by skin contact and is a relatively minor irritant to the eyes and mucous membranes. Overexposure to NF_3 via inhalation induces the conversion of hemoglobin to methemoglobin. The formation of methemoglobin reduces the amount of oxygen available to body tissues. This can lead to chemical cyanosis, headache, dizziness, weakness, confusion, and other manifestations associated with a reduced oxygen supply. Hemolytic anemia, enlargement of the spleen, and pathologic changes in the liver, kidneys, and heart muscle may occur as secondary effects of methemoglobinemia. At the cessation of NF_3 exposure, methemoglobin spontaneously reverts to hemoglobin. While methemoglobinemia clears over several hours, hemolytic anemia may take several weeks to resolve.

Toxicological Properties

Inhalation LC_{50} = 6,700 ppm (1 hour) rat. For all species tested, the immediate effect of acute exposure to high concentrations of NF_3 is extensive methemoglobin formation with subsequent hypoxia. This is often followed by hemolytic anemia that can cause liver, kidney, spleen, and sometimes heart effects. Vomiting has also been observed in dogs and monkeys that have inhaled NF_3. Exposure of rats to 100 ppm NF_3 by inhalation for 7 hours per day, 5 days per week for 19 weeks resulted in mild to moderate pathological changes in the liver and kidneys. No other effects were noted. These chronic exposures failed to produce any measurable changes in the general appearance, appearance of teeth, activity, growth, mortality, blood, serum chemistry, or fluorine content of the teeth and bones of the rats tested.

NF_3 has been found to be weakly mutagenic in bacterial cells and nonmutagenic in animal cells and whole animal test systems.

Exposure Levels

The National Academy of Sciences—National Research Council, Committee of Toxicology, has recommended an Emergency Exposure Limit (EEL) for NF_3 of 22,500 ppm. This is based upon actual measurements which indicate that exposure of up to 30,000 ppm x min did not cause any negative health effects in laboratory animals, while anemia did occur at exposures of 120,000 ppm x min. The EEL is a concentration that is believed not to result in a period of disability or interfere with the performance of tasks. While exposure at these levels may produce injury, the injury would be reversible. The EEL represents a cumulative exposure limit, taking into account both the time of exposure and the concentration at which the exposure occurs. Any combination of time of exposure and concentration that is less than the recommended level of 22,500 ppm x min is acceptable. Table 2 illustrates acceptable exposure times for varying concentrations of NF_3 in air at the EEL of 22,500 ppm x min. The TLV-TWA (10 ppm or 29 mg/m^3 [ACGIH, 1997]) for NF_3 was set by the American Conference of Governmental Industrial Hygienists at one-tenth the test level of the previously cited 19-week study under Toxicological Properties.

Fire Potential

Let's look at the basic fire triangle. All three legs of the triangle must be present to produce a fire—a fuel, an oxidizer, and an ignition source. Nitrogen trifluoride satisfies the oxidizer requirement. If asked to name some fuels, materials like wood, coal, oil, and gas would be mentioned. But would anyone list materials like aluminum, steel, stainless steel? What is the primary reason we can light a piece of wood with a match but not a steel rod? The ignition temperature of the wood is much lower than that of the steel rod, and the heat from the match is sufficient for ignition. In the case of oxidizers, as the

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Table 1 Physical and Chemical Properties

(NF_3 is a colorless, odorless gas. Trace impurities can impart a musty or pungent odor to the gas.)	
Melting Point -340.2°F (-206.8°C)	**Standard Enthalpy of Formation at 298 K** -29.80 kcal/mol (-124.77 kj/mol)
Boiling Point -200.2°F (-129°C)	**Standard Entropy at 298 K** 62.2 cal/mol-K (260.5 j/mol-K)
Critical Temperature -38.5°F (-39.3°C)	**Gibbs Free Energy of Formation at 298 K** -21.4 kcal/mol (-89.6 kj/mol)
Critical Pressure -44.02 atm (4.46 MPa)	**Heat Capacity at 298 K at Constant Pressure** 12.79 cal/mol-K (53.54 j/mol-K)
Liquid Density (atm at Boiling Point) 97.13 lb/ft^3 (1554 kg/m^3)	**Molecular Weight** 71.002
Gas Density (atm, 70°F) x 0.184 lb/ft^3 (2.95 kg/m^3)	**Geometry** Pyramidal
Heat of Vaporization at Normal Boiling Point 2.77 kcal/mol (11.60 kj/mol)	**N-F Bond Length** 1.37 Angstroms
Heat of Fusion 0.095 kcal/mol (0.40 kj/mol)	**N-F Bond Angle** 103 Degrees
Specific Gravity (70°F, air=1) 2.503	**Mean Bond Energy** 66.4 kcal/mol (278.0 kj/mol)
Specific Volume (70°F, atm) 5.43 ft^3/lb (0.339 m^3/kg)	**Dipole Moment** .234 D
Standard Enthalpy of Formation at 0 K -28.43 kcal/mol (-119.03kj/mol)	**Solubility (slightly soluble in water)** 1.43 x 10.5 mole fraction at 1 atm/22°C

Table 2 Acceptable Exposure Times for Varying Concentrations of NF_3 in Air

Time of Exposure (min)	Concentration (ppm)
1	22,500
10	2,250
30	750
60	375

Source: "Recommendation for Revised Emergency Exposure Limits for Spills of NF_3," NAS/NRC Committee on Toxicology, 1974.

concentration of the oxidizer increases, the ignition temperature of potential fuels lowers. So materials that cannot be ignited in normal air may burn readily in oxidizer atmospheres. With this is mind, we can see that in an oxidizer system we have two legs of the fire triangle present. The oxidizer is one leg and the materials of construction in the system are the fuels, or second leg. All that is required for an ignition is an energy source.

Now let's consider ignition sources. Typical sources of ignition would be fire, open flames, sparks, cigarettes, etc. But that is in the world of normal air. The auto-ignition temperature is the lowest temperature required to ignite a material in the absence of a flame or spark. Could gas velocity, friction, adiabatic heat, or contamination provide the ignition source? Yes.

In the case of gas velocity, it is not the flow of gas that can cause ignition, but a particle that has been propelled by the gas and impacts the system with sufficient force to ignite. The heat generated may be sufficient to start a fire, depending on the material impacted. Friction from a malfunctioning or poorly operating component can generate heat. Friction between two materials generates fine particles, which may ignite from the heat generated.

Adiabatic heat is sometimes confused with the heat of compression. The heat of compression causes the temperature of a system to rise. An example would be a tire pump. The barrel or compression chamber builds heat as the pump compresses air. This process occurs relatively slowly, and the system takes on the heat. Adiabatic heat is caused by the rapid pressurization of a system where the gas absorbs the energy and the gas temperature rises. This heating occurs at the point of compression, or the point where the flow of gas is stopped, such as at a valve or regulator seat. Depending on the material in use where the hot gas impinges, the heat may be sufficient to ignite the material. The reason APS limits the fill pressure of nitrogen trifluoride is to minimize the heat that can be generated by this mechanism.

All of these energy sources can be enhanced by the presence of a contaminant. Contaminants are typically easier to ignite than the components of the system. If they react with the oxidizer, they may generate sufficient heat to propagate a reaction to the system.

Ignitions typically take place at points in the systems that are more vulnerable to the effects of the above ignition mechanisms. Particle impingement is more likely in an area that changes the direction of flow, such as an elbow. Adiabatic heat is generated in dead ends and created by valves or regulators. If the valve or regulator has a seat made of a non-metallic material, it may be more prone to ignition because non-metals typically have lower ignition temperatures than metals. If the ignition of the non-metal generates enough heat, the ignition may propagate to the metal. This is called the kindling chain, where ignition is promoted from materials of low ignition temperature to materials of higher ignition temperature.

Contamination other than particles can lead to ignition. Other contaminants, such as hydrocarbons, can be easily ignited in oxidizer systems. They can potentially burn with sufficient heat to propagate the ignition to system components. This is another example of the kindling chain.

Reactivity

Reactivity is similar to that of oxygen at room temperature. NF_3 is relatively inert at ambient temperature and pressure conditions and exhibits little, if any, reactivity. However, at higher temperatures (>300°C), NF_3 will dissociate into reactive fluorine species that react with most materials. These reactive species can lead to uncontrolled reactions with polymers and certain metals, liberating heat and causing further dissociation of NF_3. As temperatures increase above 400°C, the reactivity of NF_3 becomes more like that of fluorine. Therefore, avoid conditions and/or mechanisms that could lead to the inadvertent heating of NF_3. For example, one such mechanism—adiabatic compression—occurs when high-pressure NF_3 is introduced rapidly into a low-pressure dead-end space. The resulting rise in gas temperature may be sufficient to cause the dissociation of NF_3. NF_3 is often used in concert with other gases, such as silane in the processing of semiconductors. Related information regarding reactivity involves API's flammability testing of NF_3/Silane (SiH_4) mixtures, which yielded consistent results with those reported at the Chemical Technology Research Lab in Tokyo, Japan in 1990. The lower and upper flammability limits (LFL and UFL) for SiH_4 in NF_3 are 0.66% and 95.3%, respectively. In other words, in a binary blend of SiH_4 and NF_3, concentrations of silane greater than or equal to 0.66% and less than or equal to 95.3%, form an explosive mixture. Dilution with nitrogen (N_2) provides a three-component flammability limit of 2.0% SiH_4/2.5% NF_3/ 95.5% N_2. Although the LFL for SiH_4 increases to 2.0% with the addition of N_3, the large range of flammability still exists. To achieve safe operating conditions in a system using SiH_4 and NF_3, dilution with N_2 is required to remain outside the flammability limits. Table 3 indicates the magnitude of the flammability range of SiH_4 and H_2 blends of NF_3, O_2, and air, respectively.

Table 3 Flammability Limits of Various Gases in NF_3

(Volume %) (70°F (21°C), 14.7 psia (1 bar))

	In NF_3		In O_2		in Air	
Fuel	LFL	UFL	LFL	UFL	LFL	UFL
Silane	0.66	95.3	NA	NA	1.37	NA
Hydrogen	5.0	90.6	4.65	93.9	4.0	75.0

Please consult the Technical Information Center at 410-833-7170 for more information on the reactivity of NF_3 with other gases.

Table 4

USA	670 standard	330 limited standard (used by APS) 640 DISS
UK	BS 14	DIN 8
Germany	DIN 8	
France	NF K	

For more information on cylinder valve connections, refer to APS SafetyAlert-31, "Cylinder Valve Outlet Connections."

Environmental Impact

NF_3 can be manufactured, used, and disposed of in a safe and environmentally responsible manner. NF_3 poses a minimal environmental hazard due to its non-reactivity and insolubility in water under normal conditions. API has sponsored research at the Massachusetts Institute of Technology to study the reactivity of NF_3 in the atmosphere. Also, APS continues to conduct and/or support the analysis of emissions from semiconductor manufacturing production tools. NF_3 has negligible impact on ozone depletion. The photolysis of NF_3 in the stratosphere yields a fluorine radical that reacts fairly rapidly to form hydrogen fluoride (HF). The stability of HF results in an ozone-depleting potential of the fluorine radical that is approximately three orders of magnitude less than that of the chlorine radical. NF_3 has a relatively short atmospheric lifetime (740 years) and dissociates more readily than C_2F_6 and CF_4. HF ultimately diffuses down to the troposphere where it is removed by wet deposition. Due to the low solubility of NF_3 in water (1.43×10^{-5} mole fraction at 1 atm partial pressure of NF_3 and 22°C) and its non-reactivity with water under normal conditions, the environmental hazards of an NF_3 leak at sea or in coastal waters during shipment are minimal. Any large release of NF_3 would dissipate before significant concentrations of gas could build up in water.

Containers

Nitrogen trifluoride is shipped and stored in high pressure cylinders, tube trailers, or ISO modules, depending upon the quantity required by the consumer. These containers are manufactured according to applicable codes and specifications for the temperatures and pressures involved.

Cylinders

A cylinder is a hollow tube with a closed concave base that permits the cylinder to stand upright. The opposite end is tapered to a small opening that is threaded to accommodate the installation of a valve. A threaded neck ring is attached to the tapered end to allow a protective cylinder valve cap to be installed.

Nitrogen trifluoride is also available in large skid-mounted containers (referred to as "Y" cylinders) that contain 430 pounds (195 kilograms) of product. These containers are mounted horizontally and are tapered and threaded at both ends. A valve assembly is installed on one end, and a pressure relief device may be installed on the opposite end.

Tube Trailers and ISO Modules

If large amounts of product are required, nitrogen trifluoride can be purchased in tube trailers or ISO modules. The most common configurations for these units are in four or eight tube bundles of 22-inch (56 centimeter) diameter tubes. These units carry as much as 12,000 pounds (5440 kilograms) of nitrogen trifluoride.

Valves and Connections

Valves

Containers used in nitrogen trifluoride service are equipped with diaphragm valves. Diaphragm valves come in two basic configurations, spring-loaded and tied diaphragm. APS uses the spring-loaded diaphragm valve on its lecture bottles and the tied diaphragm valve on all other containers. The tied diaphragm valve is provided in a manually operated design and pneumatically operated design for remote operation. For information on the construction and operation of these valves, refer to APS SafetyAlert-23, "Cylinder Valves." Many regulatory agencies and local code officers require these cylinder valves to be equipped with restrictive flow orifices (RFOs). The RFO is a small plug that screws into the valve outlet. It has a hole in the middle that can range in size from 0.006 to 0.16 inches (0.15 to 4 millimeters) in diameter. The purpose of the RFO is to restrict the amount of flow that can come from the cylinder in the event of a system failure. There are recommended sizes for most products, but customers can specify their requirements.

Connections

Valve connections for nitrogen trifluoride may vary from country to country. Table 4 gives some of the connection designations used by the various countries.

Pressure Relief Devices

Cylinders containing nitrogen trifluoride in the European Union are not equipped with pressure relief devices. In North America these containers are equipped with combination pressure relief devices. These devices consist of a frangible disc rated at 5/3 the working pressure of the container. The atmospheric side of the disc is backed with a fusible metal alloy, which melts at one of two nominal temperatures, 165°F or 212°F. These devices require both the temperature condition and pressure condition be satisfied in order to function. These devices are intended to protect the container in a fire situation. For more information on cylinder pressure relief devices, refer to APS SafetyAlert-15, "Cylinder Pressure Relief Devices."

Note: API has been granted an exemption by the United States Department of Transportation (DOT) to eliminate pressure relief devices from both cylinders and tubes in NF_3 service. These devices will gradually be phased out on API containers.

Storage and Handling

Always store and handle cylinders containing nitrogen trifluoride and other compressed gas cylinders in accordance with Compressed Gas Association Pamphlet P-1, "Safe Handling of Compressed Gases in Containers." For more information, refer to APS SafetyAlert-10, "Handling, Storage, and Use of Compressed Gas Cylinders."

International or local regulations may require additional safeguards for storage or use. Personnel must know and understand the properties, proper uses, and safety precautions for the specific product before using the product and/or associated equipment.

Storage

Cylinders should be secured in an upright position and stored in a well-ventilated area protected from the weather. The storage area should be secure with limited access. Storage area temperatures should not exceed 125°F (52°C), and should be free from combustible materials and free from ignition sources. Storage should be away from heavily traveled areas and emergency exits. Avoid areas where salt or other corrosive materials are present. Valve protection caps and valve outlet seals must remain on cylinders not connected. When returning a cylinder to storage, the valve outlet seal must be installed leak-tight. Separate full and empty cylinders. Avoid excess inventory and storage time. Visually inspect stored cylinders on a routine basis, at least weekly, for any indication of leakage or other problems. Use a first in-first out inventory system and keep up-to-date inventory records. The use of "FULL," "IN USE," and "EMPTY" tags is highly recommended. Storage areas must be posted with the proper signage, such as "No Smoking or Open Flames" and NFPA 704 ratings.

Handling and Use

Use only in well-ventilated areas, preferably in a gas cabinet. Use a suitable handcart designed for cylinder movement. Do not drag, roll, or slide cylinders. Never attempt to lift a cylinder by its cap. Secure cylinders at all times during storage, transportation, and use. Use a pressure-reducing regulator or separate control valve to discharge gas from the cylinder. Never apply flame or local heat to any part of a cylinder. Do not allow any part of the cylinder to exceed 125°F (52°C). High temperature may cause damage to the cylinder. If user experiences any difficulty operating the cylinder valve, discontinue use and contact the supplier. Use an adjustable strap-wrench to remove overly tight cylinder caps. Never insert anything into the cap holes to assist in cap removal.

Ensure that cylinder valve is properly closed, valve outlet seal has been reinstalled leak-tight, and valve protection cap is installed before returning to storage, moving, or shipping cylinder.

Abatement

Return unused product to the supplier. APS will assist customers in determining and implementing appropriate methods to control and monitor NF_3 emissions. The method and degree of control and regulatory compliance is the ultimate responsibility of the end user. If your facility implements an abatement policy, please contact your APS representative for specific recommendations.

System Design and Maintenance

NF_3 is available in several types of high-pressure containers, including cylinders, Y cylinders, tube trailers, and ISO modules. Leak-checking NF_3 cylinders prior to service is recommended. After placement in a gas cabinet, the cylinder valve should be checked for trace leaks at the valve connection, valve stem, pressure relief device, and cylinder/valve connection. Similar steps should be taken for bulk containers (Y cylinders, tube trailers, and ISO modules). Any of the following techniques should be used:

- An electron-capture type halogen leak detector, thermal conductivity, or an NF_3 point detector can be used.

- An outboard mass spectrophotometer leak detector can be used for a system pressurized with helium or a helium/ inert gas mixture.

- GASGUARD® systems will perform pressure and vacuum decay testing of the cylinder connection to the gas system as part of the standard control software configuration.

Gasguard Gas Cabinets
NF_3 should be delivered from a system within an exhausted enclosure with proper and continuous ventilation. When using bulk supply of NF_3, such as a Y cylinder, tube trailer, or ISO module, the pigtail-to-valve connection should also be ventilated. Purging of the gas systems with a dry, inert gas, such as nitrogen or argon, is recommended prior to breaking any connection of the gas system. Automation provided by GASGUARD systems ensures thorough and complete purging of the gas delivery system.

Process Lines
Gas distribution lines for NF_3 service should be fabricated from compatible materials (next page) and thoroughly cleaned to remove any oxidizable material. The following steps are crucial for adequate line preparation:

- Clean the line thoroughly with an appropriate cleaning agent and dry with oil-free nitrogen or helium. Shop compressor air should not be used because oil mist will recontaminate the line. Be alert for any dead space where degreasing agents can be trapped.

- Inspect the system for any indications of reaction, leaks, changes in mass flow, or changes in delivery pressure across line filters.

- NF_3 leaks in a process line or equipment may be detected by the two techniques mentioned previously.

Ventilation
NF_3 has no detectable odor, so forced air/exhaust ventilation and ambient air monitoring are recommended where NF_3 is stored or used. Ventilation ducts should be designed for high-flow interference. Standard flow ventilation requirements for gas cabinets adequate for NF_3 include average face velocity of 200 fpm at access ports with 150 fpm as the minimum velocity at any point. Laminar flow is strongly recommended for nonload lock systems.

Monitors
NF_3 specific detectors are highly recommended since NF_3 has no detectable odor. Prolonged breathing of high concentrations of NF_3 should be avoided. The most accurate technique for NF_3 detection is infrared spectral absorption in the 11-micron (900 cm^{-1}) region.

Materials Compatibility

Metals
Systems must be cleaned for oxidizer service. Clean and degrease all metals coming into contact with NF_3 using detergent or suitable cleaning agents that are free of finely divided metal chips and particles. Gaseous NF_3 containing 0.1% or less active fluorides (calculated as HF) was found to be noncorrosive toward several different parent and welded metal specimens. During static exposure of aluminum, stainless steel, Inconel®, Monel®, nickel, titanium, steel, copper, beryllium copper, aluminum bronze, maraging steel, and tungsten, no metal exhibited corrosion penetration rates greater than 0.43 mils per year (mpy). Generally, a corrosion penetration rate of 1 mpy or less is considered acceptable for long-term compatibility. The tests were conducted for 270 days at temperatures ranging from -78°C to 71°C and pressures ranging from 2×10^{-7} to 2.5×10^{-6} psi. Carbon steel, stainless steel, nickel and its alloys, and copper are suitable materials of construction for low-pressure service (<70 psig) and temperatures up to 150°C. For pressures up to 1450 psig at ambient temperatures, carbon steel and stainless steel are suitable materials. For high-pressure and higher-temperature service, nickel and certain alloys of nickel and copper are preferred. Most metals will react with NF_3 at temperatures in excess of 300°C. The presence of contaminants in the system can significantly affect the corrosion resistance and compatibility of many metals. For example, both HF and water decrease the corrosion resistance and compatibility of metals exposed to NF_3, and both impurities should be minimized. The presence of fingerprints, halocarbon oils, and machine oils have been shown to significantly reduce the temperature resistance of metals, including stainless steel and nickel.

Nonmetals
All nonmetal components should be thoroughly cleaned and free of oils, grease, and dirt using either detergent or a suitable cleaning agent. Thoroughly clean and dry the components prior to use. Highly fluorinated polymers such as Teflon®, Viton®, Kel-F®, or Neoflon® are materials of choice. Studies have shown that PTFE (Teflon) is the most compatible at temperatures up to 150°C.

Lubricants
Use of perfluorinated lubricants (Krytox® or Fomblin®) for vacuum pumps in NF_3 service is recommended. Hydrocarbon lubricants can react violently with NF_3 and should not be used. NF_3 dissolves some halocarbon greases.

Safety Issues

The following general safeguards are important in handling NF_3:

- Avoid conditions that can result in high temperatures, such as adiabatic compression.

- Do not attempt purification of NF_3 via adsorption. This can result in large energy releases.

- Stainless steel and copper are suitable materials of construction for low-pressure service.

- If elastomers must be used, Teflon and PCTFE materials are acceptable for NF_3 service.

- Ball valves are not recommended for general use in NF_3 service due to the potential for adiabatic compression in closed downstream systems occurring as the result of the rapid opening of this type of valve. Use of ball valves should be restricted to isolation functions only. Any valve that is used in NF_3 service should be opened slowly to prevent adiabatic compression.

- All components should be free of grease, oil, and other contaminants. It is recommended that procedures for cleaning systems for oxygen service as described in CGA Pamphlet G-4.1 be used.

- The operation of high-pressure systems should be done remotely and by personnel wearing appropriate personal protective equipment. APS' GASGUARD line of gas delivery systems provides an excellent means to minimize direct operator contact by providing an external control interface.

- Observe the same measures and precautions necessary for the safe handling of any compressed gas.

- NF_3 cylinders must be securely supported while in use to prevent movement and straining of connections. Always protect NF_3 cylinders from mechanical shock or abuse. Never heat NF_3 cylinders with a torch, heat lamp, or water bath. In some delivery systems, NF_3 may be subjected to adiabatic compression. This can occur when a valve between a high-pressure gas source and a low-pressure flow circuit is opened quickly. As gas enters such spaces and rapidly comes to a higher pressure, shock waves may be dissipated on material surfaces in a very short time. When high gas temperatures are expected, systems designed for such service should avoid the use of plastics or polymers in contact with gas-wetted surfaces. In addition, rapid-opening valves, such as ball valves, should be restricted to use only as isolation valves in NF_3 service.

Purification processes using dry media, such as activated charcoal (carbon) or molecular sieve, may be subject to rapid exotherms (and potential system failures) from sudden exposure of the media to large quantities of NF_3.

APS does not recommend purification adsorption of NF_3.

Emergencies

Leaks

If a leak develops in a customer system, close the cylinder valve, vent residual product, and purge the lines with inert gas before attempting repairs. Use appropriate protective equipment. Leaks occurring at the cylinder valve's pressure relief device, diaphragms, or valve to the cylinder connection cannot be repaired. **Attempts to repair these leaks may result in catastrophic failure of the package.**

If such a leak develops or the cylinder valve cannot be closed, immediately contact the APS Emergency Response System.

Fire

In North America, NF_3 cylinder valves are equipped with pressure relief devices consisting of a frangible rupture disc backed by a fusible alloy. This allows the cylinder contents to be released, minimizing the potential for a cylinder failure under fire conditions. Where no pressure relief devices are used, the potential for catastrophic failure of a cylinder in a fire is much greater. Although NF_3 is nonflammable, it will vigorously support combustion. Do not use HALON 1301, dry ammonium phosphate, or bicarbonate on NF_3 fires because they produce toxic by-products. Use carbon dioxide (CO_2) extinguishers to extinguish small fires. Use large amounts of water to extinguish fires covering a large area. Although NF_3 is not water-soluble, many of the toxic by-products such as HF are water-soluble. If a container of nitrogen trifluoride is involved in a fire, cool the cylinder with water spray if this can be done safely. If nitrogen trifluoride is feeding the fire, try to shut off the source to aid in extinguishment.

First Aid Treatment

An individual exhibiting symptoms of acute NF_3 poisoning from concentrations in excess of 6,000 ppm should be removed from the contaminated area as quickly as possible. Then trained personnel should start oxygen therapy at once, and a physician should be notified immediately.

Observe these follow-up first-aid measures:

- Continue therapy for up to six hours.

- Individual should rest under close supervision until all possibility of secondary complications can be discounted.

- Be aware of possible anemia and impaired kidney functions.

- Individual should receive follow-up examinations by a physician.

Transportation Information

Proper Shipping Name: Nitrogen Trifluoride, Compressed, 2.2, UN2451

Identification Number: UN2451

Hazard Class: 2.2, Non-Flammable Compressed Gas

Subsidiary Risk: 5.1, Oxidizer

Shipping Labels: Non-Flammable Gas, Oxidizer

Placard: Non-Flammable Gas

Special Shipping Information: Always ensure that cylinder valve is closed, outlet seal is installed gas-tight, and protective cap is in place before shipping. Cylinders must be properly secured for transport.

Information Sources

- Compressed Gas Association
  1725 Jefferson Davis Highway, Suite 1004
  Arlington, VA 22202-4102
  Phone: 1-703-412-0900
- National Fire Protection Association
  1 Batterymarch Park, P.O. Box 9101
  Quincy, MA 02269-9101
  Phone: 1-800-344-3555

Emergency Response Telephone Numbers
<u>USA</u>

CHEMTRAC
1-800-424-9300 (Toll Free in the U.S., Canada, and U.S. Virgin Islands)
703-527-3887 for calls originating elsewhere (Collect calls are accepted)

CHEM-TEL, INC.
1-800-255-3924 (Toll Free in the U.S., Canada, and U.S. Virgin Islands)
813-248-0585 for calls originating elsewhere (Collect calls are accepted)

INFOTRAC
1-800-535-5053 (Toll Free in the U.S., Canada, and U.S. Virgin Islands)
352-323-3500 for calls originating elsewhere (Collect calls are accepted)

3E COMPANY
1-800-451-8346 (Toll Free in the U.S., Canada, and U.S. Virgin Islands)
760-602-8703 for calls originating elsewhere (Collect calls are accepted)

NATIONAL RESPONSE CENTER (NRC)
Call NRC (24 Hours)
1-800-424-8802 (Toll Free in the U.S., Canada, and U.S. Virgin Islands)
202-267-2675 in the District of Columbia

MILITARY SHIPMENTS
703-697-0218 Explosives/Ammunition Incidents (Collect calls accepted)
1-800-851-8061 All other dangerous goods incidents

NATIONWIDE POISON CONTROL CENTER (United States Only)
1-800-222-1222 (Toll Free in the U.S.)

<u>CANADA</u>

CANUTEC
613-996-6666 (Collect calls are accepted)
*666 Cellular (In Canada only)

Visit Web Site: www.apsusa.biz for further information
or
Call 410-833-7170
or
Ask your local sales representative