Safetygram 20
Nitrous Oxide (N_2O)

Introduction

Nitrous oxide is a colorless, noncorrosive, nontoxic gas. It is essentially odorless with a barely perceptible sweet odor.

Nitrous oxide is nonflammable, but is an oxidizer that can cause or intensify fires. At elevated temperatures, nitrous oxide decomposes. The decomposition reaction is exothermic and can be self-sustaining and violent. Because of these properties, when handling nitrous oxide, avoid contact with oil, grease and other combustible materials and any source of heat. Temperatures above 150°C (302°F) must be avoided.

Table 1 lists the physical and chemical properties of nitrous oxide. Nitrous oxide can be packaged in high-pressure cylinders as a liquid under its own vapor pressure. Gaseous nitrous oxide is heavier than air. If nitrous oxide liquid is released to the atmosphere, it will evaporate and disperse along the ground and may enter low-lying areas or confined spaces. Because it is odorless, a person can walk into an area of high concentration without realizing its presence and lose consciousness without warning. Lack of oxygen can result in immediate physical inability to function and to save oneself. It is important to handle nitrous oxide in well-ventilated locations to minimize this hazard.

Nitrous oxide is sometimes wrongly used by people for its euphoric characteristics on inhalation. This abuse can result in the theft of containers and attempts to purchase it for illegitimate, and in some cases, illegal use. Nitrous oxide containers should be properly secured to prevent theft. CGA SB-6, *Nitrous Oxide Security and Control*, contains specific security recommendations for nitrous oxide.

Warning: The improper use of nitrous oxide is life-threatening. Overexposure to nitrous oxide can cause death by reducing the level of oxygen below that required to support life.

Applications

Several different grades of nitrous oxide are available to support different applications. Medical-grade product is primarily used in the medical industry as an anesthetic. Other healthcare services and the dental industry use nitrous oxide mixed with oxygen as an analgesic to reduce pain. Medical gases must comply with regional pharmaceutical legislation, e.g., for Europe with the European Medicines Agency, or for the US with the Food and Drug Administration. Industrial-grade product is used in food processing as a propellant and to a limited extent in auto racing to enhance engine performance. High-purity grades are used in analytical applications and very high-purity grades are used in the manufacture of semiconductors and other microelectronic devices.

Air Products strictly controls the sale of nitrous oxide for nonmedical applications to minimize potential misuse. Special conditions must be met for the sale of nitrous oxide in auto racing and engine tuning applications to ensure it is handled safely.

Production

Nitrous oxide is produced by the thermal decomposition of ammonium nitrate and by recovery from a by-product stream from adipic acid manufacturing.

Safety Considerations

Health Effects

Acute Effects

Nitrous oxide is a simple asphyxiant and a weak narcotic. Dizziness, confusion, headaches, nausea, vomiting, and loss of consciousness or death may occur if nitrous oxide is present in quantities sufficient to dilute the oxygen concentration in air.

Skin contact with refrigerated liquid nitrous oxide can cause frostbite injury.

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Chronic Effects

Most, if not all, chronic effects of nitrous oxide are related to vitamin B_{12} inactivation by the gas. Therefore, individuals with a vitamin B_{12} deficiency may be more vulnerable to effects. Long-term exposure to nitrous oxide has been associated with peripheral neuropathy (disorder of the nerves typically starting in the hands and feet) and megaloblastic anemia (red blood cell disorder). Some epidemiologic studies suggest that long-term exposure of operating room and dental personnel to nitrous oxide may cause feto-toxic effects and higher incidents of spontaneous abortion. Other studies characterized as more robust in design have shown no such effects. Published data confirms that animals exposed to atmospheres containing ≤ 500 ppm nitrous oxide show no evidence of any reproductive effects. Based on the animal data, the current occupational exposure limits should adequately protect against potential adverse reproductive effects of nitrous oxide exposure in occupational settings.

Exposure Limits

The occupational exposure limit (25 to 100 ppm time-weighted average for eight hours daily according to different national regulations) must not be exceeded. Under normal operating conditions, natural or mechanical room ventilation should be adequate. Medical areas in which inhalation anesthesia is performed can be equipped with a scavenging system to reduce personnel exposure.

Reactivity

Although nonflammable, nitrous oxide supports combustion. Nitrous oxide is an oxidizing agent that can ignite combustible materials such as wood, paper, oils and grease, and may support, accelerate and intensify the burning of combustible materials in a fire. Some materials that do not normally burn, may burn in an enriched nitrous oxide atmosphere.

Systems must be designed with special considerations required for the safe handling of oxidizers. Like other oxidizer systems, nitrous oxide systems require special cleaning to prevent contact with any incompatible material or any contamination that could provide ignition mechanisms. See CGA G-4.1, *Cleaning Equipment for Oxygen Service.* In addition, Safetygram 33, *The Hazards of Oxygen and Oxygen-Enriched Mixtures,* covers fire chemistry changes that occur in oxidizing atmospheres.

Table 1

Physical and Chemical Properties

Chemical Formula	N_2O
Molecular Weight	44.0
Gas Density (21.1°C [70°F] @1atm)	1.79 kg/m^3 (0.112 lb/ft^3)
Specific Gravity (air = 1)	1.53
Specific Volume (21.1°C [70°F] @ 1atm)	0.545m^3/kg (8.74 ft^3/lb)
Vapor Pressure	52.4 bar @ 21.1°C (760 psia @ 70°F)
Boiling Point	-88.6°C (-127°F)
Melting Point	-93.06°C (-131.5°F)
Liquid Density (saturation pressure at 0°C)	0.913 kg/l (57.0 lb/ft^3)
Critical Temperature	36.4°C (97.6°F)
Critical Pressure	72.5 bar (1,052 psia)

At room temperature, nitrous oxide is a stable compound. Under certain conditions, nitrous oxide vapor decomposes to nitrogen and oxygen. The decomposition reaction is exothermic and can be self-sustaining and violent. Toxic nitrogen oxides can also be formed as by-products of nitrous oxide decomposition. The tendency for decomposition increases as temperature, pressure and energy input increase, but other factors such as catalyst, product impurities, container size, cleanliness and heat loss rate can influence decomposition behavior.

In the presence of an ignition source, nitrous oxide can decompose explosively. Ignition sources that have caused the decomposition reaction include welding/brazing, direct impingement of flame, electric immersion heaters, heat from dry running pumps, heat of compression, static discharge, and a spark from metal-to-metal contact. When handling nitrous oxide, avoid combustible materials and any uncontrolled heat input. Temperatures above 150°C (302°F) must be avoided.

For additional information on the dependence of temperature, pressure and ignition sources and preventative measures, consult EIGA Doc. 116/07/E, *Code of Practice Nitrous Oxide* and CGA SB-37, *Nitrous Oxide Decomposition.*

Containers

Nitrous oxide is packaged in high-pressure cylinders as a liquid under its own vapor pressure or in cryogenic containers as a refrigerated liquid. Codes are established by transportation authorities that include the DOT in the United States and the ADR in the European Union. Code specifications will include the material of construction, method of manufacture, testing, products permitted for filling, and other details for the pressure and temperatures involved.

High-Pressure Cylinders

Nitrous oxide can be packaged in high-pressure cylinders as a liquid under its own vapor pressure of 52.4 bar @ 21°C (760 psia @ 70°F). Nitrous oxide cylinders are made from carbon steel or aluminum. Cylinders and systems containing pressure hold a large amount of stored energy and must be handled with care to prevent damage that may cause an uncontrolled release of this pressure. Such releases can result in injury or death.

Cylinders of liquefied gas contain both liquid and vapor phases. The vapor pressure, and thus cylinder pressure, will be directly affected by temperature (i.e., the higher the temperature, the higher the cylinder pressure). Therefore, the amount of product contained in the cylinder cannot be determined by a pressure reading. Cylinder content can only be determined by product weight.

Rapid withdrawal of product (vapor phase) from a cylinder will cause the temperature of the remaining liquid to drop. This may cause sweating or frosting on the outside of the cylinder at the liquid level. The cold temperature of the liquid will decrease the vapor pressure in the cylinder. This may reduce product withdrawal rates below the requirements of the process or may reverse the flow and allow other process products to backflow into the cylinder. This is an extremely dangerous situation and must be prevented. Extreme care must also be used in compensating for temperature and flow drops. For more information on the proper handling of liquefied compressed gases, refer to Air Products' Safetygram 30, *Handling Liquefied Compressed Gas.*

Nitrous oxide is also available in large skid-mounted cylinders (referred to as "Y" cylinders) that contain 272 kg (600 pounds) of product. The "Y" cylinder valve is equipped with a dip tube that, depending on orientation, will allow either gas or liquid withdrawal.

Air Products uses different types of valves in nitrous oxide service, depending on the application, including packed, pressure seal and diaphragm designs. Each cylinder valve type has its own specific operating requirements. Please see Air Products' Safetygram 23, *Cylinder Valves*, for identifying features, detailed operating instructions, strengths and weaknesses, and cutaway drawings of the various cylinder valve types. If you are not sure which valve is on your container, contact your supplier for verification.

Valve outlet connections must comply with national standards to avoid connection mix-ups. For a more detailed explanation of how cylinder valve connections work, recommended closing torques and cutaway diagrams, refer to Air Products' Safetygram 31, *Cylinder Valve Connections*.

Regulations in some regions of the world do not allow the use of pressure relief devices on high-pressure cylinders containing liquefied compressed nitrous oxide. In other regions, including North America, pressure relief devices are required by Dangerous Goods transport regulations. When a pressure relief device is required on a high-pressure cylinder containing nitrous oxide, a frangible disk rated at not more than 5/3 the working pressure of the cylinder is required.

Cryogenic Liquid Containers

Refrigerated liquid is transported in a cryogenic liquid cylinder or bulk container. Cryogenic liquid containers, also referred to as liquid cylinders, are double-walled vacuum vessels with multilayer insulation in the vacuum space. The primary advantage of a cryogenic liquid cylinder is that it contains a large mass of product at a relatively low pressure. The pressure in this type of container is determined by the amount of liquid that converts to a gas and collects in the headspace. These cylinders typically operate within a pressure range of 7 to 24 barg (100 to 350 psig). As with the liquefied gas cylinder, the amount of product in the cryogenic liquid cylinder cannot be determined by pressure reading, only by weight.

Cryogenic liquid cylinders use a pressure relief valve. This is a spring-loaded device with a set pressure of 24 barg (350 psig). When the internal pressure increases to a pressure that exceeds this setting, the spring is compressed, allowing the excess pressure to vent. When the pressure drops low enough, the valve re-closes and stops the venting. Venting of cryogenic liquid containers is normal.

The liquid phase of a gas must never be trapped within a system without a relief device being present. If no relief is provided and the system becomes liquid-full, the liquid can begin to generate hydrostatic pressures as the liquid warms that can quickly cause catastrophic failure of the system.

Gas phase product is provided by the evaporation of liquid via a vaporizer located between the inner and outer shells of the cylinder. These vaporizers have a limited flow capacity, and care must be taken not to withdraw product at a rate that would overwhelm the vaporizer and allow very cold vapor or liquid to enter the end user's system.

Air Products' Safetygram 27, *Cryogenic Liquid Containers*, provides information on the operation of cryogenic liquid cylinders and details proper techniques for handling. Cryogenic liquid cylinders are very heavy and require special handling equipment.

Storage and Handling

Always store and handle cylinders containing compressed and liquefied gases in accordance with international or local regulations, such as ISO 11625, *Gas Cylinders—Safe Handling*, and Air Products' Safetygram 10, *Handling, Storage, and Use of Compressed Gas Cylinders*. Personnel must know and understand the properties, proper uses, and safety precautions for the specific product before using the product or associated equipment.

Cylinders should be secured in an upright position and stored in a well-ventilated area protected from the weather. Ensure that the cylinder valve is properly closed, the valve outlet seal has been reinstalled leak-tight, and valve protection cap is in place before storing, moving, or shipping the cylinder.

Nitrous oxide will support combustion. It must be kept away from oil, grease, and other combustible materials.

The storage area should be secure with limited access. Additional security may need to be provided for storage areas since nitrous oxide is subject to theft for illegal use. Detailed recommendations for nitrous oxide storage locations are given in CGA G-8.1, *Standard for Nitrous Oxide Systems at Consumer Sites*.

Disposal

Nitrous oxide is a global warming gas, and venting to the atmosphere should be limited where possible.

Since disposal of nitrous oxide must be done in an environmentally acceptable manner in compliance with all applicable national and local codes, return unused product to the supplier.

Personal Protective Equipment

Safety glasses with side shields, leather gloves, and safety shoes are recommended for cylinder handling and system operation. Gloves must be clean and free of oil and grease. If exposure to liquid phase is possible or when handling the refrigerated liquid, users should also wear a long-sleeved shirt and face shield.

Emergency Operations

In the event of a leak or spill, only qualified emergency responders who are thoroughly familiar with the product and package should respond to the incident. The leaking cylinder should be isolated and the supplier contacted for technical assistance or emergency response.

In emergencies, self-contained breathing apparatus (SCBA) or an air-supplied respirator must be used. If an airline mask is used, an escape pack must also be worn.

First Aid

Skin and Eye Contact

Contact with liquid nitrous oxide can freeze tissue. In case of frostbite, place the affected area in a warm water bath that has a temperature not in excess of 40°C (105°F). DO NOT RUB. Cover the area with a clean, sterile dressing and seek medical attention.

Inhalation

Persons exposed to high levels of nitrous oxide should be quickly moved to fresh air. If the victim is not breathing, artificial respiration should be administered immediately. If the victim is breathing, give supplemental oxygen. Seek medical assistance.

Fire Fighting

Nitrous oxide is not flammable, but is an oxidizer, which means it can support and enhance combustion. Use respiratory protection while extinguishing fires, since a fire in the presence of nitrous oxide may produce irritating and toxic gases. Violent decomposition can also occur in case of fire. Cylinders exposed to fire may have their pressure relief devices activate, if present, and the cylinders themselves may fail, especially aluminum cylinders. From a safe distance, cool the cylinders with a water spray. Use an extinguishing medium appropriate for the surrounding fire.

Transportation Information

Shipping Name
Nitrous Oxide, 2.2, UN1070, Nonflammable Gas

Hazard Class
2.2

Identification Number
UN1070

Shipping Labels
Nonflammable Gas (primary), Oxidizer

Placard
Nonflammable Gas

Additional Resources

This list provides a sampling of nitrous oxide references.

EIGA Doc. 116/07/E, *Code of Practice Nitrous Oxide*; EIGA Doc. MGC 153/08/E, *Review of Toxicological Data on Nitrous Oxide*; EIGA PP-24, *Abuse of Gases*, European Industrial Gases Association, Avenue des Arts 3-5, B 1210 Brussels, Belgium.
www.eiga.org

CGA G-4.1, *Cleaning Equipment for Oxygen Service*; CGA G-8.1, *Standard for Nitrous Oxide Systems at Customers Sites*; P-2, *Characteristics and Safe Handling of Medical Gases*; SB-6, *Nitrous Oxide Security and Control*; SB-37, *Nitrous Oxide Decomposition*, Compressed Gas Association, Inc., 4221 Walney Rd., 5th Floor, Chantilly, Va. 20151.
www.cganet.com

Emergency Response System

- Call: 1-800-523-9374
  (Continental U.S. and Puerto Rico)
- Call: +1-610-481-7711 (other locations)
- 24 hours a day, 7 days a week
- For assistance involving Air Products and Chemicals, Inc. products

Product Safety Information

- For MSDS, Safetygrams,
  and Product Safety Information
  www.airproducts.com/productsafety

Technical Information Center

- Call: 1-800-752-1597 (U.S.)
- Call: +1-610-481-8565 (other locations)
- Fax: 1-610-481-8690
- E-mail: gasinfo@airproducts.com
- Monday–Friday, 8:00 a.m.–5:00 p.m. EDT

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