

CGA G-14—2017
NITROGEN TRIFLOURIDE
THIRD EDITION

PREFACE

As part of a program of harmonization of industry standards, the Compressed Gas Association (CGA) has issued **CGA G-14, Nitrogen Trifluoride**, jointly produced by members of the International Harmonization Council and originally published by the European Industrial Gases Association (EIGA) as EIGA Doc 92, *Nitrogen Trifluoride*.

This publication is intended as an international harmonized standard for the worldwide use and application of all members of the Asia Industrial Gases Association (AIGA), Compressed Gas Association (CGA), European Industrial Gases Association (EIGA), and Japan Industrial and Medical Gases Association (JIMGA). Each association's technical content is identical, except for regional regulatory requirements and minor changes in formatting and spelling.

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Specialty Gases Committee

NOTE—Technical changes from the previous edition are underlined.

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1 Introduction

Nitrogen trifluoride is an oxidizing compressed gas that is used in a number of applications as a fluorinating agent. It is this property that makes it valuable as a nonreactive source of fluorine for etching and cleaning applications. The active fluorine is released only if sufficient energy is applied. Once initiated, the reaction is self-propagating and presents a hazard for materials that are incompatible with fluorine, for example, flammable gas and metals.

Nitrogen trifluoride can be safely handled if equipment is properly designed and handling precautions are taken.

NOTE—This publication shall be used in conjunction with [CGA P-63](#), *Disposal of Gases*, EIGA Doc 80, *Handling Gas Container Emergencies*, and [CGA G-4.4](#), *Oxygen Pipeline and Piping Systems* [1, 2, 3].¹⁾

2 Scope and purpose

Because of its widespread use and its potential for mishandling, this publication has been written and is intended for suppliers, distributors, and users of nitrogen trifluoride and its handling equipment. This publication provides a description of the potential hazards involved in handling nitrogen trifluoride and the guidelines to be taken to minimize risk potential.

The manufacture, purification, and analysis of nitrogen trifluoride are beyond the scope of this publication, although the general guidance given is also relevant to these processes.

[Appendix A](#) of this publication is an audit checklist.

3 Definitions

For the purpose of this publication, the following definitions apply.

3.1 Publication terminology

3.1.1 Shall

Indicates that the procedure is mandatory. It is used wherever the criterion for conformance to specific recommendations allows no deviation.

3.1.2 Should

Indicates that a procedure is recommended.

3.1.3 May

Indicates that the procedure is optional.

3.1.4 Will

Is used only to indicate the future, not a degree of requirement.

3.1.5 Can

Indicates a possibility or ability.

3.2 Technical definitions

3.2.1 Autoignition temperature

Temperature at which a substance will spontaneously ignite in a specified oxidant at a given pressure.

¹ References are shown by bracketed numbers and are listed in order of appearance in the reference section.

3.2.2 Container

3.2.2.1 Bundle of cylinders

Arrangement of cylinders into a cluster where the cylinders are confined into a grouping or arrangement with a strapping or frame system and connections are made to a common manifold. Also known as cylinder packs.

3.2.2.2 Cylinder

Seamless pressure vessel having a nominal water capacity up to 50 L.

3.2.2.3 International Organization for Standardization (ISO) module

Multi-modal assembly of cylinders, tubes, or bundles of cylinders that are interconnected by a manifold and assembled within a framework.

NOTE—The ISO module includes service equipment and structural equipment necessary for the transport of gases. The frame of an ISO module and its corner castings are specially designed and dimensioned for use in multi-modal transportation service on container ships, special highway chassis, and container-on-flatcar railroad equipment. An ISO module may also be referred to in regulations as a multiple-element gas container (MEGC) and its' equivalent.

3.2.2.4 Multiple-element gas container (MEGC)

Assembly of cylinders, tubes, or bundles of cylinders that are interconnected by a manifold and are assembled within a framework.

NOTE—The MEGC module includes service equipment and structural equipment necessary for the transport of gases.

3.2.2.5 Packages greater than 50 L

Any individual or manifolded collection of seamless pressure vessel(s) having a collective nominal water capacity greater than 50 L.

NOTE—These can include an ISO module, MEGCs, tubes, tube trailers, cylinder packs, nominal 450 L (ton tank), or other packages as defined by regulations or codes.

3.2.2.6 Ton tank

Seamless pressure vessel having a nominal water capacity of 450 L.

3.2.2.7 Tube

Seamless pressure vessel having a nominal water capacity exceeding 150 L but not more than 3000 L.

3.2.2.8 Tube trailer

Truck or semitrailer on which a number of tubes have been mounted and manifolded into a common piping system.

3.2.3 Filling ratio

Ratio of the mass of a gas introduced in a container to the mass of water at 59° F (15 °C) that would fill the same container fitted ready for use. Also known as fill density, filling factor, maximum fill degree, or maximum fill pressure.

NOTE—The water capacity stamped on the cylinder may apply to the minimum water capacity designed without internal fittings, in which case the net water capacity shall be determined.

3.2.4 Gas

Gas or gas under pressure as defined in the United Nations (UN) *Recommendations on the Transport of Dangerous Goods, Model Regulations* and in *Globally Harmonized System of Classification and Labelling of Chemicals (GHS)* [4, 5].

A gas is a substance that (a) At 50 °C has a vapor pressure greater than 300 kPa; or (b) is completely gaseous at 20 °C at a standard pressure of 101.3 kPa.

3.2.5 Gas cabinet

Fully enclosed, noncombustible enclosure used to provide an isolated environment for compressed gas cylinders in storage or use.

NOTE—Doors and access ports for exchanging cylinders and accessing pressure regulating controls are allowed to be included.

3.2.6 Oxipotential

Oxidizing power of a gas compared to that of oxygen given as a dimensionless number where oxygen = 1. See ASTM STP 1395, *Flammability and Sensitivity of Materials in Oxygen-Enriched Atmospheres* [6].

3.2.7 Passivation

Pretreatment method to allow the formation of a self-limiting protective fluoride film on the surface of the material in a controlled manner that limits any additional fluorine reaction.

3.2.8 Risk assessment

Documented assessment of the risks of a specific operation to personnel and the environment. This process usually takes into account safety controls inherent in equipment, operating procedures, and personal protective equipment (PPE) provided. Sometimes, it may be deemed necessary to improve operational safety controls after undertaking a risk assessment.

3.2.9 Swarf

Small strips or particles of metal that can arise from machining operations.

4 Properties of nitrogen trifluoride

4.1 Nitrogen trifluoride identification and physical properties

Table 1 shows properties of nitrogen trifluoride.

Table 1—Physical properties of nitrogen trifluoride

Property	SI Units	U.S. Units
Chemical formula	NF ₃	
CAS number	7783-54-2	
EC number	232-007-1	
UN number	UN 2451	
<u>Molecular weight</u>	71	
<u>Melting point at 1 atm</u>	−206.8 °C	−340.2 °F
<u>Latent heat of fusion at melting point</u>	1.34 cal/g	2.41 Btu/lb
<u>Boiling point at 1 atm</u>	−129.1 °C	−200.3 °F
<u>Density of the liquid at boiling point</u>	1538 kg/m ³	96.01 lb/ft ³
<u>Density of the gas at 21.1 °C (70 °F) and 1 atm (air = 1)</u>	2.95 kg/m ³	0.1843 lb/ft ³
<u>Specific gravity of the gas at 21.1 °C (70 °F) and 1 atm (air = 1)</u>	2.46	2.46
<u>Specific volume of the gas 21.1 °C (70 °F) and 1 atm (air = 1)</u>	0.337 m ³ /kg	5.43 ft ³ /lb
<u>Latent heat of vaporization at boiling point</u>	162 kJ/kg	70.1 Btu/lb
Critical temperature	−39.2 °C	−38.5 °F
Critical pressure	4460 kPa, abs	646.9 psia
Critical density	562.3 kg/m ³	35.1 lb/ft ³
Heat capacity at 25 °C (77 °F)	0.1794 kcal/(kg • K)	0.0428 Btu/(lb • °F)
Entropy at 25 °C (77 °F) and 1 atm	−0.877 kcal/(kg • K)	−0.471 Btu/(lbm • R)
Enthalpy at 25 °C (77 °F) and 1 atm	−29.8 kcal/mol	−800.39 Btu/lbm

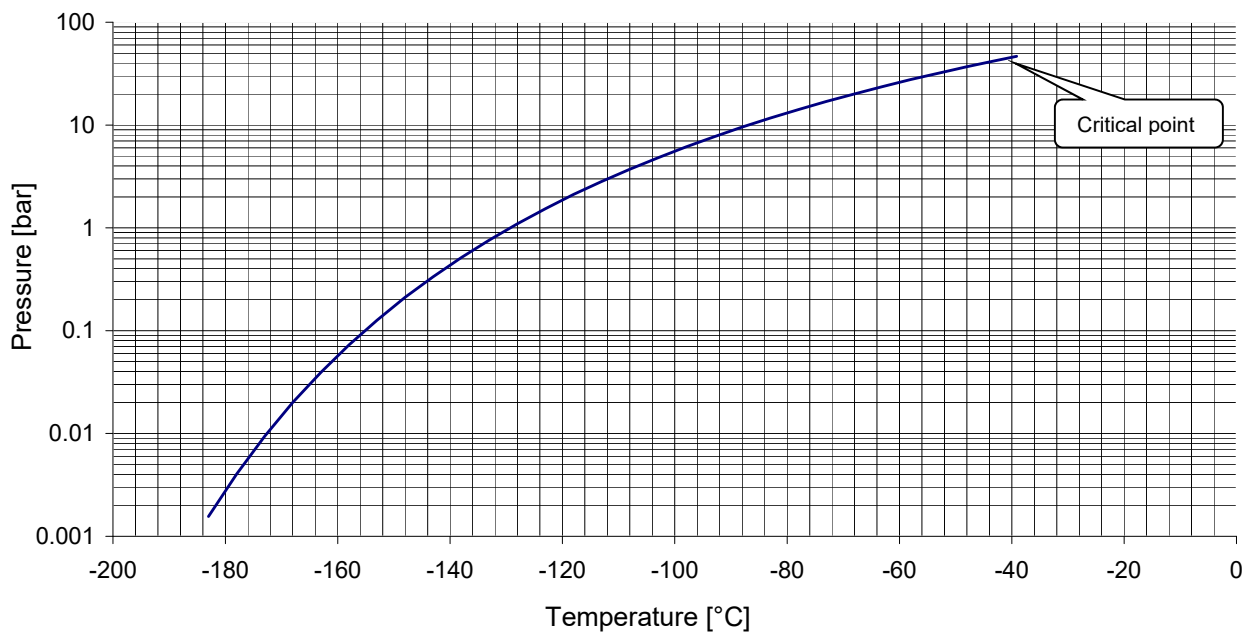


Figure 1—Vapor pressure curve (SI Units)

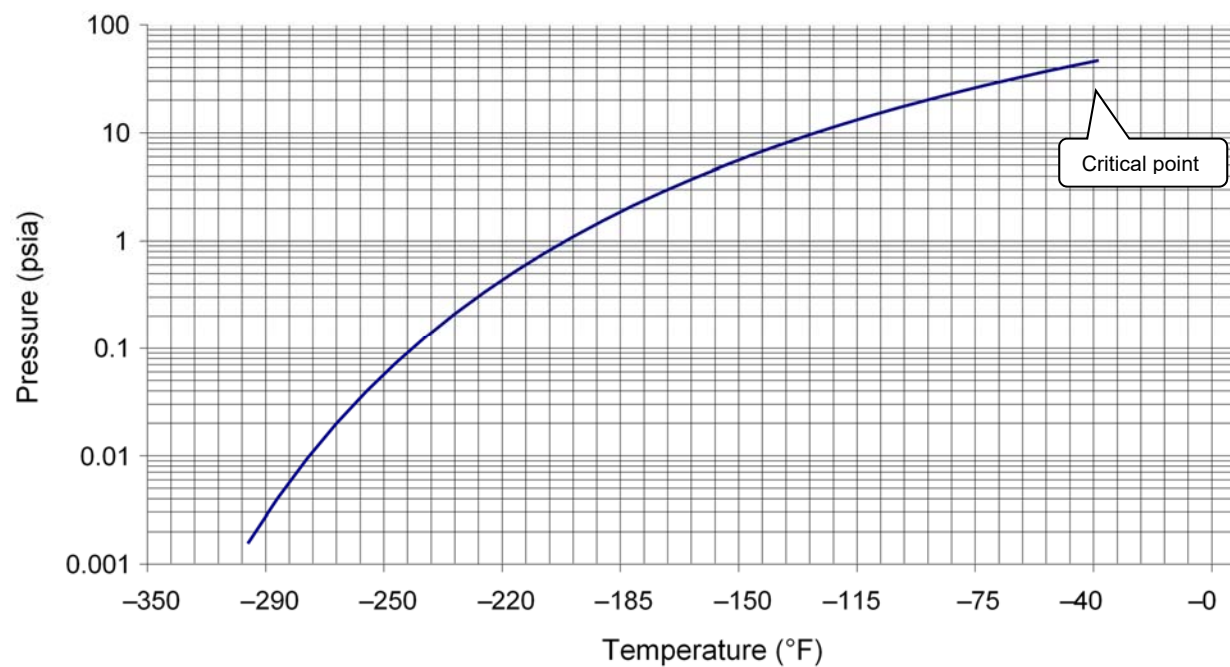


Figure 2—Vapor pressure curve (U.S. Units)

4.2 Chemical properties

Nitrogen trifluoride is a stable, slightly toxic (see 4.3), oxidizing gas. Nitrogen trifluoride is a colorless and essentially odorless gas. At lower purities of nitrogen trifluoride, there can be a moldy smell.

Oxipotential: 1.6 [6].

Ignition temperatures of some metals in nitrogen trifluoride at 1 bar and 7 bar are as follows:

	Copper	Iron	Nickel
1 bar	1022 °F (550 °C)	1503 °F (817 °C)	2168 °F (1187 °C)
7 bar	887 °F (475 °C)	1133 °F (612 °C)	1772 °F (967 °C)

NOTE—In Europe, nitrogen trifluoride is classified according to the Classification, Labelling and Packaging (CLP) Regulation as Ox. Gas 1, H270; Press. Gas (Liq.), H280; Acute Tox. 4 (Inhalation:gas), H332; STOT RE 2, H373 (see also Annex 2) [7].

NOTE—For classification of nitrogen trifluoride in the U.S., see [CGA C-7, Guide to Classification and Labeling of Compressed Gases](#) [8].

4.3 Toxicology

Established levels of nitrogen trifluoride exposure vary between countries and agencies. Refer to the governing agency in the country where nitrogen trifluoride is being used. See Table 2 for examples of established maximum limits of nitrogen trifluoride exposure to personnel used in the industrial gas industry.

NOTE—Thermal decomposition of nitrogen trifluoride can be very toxic.

Table 2—Exposure limits for nitrogen trifluoride

Occupational Safety and Health Administration (OSHA) Time Weighted Average (TWA)—Permissible Exposure Limit (PEL) [9]	10 ppm (29 mg/m ³)
National Institute for Occupational Safety and Health (NIOSH) recommended exposure limit (REL)—TWA [10]	10 ppm (29 mg/m ³)
American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value—TWA (TLV®—TWA) [11]	10 ppm (29 mg/m ³)
NIOSH Immediate danger to life and health (IDLH) [10]	1000 ppm
LC ₅₀ (1-hr rat) [12]	6700 ppm
Emergency Exposure Level (EEL) [13]	≥ 22 500 ppm x min
Acute Exposure Guideline Levels (AEGLs) [14]	
AEGL-1 (30 minutes)	400 ppm
AEGL-2 (30 minutes)	1100 ppm
AEGL-3 (30 minutes)	1700 ppm
NOTES	
1 OSHA limits are the legal exposure limits allowed by U.S. law and are enforceable.	
2 NIOSH limits are recommended values and are not enforceable by law.	
3 ACGIH limits are recommended values and are not enforceable by law.	
4 AEGL-1 is the airborne concentration (expressed as parts per million or milligrams per cubic meter [ppm or mg/m ³] of a substance above which it is predicted that the general population, including susceptible individual, could experience notable discomfort, irritation, or certain asymptomatic, nonsensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure.	
AEGL-2 is the airborne concentration (expressed as ppm or mg/m ³) of a substance above which it is predicted that the general population, including susceptible individual, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.	
AEGL-3 is the airborne concentration (expressed as ppm or mg/m ³) of a substance above which it is predicted that the general population, including susceptible individuals, could experience life threatening health effects or death.	
5 In Europe, supplier safety data sheets (SDS) shall be consulted to find the applicable regulatory exposure limits in the different European countries, where determined.	