

NFPA 55

Standard for the Storage, Use, and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders, and Tanks

2003 Edition



NFPA, 1 Batterymarch Park, PO Box 9101, Quincy, MA 02269-9101
An International Codes and Standards Organization

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NFPA 55

Standard for the

Storage, Use, and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders, and Tanks

2003 Edition

This edition of NFPA 55, *Standard for the Storage, Use, and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders, and Tanks*, was prepared by the Technical Committee on Industrial and Medical Gases and acted on by NFPA at its November Association Technical Meeting held November 16–20, 2002, in Atlanta, GA. It was issued by the Standards Council on January 17, 2003, with an effective date of February 6, 2003, and supersedes all previous editions.

This edition of NFPA 55 was approved as an American National Standard on January 17, 2003.

Origin and Development of NFPA 55

NFPA 55 was developed by the Industrial and Medical Gases Committee in recognition of the need to provide information on the use of cylinder gases in one standard. The Compressed Gas Association assisted the project by submitting a draft that was used as the framework for the standard.

NFPA 55 supersedes NFPA 43C, *Code for the Storage of Gaseous Oxidizing Materials*, which was developed by the Committee on Hazardous Chemicals and transferred to the Industrial and Medical Gases Committee. The committee believed that one standard covering storage of all gas cylinders was needed and, with the new NFPA 55, the need for NFPA 43C no longer existed.

Since this standard was introduced in 1993, it has been widely used and accepted by users of different types of gases as a single source covering requirements for installation and usage of gases in portable cylinders. The 1998 edition clarified many requirements and provided additional advisory information to assist the users of the standard. Editorial changes were also incorporated for clarity.

The 2003 edition of NFPA 55 is a complete revision of the document that significantly expands the document scope and introduces requirements for areas not addressed in previous editions. The 1998 edition covered only compressed and liquefied gases in portable cylinders and only at consumer (user) locations. The 2003 edition covers the use of compressed and liquefied gases in portable and stationary containers and at manufacturer sites and consumer sites. This expansion to manufacturer sites takes a large portion of gas usage that was outside of the scope of NFPA 55 and places it under NFPA 55.

There are many new subjects and requirements in the 2003 edition that include the following:

- (1) Requirements for cryogenic fluids
- (2) Use of the concept of control areas for defining storage amounts and requirements
- (3) An expanded classification scheme to cover a greater range of gaseous materials
- (4) Specifications for a Hazardous Materials Management Plan
- (5) Requirements for treating waste gases
- (6) More detailed requirements in many of the areas than the 1998 edition of NFPA 55 covered

The document has also been restructured to comply with the NFPA *Manual of Style*.

Technical Committee on Industrial and Medical Gases

Douglas F. Nelson, *Chair*

GE Global Asset Protection Services, PA [I]

John Anicello, Airgas, Incorporated, CA [IM]

Rep. Compressed Gas Association

William H. Barlen, Barlen and Associates, Inc., CT [M]

Rep. Airgas, Inc.

Francis X. Bender, Hazards Research Corporation, NJ [SE]

Carl A. Caves, U.S. Department of Energy, MD [U]

Rick Ginn, Wright Brothers, Inc., OH [M]

Rep. National Welding Supply Association

Charles B. Henrici, River Forest Fire Department, IL [E]

Rep. International Association of Fire Chiefs

Gary W. Howard, Stuart Energy Systems, Canada [M]

Ronald Keefer, Menlo Park Fire Protection District, CA [E]

Anthony J. McErlean, Messer Group (MG Industries), PA [IM]

Rep. Compressed Gas Association

George Mills, MM EC, Ltd., IL [U]

Rep. American Society for Healthcare Engineering

David Namyst, Intel Corporation, CA [M]

William J. Satterfield, III, RODE & Associates, LLC, RI [SE]

Michael W. St. Clair, The Ohio State University, OH [U]

Rep. NFPA Industrial Fire Protection Section

Peter W. Steiner, Air Products & Chemicals, Inc., PA [IM]

Rep. Compressed Gas Association

Gary F. Trojak, Chlorine Institute Incorporated, DC [M]

Randolph Viscomi, ARC Specialty Products Corp., NJ [IM]

Robert A. Zeman, Underwriters Laboratories Inc., IL [RT]

Alternates

Leonard A. Farello, Intel Corporation, NM [M]

(Alt. to D. Namyst)

Larry L. Fluor, Fluor, Incorporated, CA [IM]

(Alt. to A. J. McErlean)

Michael E. Lyden, The Chlorine Institute, Inc., DC [M]

(Alt. to G. F. Trojak)

Roger A. Smith, Compressed Gas Association, Inc., VA [IM]

(Alt. to J. Anicello)

William A. Thornberg, GE Global Asset Protection Services, CT [I]

(Alt. to D. F. Nelson)

Edgar Wolff-Klammer, Underwriters Laboratories Inc., IL [RT]

(Alt. to R. A. Zeman)

Nonvoting

Joanne E. Slattery, U.S. Department of Labor, DC

Carl H. Rivkin, NFPA Staff Liaison

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This list represents the membership at the time the Committee was balloted on the final text of this edition. Since that time, changes in the membership may have occurred. A key to classifications is found at the back of the document.

NOTE: Membership on a committee shall not in and of itself constitute an endorsement of the Association or any document developed by the committee on which the member serves.

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NFPA 55**Standard for the****Storage, Use, and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders, and Tanks****2003 Edition**

NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates that explanatory material on the paragraph can be found in Annex A.

A reference in brackets [] following a section or paragraph indicates material that has been extracted from another NFPA document. As an aid to the user, Annex C lists the complete title and edition of the source documents for both mandatory and nonmandatory extracts. Editorial changes to extracted material consist of revising references to an appropriate division in this document or the inclusion of the document number with the division number when the reference is to the original document. Requests for interpretations or revisions of extracted text shall be sent to the technical committee responsible for the source document.

Information on referenced publications can be found in Chapter 2 and Annex C.

Chapter 1 Administration**1.1 Scope.**

1.1.1 Applicability. This standard shall apply to the installation, storage, use, and handling of compressed gases and cryogenic fluids in portable and stationary containers, cylinders, and tanks in all occupancies.

1.1.2 Exemptions. This standard shall not apply to the following:

- (1)*Off-site transportation of materials covered by this standard
- (2) Storage, use, and handling of radioactive gases in accordance with NFPA 801, *Standard for Fire Protection for Facilities Handling Radioactive Materials*
- (3) Storage, use, and handling of medical compressed gases at health care facilities in accordance with NFPA 99, *Standard for Health Care Facilities*
- (4) Systems consisting of cylinders of oxygen and cylinders of fuel gas used for welding and cutting in accordance with NFPA 51, *Standard for the Design and Installation of Oxygen-Fuel Gas Systems for Welding, Cutting, and Allied Processes*
- (5) Acetylene cylinders in acetylene cylinder charging plants in accordance with NFPA 51A, *Standard for Acetylene Cylinder Charging Plants*
- (6) Ethylene oxide containers stored, handled, or used for sterilization and fumigation in accordance with NFPA 560, *Standard for the Storage, Handling, and Use of Ethylene Oxide for Sterilization and Fumigation*
- (7)*Flammable gases used as a vehicle fuel when stored on a vehicle
- (8)*Storage, use, and handling of liquefied and nonliquefied compressed gases, in laboratory work areas that are in accordance with NFPA 45, *Standard on Fire Protection for Laboratories Using Chemicals*

- (9) Storage, use, and handling of liquefied petroleum gases in accordance with NFPA 58, *Liquefied Petroleum Gas Code*
- (10) Storage, use and handling of gases within closed-cycle refrigeration systems complying with the mechanical code
- (11) LNG storage at utility plants under NFPA 59A, *Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG)*
- (12) LNG handled as a vehicle fuel under NFPA 57, *Liquefied Natural Gas (LNG) Vehicular Fuel Systems Code*
- (13) CNG handled as a vehicle fuel under NFPA 52, *Compressed Natural Gas (CNG) Vehicular Fuel Systems Code*

1.2* Purpose. The purpose of this standard shall be to provide fundamental safeguards for the installation, storage, use, and handling of compressed gases and cryogenic fluids in portable and stationary containers, cylinders, and tanks.

1.3 Application. The requirements in this standard shall apply to users, producers, distributors, and others who are involved with the storage, use, or handling of compressed gases or cryogenic fluids.

1.4 Retroactivity. The provisions of this standard reflect a consensus of what is necessary to provide an acceptable degree of protection from the hazards addressed in this standard at the time the standard was issued.

1.4.1 Unless otherwise specified, the provisions of this standard shall not apply to facilities, equipment, structures, or installations that existed or were approved for construction or installation prior to the effective date of the standard. Where specified, the provisions of this standard shall be retroactive.

1.4.2 In those cases where the authority having jurisdiction determines that the existing situation presents an unacceptable degree of risk, the authority having jurisdiction shall be permitted to apply retroactively any portions of this standard deemed appropriate.

1.4.3 The retroactive requirements of this standard shall be permitted to be modified if their application clearly would be impractical in the judgment of the authority having jurisdiction, and only where it is clearly evident that a reasonable degree of safety is provided.

1.5 Equivalency. Nothing in this standard is intended to prevent the use of systems, methods, or devices of equivalent or superior quality, strength, fire resistance, effectiveness, durability, and safety over those prescribed by this standard.

1.5.1 Technical documentation shall be submitted to the authority having jurisdiction to demonstrate equivalency.

1.5.2 The system, method, or device shall be approved for the intended purpose by the authority having jurisdiction.

1.6 Units and Formulas. International (SI) units shall be used as the standard unit of measure. SI units shall be followed by inch-pound units in parentheses.

Chapter 2 Referenced Publications

2.1 General. The documents or portions thereof listed in this chapter are referenced within this standard and shall be considered part of the requirements of this document.

2.2 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2002 edition.

NFPA 45, *Standard on Fire Protection for Laboratories Using Chemicals*, 2000 edition.

NFPA 50, *Standard for Bulk Oxygen Systems at Consumer Sites*, 2001 edition.

NFPA 50A, *Standard for Gaseous Hydrogen Systems at Consumer Sites*, 1999 edition.

NFPA 50B, *Standard for Liquefied Hydrogen Systems at Consumer Sites*, 1999 edition.

NFPA 51, *Standard for the Design and Installation of Oxygen-Fuel Gas Systems for Welding, Cutting, and Allied Processes*, 2002 edition.

NFPA 51A, *Standard for Acetylene Cylinder Charging Plants*, 2001 edition.

NFPA 52, *Compressed Natural Gas (CNG) Vehicular Fuel Systems Code*, 2002 edition.

NFPA 57, *Liquefied Natural Gas (LNG) Vehicular Fuel Systems Code*, 2002 edition.

NFPA 58, *Liquefied Petroleum Gas Code*, 2001 edition.

NFPA 59A, *Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG)*, 2001 edition.

NFPA 69, *Standard on Explosion Prevention Systems*, 2002 edition.

NFPA 70, *National Electrical Code*®, 2002 edition.

NFPA 72®, *National Fire Alarm Code*®, 2002 edition.

NFPA 99, *Standard for Health Care Facilities*, 2002 edition.

NFPA 110, *Standard for Emergency and Standby Power Systems*, 2002 edition.

NFPA 560, *Standard for the Storage, Handling, and Use of Ethylene Oxide for Sterilization and Fumigation*, 2002 edition.

NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response*, 2001 edition.

NFPA 801, *Standard for Fire Protection for Facilities Handling Radioactive Materials*, 2003 edition.

2.3 Other Publications.

2.3.1 ASME Publications. American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10016-5990.

ASME A13.1, *Scheme for the Identification of Piping Systems*, 1996 edition.

ASME B31.3, *Process Piping*, 2002 edition.

ASME International, *Boiler and Pressure Vessel Code*, “Rules for the Construction of Unfired Pressure Vessels,” Section VIII, 2001 edition.

2.3.2 ASTM Publication. American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM E 681-01, *Standard Test Method for Concentration Limits of Flammability of Chemicals (Vapors and Gases)*, 2002 edition.

2.3.3 CGA Publications. Compressed Gas Association, 1725 Jefferson Davis Highway, Arlington, VA 22202-4100.

CGA P-1, *Safe Handling of Compressed Gases in Containers*, 2000 edition.

CGA C-7, *Guide to the Preparation of Precautionary Labeling and Marking of Compressed Gas Containers*, 2000 edition.

CGA P-18, *Standard for Bulk Inert Gas Systems at Consumer Sites*, 1992 edition.

CGAP-20, *Standard for the Classification of Toxic Gas Mixtures*, 1995 edition.

CGA P-23, *Standard for Categorizing Gas Mixtures Containing Flammable and Nonflammable Components*, 1995 edition.

CGA P-32, *Safe Storage and Handling of Silane and Silane Mixtures*, 2000 edition.

CGA S-1.1, *Pressure Relief Device Standards – Part 1 – Cylinders for Compressed Gases*, 2001 edition.

CGAS-1.2, *Pressure Relief Device Standards – Part 2 – Cargo and Portable Tanks for Compressed Gases*, 1995 edition.

CGAS-1.3, *Pressure Relief Device Standards – Part 3 – Stationary Storage Containers for Compressed Gases*, 1995 edition.

2.3.4 CTC Publication. Canadian Transport Commission, Queen's Printer, Ottawa, Ontario, Canada.

Transportation of Dangerous Goods Regulations, Canadian Communications Group Publication Centre, Ordering Department, Ottawa, Canada, K1A 0S9.

Applicable equivalent regulations apply in the country of use.

2.3.5 International Organization for Standardization Publications. ISO, 1 rue de Varembe, Case Postale 56, CH-1211 Genève 20 Switzerland.

ISO 10156, *Gases and gas mixtures – Determination of fire potential and oxidizing ability for the selection of cylinder valve outlets*, 1996 edition.

ISO 10298, *Determination of toxicity of a gas or gas mixture*, 1995 edition.

2.3.6 U.S. Government Publications. U.S. Government Printing Office, Washington, DC 20402.

Title 16, *Code of Federal Regulations*, Parts 1500.41 and 1500.42.

Title 29, *Code of Federal Regulations*, Parts 1910.1000 and 1910.1200.

Title 40, *Code of Federal Regulations*, Parts 370 and 372.

Chapter 3 Definitions

3.1 General. The definitions contained in this chapter shall apply to the terms used in this standard. Where terms are not included, common usage of the terms shall apply.

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

3.2.2* Authority Having Jurisdiction (AHJ). The organization, office, or individual responsible for approving equipment, materials, an installation, or a procedure.

3.2.3 Labeled. Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

3.2.4* Listed. Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose.

3.2.5 Shall. Indicates a mandatory requirement.

3.2.6 Should. Indicates a recommendation or that which is advised but not required.

3.2.7 Standard. A document, the main text of which contains only mandatory provisions using the word “shall” to indicate requirements and which is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions shall be located in an appendix or annex, footnote, or fine-print note and are not to be considered a part of the requirements of a standard.

3.3 General Definitions.

3.3.1 Absolute Pressure. Pressure based on a zero reference point, the perfect vacuum. Measured from this reference point, the standard atmospheric pressure at sea level is an absolute pressure of 101.325 kPa (14.7 psia). Absolute pressure in the inch-pound system is commonly denoted in terms of pounds per square inch absolute (psia).

3.3.2 Area.

3.3.2.1 Control Area. A designated area, either indoors or outdoors, within which limited quantities of hazardous materials are allowed to be stored, used, handled, or dispensed.

3.3.2.2 Indoor Area. An area that is within a building or structure having overhead cover, other than a structure qualifying as “weather protection” in accordance with 6.6.2. (See definition 3.3.2.3, *Outdoor Area*.)

3.3.2.3 Outdoor Area. An area that is not an indoor area.

3.3.3 ASME. American Society of Mechanical Engineers. [58:1.7]

3.3.4 ASTM. American Society for Testing and Materials.

3.3.5 Building. Any structure used or intended for supporting or sheltering any use or occupancy. [101:3.3]

3.3.6 Building Code. The building or construction code adopted by the jurisdiction.

3.3.7 CFR. The Code of Federal Regulations of the United States Government.

3.3.8 CGA. Compressed Gas Association.

3.3.9 Container. A vessel, such as a cylinder, portable tank, or stationary tank, that varies in shape, size, and material of construction.

3.3.9.1 Compressed Gas Container. A pressure vessel designed to hold compressed gas at an absolute pressure greater than 1 atmosphere at 20°C (68°F) that includes cylinders, containers, and tanks.

3.3.10 Cryogenic Fluid. A fluid with a boiling point lower than -90°C (-130°F) at an absolute pressure of 101.325 kPa (14.7 psia).

3.3.11 Cylinder. Cylinder means a pressure vessel designed for pressures higher than 276 kPa (40 psia) and having a circular cross section. It does not include a portable tank, multi-unit tank car tank, cargo tank, or tank car.

3.3.12 Cylinder Containment Vessel. A gastight recovery vessel designed so that a leaking compressed gas container can be placed within its confines, thereby encapsulating the leaking container.

3.3.13 Distributor. A business engaged in the sale or resale, or both of compressed gases or cryogenic fluids, or both.

3.3.14 DOT. United States Department of Transportation.

3.3.15 Excess Flow Control. A fail-safe system or approved means designed to shut off flow due to a rupture in pressurized piping systems.

3.3.16* Exhausted Enclosure. An appliance or piece of equipment that consists of a top, a back, and two sides that provides a means of local exhaust for capturing gases, fumes, vapors, and mists.

3.3.17 Gas.

3.3.17.1* Compressed Gas. A material, or mixture of materials, that (1) is a gas at 20°C (68°F) or less at an absolute pressure of 101.325 kPa (14.696 psia) and (2) that has a boiling point of 20°C (68°F) or less at an absolute pressure of 101.325 kPa (14.7 psia) and that is liquefied, nonliquefied, or in solution, except those gases that have no other health or physical hazard properties are not considered to be compressed gases until the pressure in the packaging exceeds an absolute pressure of 280 kPa (40.6 psia) at 20°C (68°F).

3.3.17.2 Corrosive Gas. A gas that causes visible destruction of or irreversible alterations in, living tissue by chemical action at the site of contact.

3.3.17.3* Flammable Gas. A material that is a gas at 20°C (68°F) or less at an absolute pressure of 101.325 kPa (14.7 psia), that is ignitable at an absolute pressure of 101.325 kPa (14.7 psia) when in a mixture of 13 percent or less by volume with air, or that has a flammable range at an absolute pressure of 101.325 kPa (14.7 psia) with air of at least 12 percent, regardless of the lower limit.

3.3.17.4 Flammable Liquefied Gas. A liquefied compressed gas that, when under a charged pressure, is partially liquid at a temperature of 20°C (68°F) and is flammable.

3.3.17.5 Highly Toxic Gas. A chemical that has a median lethal concentration (LC₅₀) in air of 200 parts per million by volume or less of gas or vapor, or 2 milligrams per liter or less of mist, fume, or dust, when administered by continuous inhalation for 1 hour (or less if death occurs within 1 hour) to albino rats weighing between 200 g and 300 g (0.44 lb and 0.66 lb) each.

3.3.17.6 Inert Gas. A nonreactive, nonflammable, noncorrosive gas such as argon, helium, krypton, neon, nitrogen, and xenon.

3.3.17.7 Irritant Gas. A chemical that is not corrosive, but that causes a reversible inflammatory effect on living tissue by chemical action at the site of contact. A chemical is a skin irritant if, when tested on the intact skin of albino rabbits by the methods of 16 CFR 1500.41, for an exposure of 4 or more hours or by other appropriate techniques, it results

in an empirical score of 5 or more. A chemical is classified as an eye irritant if so determined under the procedure listed in 16 CFR 1500.42, or other appropriate techniques.

3.3.17.8 Nonflammable Gas. A gas that does not meet the definition of a flammable gas.

3.3.17.9 Other Gas. A gas that is not a corrosive gas, flammable gas, highly toxic gas, oxidizing gas, pyrophoric gas, toxic gas, or unstable reactive gas with a hazard rating of Class 2, Class 3, or Class 4 gas, that might be a nonflammable gas or inert gas.

3.3.17.10 Oxidizing Gas. A gas that can support and accelerate combustion of other materials.

3.3.17.11 Pyrophoric Gas. A gas with an autoignition temperature in air at or below 704°C (1300°F).

3.3.17.12 Toxic Gas. A gas with a median lethal concentration (LC₅₀) in air of more than 200 ppm, but not more than 2000 ppm by volume of gas or vapor, or more than 2 mg/L, but not more than 20 mg/L of mist, fume, or dust, when administered by continuous inhalation for 1 hour (or less if death occurs within 1 hour) to albino rats weighing between 200 g and 300 g (0.44 lb and 0.66 lb) each.

3.3.17.13* Unstable Reactive Gas. A gas that, in the pure state or as commercially produced, will vigorously polymerize, decompose or condense, become self-reactive, or otherwise undergo a violent chemical change under conditions of shock, pressure, or temperature.

3.3.17.13.1 Class 2 Unstable Reactive Gas. Materials that readily undergo violent chemical change at elevated temperatures and pressures.

3.3.17.13.2 Class 3 Unstable Reactive Gas. Materials that in themselves are capable of detonation or explosive decomposition or explosive reaction, but that require a strong initiating source or that must be heated under confinement before initiation.

3.3.17.13.3 Class 4 Unstable Reactive Gas. Materials that in themselves are readily capable of detonation or explosive decomposition or explosive reaction at normal temperatures and pressures.

3.3.18* Gas Cabinet. A fully enclosed, noncombustible enclosure used to provide an isolated environment for compressed gas cylinders in storage and use.

3.3.19 Gas Manufacturer/Producer. A business that produces compressed gases or cryogenic fluids, or both, or fills portable or stationary gas containers, cylinders, or tanks.

3.3.20* Gas Room. A room designed for storage and use of compressed gases.

3.3.21 Handling. The deliberate movement of material in containers by any means to a point of storage or use.

3.3.22* Hazard Rating. The numerical rating of the health, flammability, and self-reactivity, and other hazards of the material, including its reaction with water, specified in NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response*.

3.3.23* Immediately Dangerous to Life and Health (IDLH). A concentration of airborne contaminants, normally expressed in parts per million (ppm) or milligrams per cubic meter, that represents the maximum level from which one could escape within

30 minutes without any escape-impairing symptoms or irreversible health effects. This level is established by the National Institute of Occupational Safety and Health (NIOSH). If adequate data do not exist for precise establishment of IDLH data, an independent certified industrial hygienist, industrial toxicologist, or appropriate regulatory agency shall make such determination.

3.3.24 Limit.

3.3.24.1 Ceiling Limit. The maximum concentration of an airborne contaminant to which a person might be exposed. The ceiling limits utilized are those published in 29 CFR 1910.1000.

3.3.24.2* Permissible Exposure Limit (PEL). The maximum permitted 8-hour, time-weighted average concentration of an airborne contaminant.

3.3.24.3* Short-Term Exposure Limit (STEL). The concentration to which it is believed that workers can be exposed continuously for a short period of time without suffering from irritation, chronic or irreversible tissue damage, or narcosis of a degree sufficient to increase the likelihood of accidental injury, impairment of self-rescue, or the material reduction of work efficiency, without exceeding the daily permissible exposure limit (PEL).

3.3.25 Material Safety Data Sheet (MSDS). Written or printed material concerning a hazardous material that is prepared in accordance with the provisions of 29 CFR 1910.1200.

3.3.26 Mechanical Code. The mechanical or mechanical construction code adopted by the authority having jurisdiction.

3.3.27 Nesting. A method of securing cylinders upright in a tight mass using a contiguous three-point contact system whereby all cylinders in a group have a minimum of three contact points with other cylinders or a solid support structure (for example, a wall or railing).

3.3.28 Normal Temperature and Pressure (NTP). A temperature of 21°C (70°F) at an absolute pressure of 101.325 kPa (14.7 psia).

3.3.29 OSHA. The Occupational Safety Health Administration of the U.S. Department of Labor.

3.3.30 Separation of Hazards. Physically separated by a specified distance, construction, or appliance.

3.3.31 Standard Cubic Foot (scf). One cubic foot of gas at 21°C (70°F) and an absolute pressure of 101.325 kPa (14.7 psia).

3.3.32 Storage. An inventory of compressed gases or cryogenic fluids in containers that are not in the process of being examined, serviced, refilled, loaded, or unloaded.

3.3.33 System.

3.3.33.1* Compressed Gas System. An assembly of equipment designed to contain, distribute, or transport compressed gases.

3.3.33.2 Continuous Gas Detection System. A gas detection system in which the instrument is maintained in continuous operation and the interval between sampling of any point does not exceed 30 minutes.

3.3.33.3 Cylinder Containment System. A gastight recovery system comprised of equipment or devices that can be placed over a leak in a compressed gas container, thereby stopping or controlling the escape of gas from the leaking container.

3.3.33.4 Treatment System. An assembly of equipment capable of processing a hazardous gas and reducing the gas concentration to a predetermined level at the point of discharge from the system to the atmosphere.

3.3.34 Tank.

3.3.34.1* Portable Tank. Any packaging over 227.1 L (60 U.S. gal) capacity designed primarily to be loaded into or on, or temporarily attached to, a transport vehicle or ship and equipped with skids, mountings, or accessories to facilitate handling of the tank by mechanical means.

3.3.34.2* Stationary Tank. A packaging designed primarily for stationary installations not intended for loading, unloading, or attachment to a transport vehicle as part of its normal operation in the process of use.

3.3.35 TC. Transport Canada.

3.3.36 Use. To place a material into action, including solids, liquids, and gases.

3.3.37 Valve Outlet Cap or Plug. A removable device that forms a gastight seal on the outlet to the control valve that is provided on a source containing a compressed gas or cryogenic fluid.

3.3.38 Valve Protection Cap. A rigid, removable cover provided for container valve protection during handling, transportation, and storage.

3.3.39 Valve Protection Device. A device attached to the neck ring or body of a cylinder for the purpose of protecting the cylinder valve from being struck or from being damaged by the impact resulting from a fall or an object striking the cylinder.

Chapter 4 General Requirements

4.1 Training. Persons responsible for or working in the areas where compressed gases or cryogenic fluids are produced, stored, handled, or used shall be trained in the chemical and physical properties of the materials and the response in the event of an emergency.

4.2 Permits. Permits shall be obtained in accordance with the requirements of the jurisdiction in which the facility operates.

4.3 Hazardous Materials Management Plan (HMMP).

4.3.1 When required by the authority having jurisdiction, an application for a permit shall include an HMMP, such as a 40 CFR 370 and 372 Superfund Authorization and Reauthorization Act (SARA) Title III, Tier II Report, or other approved statement.

4.3.2 The HMMP shall include the following information:

- (1) Manufacturer's name
- (2) Chemical name, trade names, hazardous ingredients
- (3) Hazard classification
- (4) MSDS or equivalent
- (5) United Nations (UN), North America (NA), or the Chemical Abstract Service (CAS) identification number
- (6) Maximum quantity stored or used on-site at one time
- (7) Storage conditions related to the storage type, temperature, and pressure

4.4 Facility Closure. Facilities shall be placed out of service in accordance with the provisions of this section.

4.4.1 Temporary Out-of-Service Facilities. Facilities that are temporarily out of service shall continue to be maintained in accordance with the requirements of this standard.

4.4.2 Permanently Out-of-Service Facilities.

4.4.2.1 Facilities for which a permit is not kept current or that are not monitored and inspected on a regular basis shall be deemed to be permanently out of service and shall be closed in an approved manner.

4.4.2.2 Where required by the authority having jurisdiction, permittees shall apply for approval to close permanently storage, use, and handling facilities.

4.4.2.3 An application shall be accompanied by an approved facility closure plan in accordance with 4.4.3.

4.4.3 Facility Closure Plan.

4.4.3.1 Where a facility closure plan is required to terminate storage, dispensing, handling, or use of hazardous materials, it shall be submitted to the code official at least 30 days prior to facility closure.

4.4.3.2 The plan shall demonstrate that hazardous materials that are stored, dispensed, handled, or used in the facility will be transported, disposed of, or reused in a manner that eliminates the need for further maintenance and any threat to public health and safety.

4.5 Emergency Plan.

4.5.1 Emergency Plan Requirements.

4.5.1.1 An emergency plan shall be prepared and updated wherever compressed gases or cryogenic fluids are produced, handled, stored, or used where required by the authority having jurisdiction.

4.5.1.2 The plan shall be available for inspection by the authority having jurisdiction upon reasonable notice and shall include the following information:

- (1) The type of emergency equipment available and its location
- (2) A brief description of any testing or maintenance programs for the available emergency equipment
- (3) An indication that hazard identification labeling is provided for each storage area
- (4) Location of posted emergency procedures
- (5) A material safety data sheet (MSDS or equivalent) that is available for each compressed gas or cryogenic fluid stored or used on the site
- (6) A list of personnel who are designated and trained to be liaison personnel for the fire department and who are responsible for the following:
 - (a) Aiding the emergency responders in pre-emergency planning
 - (b) Identifying the location of the compressed gases and cryogenic fluids stored or used
 - (c) Accessing material safety data sheets
 - (d) Knowledge of the site emergency procedures
- (7) A list of the types and quantities of compressed gases and cryogenic fluids found within the facility

Chapter 5 Classification of Hazards

5.1 Hazardous Materials Classification.

5.1.1 Pure Gases. Hazardous materials shall be classified according to hazard categories as follows:

- (1) Physical hazards, which shall include the following:
 - (a) Flammable gas
 - (b) Nonflammable gas
 - (c) Oxidizing gas
 - (d) Pyrophoric gas
 - (e) Unstable reactive (detonable) gas, Class 3 or Class 4
 - (f) Unstable reactive (nondetonable) gas, Class 2 or Class 3
- (2) Health hazards, which shall include the following:
 - (a) Corrosive gas
 - (b) Cryogenic fluids
 - (c) Highly toxic gas
 - (d) Toxic gas
 - (e) Irritant gas

5.1.2 Other Hazards. Although it is possible that there are other known hazards, the classification of such gases is not within the scope of this standard and they shall be handled, stored, or used as an *other gas*.

5.1.3 Mixtures. Mixtures shall be classified in accordance with the hazards of the mixture as a whole.

5.1.4 Responsibility for Classification. Classification shall be performed by an approved organization, individual, or testing laboratory.

5.1.4.1 Toxicity. The toxicity of gas mixtures shall be classified in accordance with CGA P-20, *Standard for Classification of Toxic Gas Mixtures*, or by testing in accordance with the requirements of 29 CFR 1910.1000 or DOT or ISO 10298, *Determination of toxicity of a gas or gas mixture*.

5.1.4.2 Flammability of Gas Mixtures. For gas mixtures other than those containing ammonia and nonflammable gases, flammability of gas mixtures shall be classified in accordance with CGA P-23, *Standard for Categorizing Gas Mixtures Containing Flammable and Nonflammable Components*, or by physical testing in accordance with the requirements of ASTM E 681-01, *Standard Test Method for Concentration Limits of Flammability of Chemicals (Vapors and Gases)*, or ISO 10156, *Gases and gas mixtures — Determination of fire potential and oxidizing ability for the selection of cylinder valve outlets*.

Chapter 6 Building Related Controls

6.1 General.

6.2 Control Areas.

6.2.1 Construction Requirements. Control areas shall be separated from each other by not less than a 1-hour fire-resistive occupancy separation as required by the building code.

6.2.2 Number. The number of control areas in buildings or portions of buildings shall not exceed that allowed by the building code.

6.3 Occupancy Protection Levels.

6.3.1 Quantity Thresholds for Compressed Gases and Cryogenic Fluids Requiring Special Provisions. Where the quantities of compressed gases or cryogenic fluids stored or used within an indoor control area exceed that shown in Table 6.3.1, the area shall meet the requirements for Protection

Level 1 through 5 in accordance with the building code based on the requirements of 6.3.2. The aggregate quantity in use and storage shall not exceed the quantity listed for storage.

6.3.1.1 Incompatible Materials. When the classification of materials in individual containers requires the area to be placed in more than one protection level, the separation of protection levels shall not be required providing the area is constructed to meet the requirements of the most restrictive protection level and that the incompatible materials are separated as required by 7.1.5.2.

6.3.1.2 Multiple Hazards. Where a compressed gas or cryogenic fluid has multiple hazards, all hazards shall be addressed and controlled in accordance with the provisions for the protection level for which the threshold quantity is exceeded.

6.3.1.3 Flammable and Oxidizing Gases. Flammable and oxidizing gases shall not be stored or used in other than industrial and storage occupancies.

6.3.1.3.1 Containers, cylinders, or tanks not exceeding 7.1 m³ (250 ft³) content at normal temperature and pressure (NTP) and used for maintenance purposes, patient care, or operation of equipment shall be permitted.

6.3.1.4 Toxic and Highly Toxic Compressed Gases. Except for containers or cylinders not exceeding 0.6 m³ (20 ft³) content at NTP stored or used within gas cabinets or exhausted enclosures of educational occupancies, toxic or highly toxic compressed gases shall not be stored or used in other than industrial and storage occupancies.

6.3.2 Classification of Protection Levels. The protection level required shall be based on the hazard class of the material involved as indicated in 6.3.2.1 through 6.3.2.5.

6.3.2.1 Protection Level 1. Occupancies used for the storage or use of unstable, reactive Class 4 and unstable, reactive Class 3 detonable compressed gases in quantities that exceed the quantity thresholds for gases requiring special provisions shall be classified Protection Level 1.

6.3.2.2 Protection Level 2. Occupancies used for the storage or use of flammable, pyrophoric, and nondetonable, unstable, reactive Class 3 compressed gases or cryogenic fluids in quantities that exceed the quantity thresholds for gases requiring special provisions shall be classified as Protection Level 2.

6.3.2.3 Protection Level 3. Occupancies used for the storage or use of oxidizing, and unstable, reactive Class 2 compressed gases or cryogenic fluids in quantities that exceed the quantity thresholds for gases requiring special provisions shall be classified as Protection Level 3.

6.3.2.4 Protection Level 4. Occupancies used for the storage or use of toxic, highly toxic, and corrosive compressed gases in quantities that exceed the quantity thresholds for gases requiring special provisions shall be classified as Protection Level 4.

6.3.2.5 Protection Level 5. Buildings and portions thereof used for fabrication of semiconductors or semiconductor research and development and containing quantities of hazardous materials exceeding the maximum allowable quantities of high hazard level 5 contents permitted in control areas shall be classified as Protection Level 5.

6.4 Gas Rooms. Gas rooms shall meet the requirements of 6.4.1 through 6.4.5.

6.4.1 Pressure Control. Gas rooms shall operate at a negative pressure in relationship to the surrounding area.

6.4.2 Exhaust Ventilation. Gas rooms shall be provided with an exhaust ventilation system.

Table 6.3.1 Quantity Thresholds for Gases Requiring Special Provisions

Material	Unsprinklered Areas		Sprinklered Areas	
	No Gas Cabinet, Gas Room, or Exhausted Enclosure	Gas Cabinet, Gas Room, or Exhausted Enclosure	No Gas Cabinet, Gas Room, or Exhausted Enclosure	Gas Cabinet, Gas Room, or Exhausted Enclosure
<i>Corrosive Gas</i>				
Liquefied	68 kg (150 lb)	136 kg (300 lb)	136 kg (300 lb)	272 kg (600 lb)
Nonliquefied	23 m ³ (810 ft ³)	46 m ³ (1620 ft ³)	46 m ³ (1620 ft ³)	92 m ³ (3240 ft ³)
<i>Cryogenic Liquid</i> (Flammable or Oxidizing)	45 gal	90 gal	90 gal	180 gal
<i>Flammable Gas</i>				
Liquefied	14 kg (30 lb)	27 kg (60 lb)	27 kg (60 lb)	55 kg (120 lb)
Nonliquefied	28 m ³ (1000 ft ³)	28 m ³ (2000 ft ³)	28 m ³ (2000 ft ³)	56 m ³ (4000 ft ³)
<i>Highly Toxic Gas</i>				
Liquefied	(0 lb)	2.3 kg (5 lb)	(0 lb)	4.5 kg (10 lb)
Nonliquefied	0 ft ³	0.6 m ³ (20 ft ³)	0 ft ³	1.1 m ³ (40 ft ³)
<i>Nonflammable Gas</i>				
Liquefied	No limit			
Nonliquefied	No limit			
<i>Oxidizing Gas</i>				
Liquefied	14 kg (30 lb)	27 kg (60 lb)	27 kg (60 lb)	55 kg (120 lb)
Nonliquefied	43 m ³ (1500 ft ³)	85 m ³ (3000 ft ³)	85 m ³ (3000 ft ³)	170 m ³ (6000 ft ³)
<i>Pyrophoric Gas</i>				
Liquefied	(0 lb)	(0 lb)	(4 lb)	(8 lb)
Nonliquefied	0 ft ³	0 ft ³	50 ft ³	100 ft ³
<i>Toxic Gas</i>				
Liquefied	68 kg (150 lb)	136 kg (300 lb)	136 kg (300 lb)	272 kg (600 lb)
Nonliquefied	23 m ³ (810 ft ³)	46 m ³ (1620 ft ³)	46 m ³ (1620 ft ³)	92 m ³ (3240 ft ³)
<i>Unstable Reactive</i> <i>(Detonable) Gas, Class 3</i> <i>or Class 4</i>				
Liquefied	(0 lb)	(0 lb)	0.5 kg (1 lb)	1 kg (2 lb)
Nonliquefied	0 ft ³	0 ft ³	0.3 m ³ (10 ft ³)	0.6 m ³ (20 ft ³)
<i>Unstable Reactive</i> <i>(Nondetonable) Gas,</i> <i>Class 3</i>				
Liquefied	1 kg (2 lb)	2 kg (4 lb)	2 kg (4 lb)	4 kg (8 lb)
Nonliquefied	1.4 m ³ (50 ft ³)	3 m ³ (100 ft ³)	3 m ³ (100 ft ³)	6 m ³ (200 ft ³)
<i>Unstable Reactive Gas,</i> <i>Class 2</i>				
Liquefied	14 kg (30 lb)	27 kg (60 lb)	27 kg (60 lb)	55 kg (120 lb)
Nonliquefied	21 m ³ (750 ft ³)	43 m ³ (1500 ft ³)	43 m ³ (1500 ft ³)	85 m ³ (3000 ft ³)

6.4.3 Construction. Gas rooms shall be constructed in accordance with the building code.

6.4.4 Separation. Gas rooms shall be separated from other occupancies by a minimum of 1-hour fire resistance.

6.4.5 Limitation on Contents. The function of compressed gas rooms shall be limited to storage and use of compressed gases and associated equipment and supplies.

6.5 Detached Buildings. Occupancies used for the storage or use of compressed gases in quantities exceeding those specified in Table 6.5 shall be in detached buildings constructed in accordance with the provisions of the building code.

Table 6.5 Detached Buildings (Detached Building Required Where Quantity of Material Exceeds Amount Shown)

Gas Hazard	Class	Quantity of Material m ³ (ft ³)
Unstable reactive (detonable)	4 or 3	Quantity thresholds for gases requiring special provisions*
Unstable reactive (nondetonable)	3	57 m ³ (2000 ft ³)
	2	283 m ³ (10,000 ft ³)
Pyrophoric gas	NA	57 m ³ (2000 ft ³)

NA = Not applicable

*Quantity thresholds for gases requiring special provisions refers to quantities listed in Table 6.3.1.

6.6 Temperature Protection.

6.6.1 Compressed Gas Containers. Compressed gas containers in quantities exceeding the quantity thresholds for gases requiring special provisions shall be kept out of direct sunlight or at or below 52°C (125°F).

6.6.2 Overhead Cover. Overhead cover shall be of noncombustible construction, open on at least three sides, and shall not be considered indoor storage.

6.7 Emergency Alarm. A manual emergency alarm system shall be provided in buildings, rooms, or areas used for the storage or use of compressed gases or cryogenic fluids in amounts that exceed quantity thresholds requiring special provisions.

6.7.1 Activation of an emergency alarm-initiating device shall sound a local alarm to alert occupants in the immediate area of an emergency situation involving a compressed gas or cryogenic fluid.

6.8 Electrical Equipment. Electrical wiring and equipment shall be in accordance with Section 6.8 and NFPA 70, *National Electrical Code*®, including Article 505.

6.8.1 Standby Power.

6.8.1.1 Where the following systems are required by this standard due to the storage or use of compressed gases or cryogenic fluids that exceed the quantity thresholds for gases requiring special provisions, such systems shall be connected to a standby power system in accordance with NFPA 70, *National Electrical Code*®:

- (1) Mechanical ventilation
- (2) Treatment systems

- (3) Temperature controls
- (4) Alarms
- (5) Detection systems
- (6) Other electrically operated systems

6.8.1.2 The requirements of 6.8.1.1 shall not apply where emergency power is provided in accordance with NFPA 70, *National Electrical Code*®.

6.8.2 Emergency Power. When emergency power is required, the system shall meet the requirements for a Protection Level 2 system in accordance with NFPA 110, *Standard for Emergency and Standby Power Systems*.

6.9 Gases Requiring Special Provisions. Gas requiring special provisions shall comply with Table 6.3.1.

6.10* Explosion Control. Explosion control shall be provided as required by Table 6.10 in accordance with NFPA 69, *Standard on Explosion Prevention Systems*, where amounts of compressed gases in storage or use exceed the quantity thresholds requiring special provisions.

Table 6.10 Explosion Control Requirements

Material	Class	Explosion Control Methods	
		Barricade Construction	Explosion Venting or Prevention Systems
Cryogenic flammable	—	Not required	Required
Flammable gas	Nonliquefied	Not required	Required
	Liquefied	Not required	Required
Pyrophoric gas	—	Not required	Required
Unstable reactive gas	4	Required	Not required
	3 (detonable)	Required	Not required
	3 (nondetonable)	Not required	Required

6.11* Fire Protection Systems. Except as provided in 6.11.1, buildings or portions thereof required to comply with Protection Levels 1 through 5 shall be protected by an approved automatic fire sprinkler system complying with NFPA 13, *Standard for the Installation of Sprinkler Systems*.

6.11.1 Rooms or areas that are of noncombustible construction with wholly noncombustible contents shall not be required to be protected by an automatic fire sprinkler system.

6.11.2 Sprinkler System Design. When sprinkler protection is provided, the area in which compressed gases or cryogenic fluids are stored or used shall be protected with a sprinkler system designed to be not less than that required by NFPA 13 for Ordinary Hazard Group 2 with a minimum design area of 278.7 m² (3000 ft²).

6.11.2.1 Flammable or Pyrophoric Gases. When sprinkler protection is provided, the area in which the flammable or pyrophoric compressed gases or cryogenic fluids are stored or used shall be protected with a sprinkler system designed to be not less than that required by NFPA 13 for Extra Hazard Group 1 with a minimum design area of 232.25 m² (2500 ft²).

6.12 Lighting. Approved lighting by natural or artificial means shall be provided.

6.13 Hazard Identification Signs.

6.13.1 Location. Hazard identification signs shall be placed at all entrances to locations where compressed gases are produced, stored, used, or handled.

(A) Ratings shall be assigned in accordance with NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response*.

(B) The authority having jurisdiction shall be permitted to waive this requirement where consistent with safety.

6.13.2 Application. Signage shall be provided as specified in 6.13.2.1 and 6.13.2.2.

6.13.2.1 Signs. Signs shall not be obscured or removed.

6.13.2.2 No Smoking. Signs prohibiting smoking or open flames within 6.1 m (25 ft) of area perimeters shall be provided in areas where toxic, highly toxic, corrosive, unstable reactive, flammable, oxidizing, or pyrophoric gases are produced, stored, or used.

6.14 Spill Control, Drainage, and Secondary Containment. Spill control, drainage, and secondary containment shall not be required for compressed gases.

6.15 Shelving.

6.15.1 Shelves used for the storage of cylinders, containers, and tanks shall be of noncombustible construction and designed to support the weight of the materials stored.

6.15.2 In seismically active areas, shelves and containers shall be secured from overturning.

6.16 Venting from Piping Systems and Controls. Venting of gas shall be to an approved location.

6.17 Ventilation. Indoor storage and use areas and storage buildings for compressed gases and cryogenic fluids shall be provided with mechanical exhaust ventilation or natural ventilation, where natural ventilation can be shown to be acceptable for the material as stored.

6.17.1 Where mechanical ventilation is provided, the system shall be operational during the time the building or space is occupied.

6.17.2 Compressed Air. The requirements of Section 6.17 and 6.17.1 shall not apply to cylinders, containers, and tanks containing compressed air.

6.17.3 Mechanical Ventilation Rate. Mechanical ventilation shall be at a rate of not less than 0.3048 m³/min/m² (1 ft³/min/ft²) of floor area over the area of storage or use.

6.17.4 Continuous Operation. Systems shall operate continuously unless an alternate design is approved by the code official.

6.17.5 Shutoff Controls. Where powered ventilation is provided, a manual shutoff switch shall be provided outside of the

room in a position adjacent to the principal access door to the room or in an approved location.

6.17.6 The switch shall be the break-glass or equivalent type and shall be labeled as follows:

VENTILATION SYSTEM EMERGENCY SHUTOFF

6.17.7 Inlets to the Exhaust System.

6.17.7.1 The exhaust ventilation system design shall take into account the density of the potential gases released.

6.17.7.2 For gases that are heavier than air, exhaust shall be taken from a point within 12 in. (304.8 mm) of the floor.

6.17.7.3 For gases that are lighter than air, exhaust shall be taken from a point within 12 in. (304.8 mm) of the ceiling.

6.17.8 Floor Level Exhaust. The location of both the exhaust and inlet air openings shall be designed to provide air movement across all portions of the floor or room to prevent the accumulation of vapors.

6.17.9 Recirculation of Exhaust. Exhaust ventilation shall not be recirculated within the room or building if the cylinders, containers, or tanks stored are capable of releasing hazardous gases.

6.17.10 Ventilation systems shall discharge a minimum of 15 m (50 ft) from intakes of air-handling systems, air-conditioning equipment, and air compressors.

6.17.11 Air Intakes. Storage and use of compressed gases shall be located not less than 15 m (50 ft) from air intakes. For material-specific requirements see Section 7.4 through Section 7.10.

6.18 Gas Cabinets.

6.18.1 Construction. Where a gas cabinet is required, is used to provide separation of gas hazards, or is used to increase the threshold quantity for a gas requiring special provisions, the gas cabinet shall be in accordance with the requirements of 6.18.1.1 through 6.18.4.

6.18.1.1 Materials of Construction. The gas cabinet shall be constructed of not less than 2.46-mm (0.097-in.) (12 gauge) steel.

6.18.2 Access to Controls. The gas cabinet shall be provided with self-closing limited access ports or noncombustible windows to give access to equipment controls.

6.18.2.1 Self-Closing Doors. The gas cabinet shall be provided with self-closing doors.

6.18.2.2 Ventilation Requirements. The gas cabinet shall be provided with an exhaust ventilation system designed to operate at a negative pressure relative to the surrounding area.

6.18.2.2.1 Control Velocity. Where toxic, highly toxic, pyrophoric, unstable, reactive Class 3 or Class 4 or corrosive gases are contained, the velocity at the face of access ports or windows, with the access port or window open, shall not be less than 61 m/min (200 ft/min) average, with not less than 46 m/min (150 ft/min) at any single point.

6.18.2.3 Fire Protection. Gas cabinets used to contain toxic, highly toxic, or pyrophoric gases shall be internally sprinklered.

6.18.3 Quantity Limits. Gas cabinets shall contain not more than three containers, cylinders, or tanks.

6.18.4 Separation. Incompatible gases, as defined by Table 7.1.5.2, shall be stored or used within separate gas cabinets.

6.19 Exhausted Enclosures.

6.19.1 Ventilation Requirements. Where an exhausted enclosure is required or used to increase the threshold quantity for a gas requiring special provisions, the exhausted enclosure shall be provided with an exhaust ventilation system designed to operate at a negative pressure in relationship to the surrounding area.

6.19.1.1 Control Velocity at Access Openings. Where toxic, highly toxic, pyrophoric, unstable, reactive Class 3 or Class 4 or corrosive gases are contained, the velocity at the face openings providing access shall be not less than 61 m/min (200 ft/min) average, with not less than 46 m/min (150 ft/min) at any single point.

6.19.1.2 Separation of Incompatible Gases within Enclosures. Cylinders, containers, and tanks within enclosures shall be separated in accordance with Table 7.1.5.2.

6.19.1.3 Fire Protection. Exhausted enclosures shall be internally sprinklered.

6.19.2 Separation. Incompatible gases, as defined by Table 7.1.5.2, shall be stored or used within separate exhausted enclosures.

Chapter 7 Compressed Gases

7.1 General. The storage, use, and handling of compressed gases in containers, cylinders, and tanks shall be in accordance with the provisions of Chapters 1 through 7.

7.1.1 Containers, Cylinders, and Tanks.

7.1.1.1 Design and Construction. Containers, cylinders, and tanks shall be designed, fabricated, tested, and marked (stamped) in accordance with regulations of DOT, Transport Canada (TC) *Transportation of Dangerous Goods Regulations*, or the ASME *Boiler and Pressure Vessel Code*, "Rules for the Construction of Unfired Pressure Vessels," Section VIII.

7.1.1.2 Defective Containers, Cylinders, and Tanks.

7.1.1.2.1 Defective containers, cylinders, and tanks shall be returned to the supplier.

7.1.1.2.2 Suppliers shall either repair the containers, cylinders, and tanks, remove them from service, or dispose of them in an approved manner.

7.1.1.3 Containers, Cylinders, and Tanks Containing Residual Gas. Compressed gas containers, cylinders, and tanks containing residual product shall be treated as full except when being examined, serviced, or refilled by a gas manufacturer or distributor.

7.1.1.4 Pressure-Relief Devices.

7.1.1.4.1 When required by 7.1.1.4.2, pressure-relief devices shall be provided to protect containers and systems containing compressed gases from rupture in the event of overpressure from thermal exposure.

7.1.1.4.2 Pressure-relief devices to protect containers shall be designed and provided in accordance with CGA S-1.1, *Pressure Relief Device Standards – Part 1 – Cylinders for Compressed Gases*, for cylinders; CGA S-1.2, *Pressure Relief Device Standards – Part 2 – Cargo and Portable Tanks for Compressed Gases*, for portable tanks; and CGA S-1.3, *Pressure Relief Device Standards – Part 3 – Station-*

ary Storage Containers for Compressed Gases, for stationary tanks or applicable equivalent requirements in the country of use.

7.1.1.4.3 Pressure-relief devices shall be sized in accordance with the specifications to which the container was fabricated.

7.1.1.4.4 The pressure-relief device shall have the capacity to prevent the maximum design pressure of the container or system from being exceeded.

7.1.2 Labeling Requirements.

7.1.2.1 Containers. Individual compressed gas containers, cylinders, and tanks shall be marked or labeled in accordance with DOT requirements or the applicable regulatory agency.

7.1.2.2 Label Maintenance. The labels applied by the gas manufacturer to identify the liquefied or nonliquefied compressed gas cylinder contents shall not be altered or removed by the user.

7.1.2.3 Stationary Compressed Gas Containers, Cylinders, and Tanks.

7.1.2.3.1 Stationary compressed gas containers, cylinders, and tanks shall be marked in accordance with NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response*.

7.1.2.3.2 Markings shall be visible from any direction of approach.

7.1.2.4 Piping Systems. Except as provided in 7.1.2.4.1, piping systems shall be marked in accordance with ASME A13.1, *Scheme for the Identification of Piping Systems*, or other applicable standards as follows:

- (1) Marking shall include the name of the gas and a direction of flow arrow.
- (2) Piping that is used to convey more than one gas at various times shall be marked to provide clear identification and warning of the hazard.
- (3) Markings for piping systems shall be provided at the following locations:
 - (a) At each critical process control valve
 - (b) At wall, floor, or ceiling penetrations
 - (c) At each change of direction
 - (d) At a minimum of every 6.1 m (20 ft) or fraction thereof throughout the piping run

7.1.2.4.1 Piping within gas-manufacturing plants, gas-processing plants, refineries, and similar occupancies shall be marked in an approved manner.

7.1.3 Security.

7.1.3.1 General. Compressed gas containers, cylinders, tanks, and systems shall be secured against accidental dislodgement and against access by unauthorized personnel.

7.1.3.2 Security of Areas. Storage, use, and handling areas shall be secured against unauthorized entry.

7.1.3.3 Physical Protection.

7.1.3.3.1 Compressed gas containers, cylinders, tanks, and systems that could be exposed to physical damage shall be protected.

7.1.3.3.2 Guard posts or other means shall be provided to protect compressed gas containers, cylinders, tanks, and systems indoors and outdoors from vehicular damage.

7.1.3.4 Securing Compressed Gas Containers, Cylinders, and Tanks. Compressed gas containers, cylinders, and tanks in use or in storage shall be secured to prevent them from falling or being knocked over by corraling them and securing them to a cart, framework, or a fixed object by use of a restraint, unless otherwise permitted by the following.

7.1.3.4.1 Compressed gas containers, cylinders, and tanks in the process of examination, servicing, and refilling shall not be required to be secured.

7.1.3.4.2 At cylinder-filling plants and distributors' warehouses, the nesting of cylinders shall be permitted as a means to secure cylinders.

7.1.4 Valve Protection.

7.1.4.1 General. Compressed gas container, cylinder, and tank valves shall be protected from physical damage by means of protective caps, collars, or similar devices.

7.1.4.2 Valve-Protective Caps. Where compressed gas containers, cylinders, and tanks are designed to accept valve-protective caps, the user shall keep such caps on the compressed gas containers, cylinders, and tanks at all times, except when empty, being processed, or connected for use.

7.1.4.3 Valve Outlet Caps or Plugs.

7.1.4.3.1 Gastight valve outlet caps or plugs shall be provided and in place for all full or partially full containers, cylinders, and tanks containing toxic, highly toxic, pyrophoric, or unstable reactive Class 3 or Class 4 gases that are in storage.

7.1.4.3.2 Valve outlet caps and plugs shall be designed and rated for the container service pressure.

7.1.5 Separation from Hazardous Conditions.

7.1.5.1 General.

7.1.5.1.1 Compressed gas containers, cylinders, tanks, and systems in storage or use shall be separated from materials and conditions that present exposure hazards to or from each other.

7.1.5.1.2 Compressed gas containers, cylinders, tanks, and systems in storage or use shall be separated in accordance with 7.1.5.

7.1.5.1.2.1 Paragraph 7.1.5.1.2 shall not apply to gases contained within closed piping systems, compressed gas containers, cylinders, tanks, and systems in storage or use when separated in accordance with 7.1.5.

7.1.5.2* Incompatible Materials. Gas containers, cylinders, and tanks shall be separated in accordance with Table 7.1.5.2.

7.1.5.2.1 The 6.1 m (20 ft) distance shall be permitted to be reduced without limit when separated by a barrier of noncombustible materials at least 1.5 m (5 ft) high that has a fire resistance rating of at least 0.5 hour.

7.1.5.2.2 The 6.1 m (20 ft) distance shall be permitted to be reduced to 1.5 m (5 ft) where one of the gases is enclosed in a gas cabinet or without limit where both gases are enclosed in gas cabinets.

7.1.5.2.3 Cylinders without pressure relief devices shall not be stored without separation from flammable and pyrophoric gases with pressure relief devices.

7.1.5.2.4 Spatial separation shall not be required between cylinders deemed to be incompatible that are connected to

manifolds for the purposes of filling and manufacturing procedures assuming the prescribed controls for the manufacture of gas mixtures are in place.

7.1.5.3 Clearance from Combustibles and Vegetation. Combustible waste, vegetation, and similar materials shall be kept a minimum of 3 m (10 ft) from compressed gas containers, cylinders, tanks, and systems.

(A) A noncombustible partition without openings or penetrations and extending sides not less than 457 mm (18 in.) above and to the sides of the storage area shall be permitted in lieu of the minimum distance.

(B) The noncombustible partition shall either be an independent structure or the exterior wall of the building adjacent to the storage area.

7.1.5.4 Ledges, Platforms, and Elevators. Compressed gas containers, cylinders, and tanks shall not be placed near elevators, unprotected platform ledges, or other areas where compressed gas containers, cylinders, or tanks could fall for distances exceeding one-half the height of the container, cylinder, or tank.

7.1.5.5 Temperature Extremes. Compressed gas containers, cylinders, and tanks, whether full or partially full, shall not be exposed to temperatures exceeding 52°C (125°F) or subambient (low) temperatures unless designed for use under such exposure.

7.1.5.6 Falling Objects. Compressed gas containers, cylinders, and tanks shall not be placed in areas where they are capable of being damaged by falling objects.

7.1.5.7 Heating. Compressed gas containers, cylinders, and tanks, whether full or partially full, shall not be heated by devices that could raise the surface temperature of the container, cylinder, or tank to above 52°C (125°F).

7.1.5.7.1 Electrically Powered Heating Devices. Electrical heating devices shall be in accordance with NFPA 70, *National Electrical Code*®.

7.1.5.7.2 Fail-Safe Design. Devices designed to maintain individual compressed gas containers, cylinders, or tanks at constant temperature shall be designed to be fail-safe.

7.1.5.8 Sources of Ignition. Open flames and high temperature devices shall not be used in a manner that creates a hazardous condition.

7.1.5.9 Exposure to Chemicals. Compressed gas containers, cylinders, and tanks shall not be exposed to corrosive chemicals or fumes that could damage containers, cylinders, tanks, or valve-protective caps.

7.1.5.10 Exposure to Electrical Circuits. Compressed gas containers, cylinders, and tanks shall not be placed where they could become a part of an electrical circuit.

7.1.6 Service and Repair. Service, repair, modification, or removal of valves, pressure relief devices, or other compressed gas container, cylinder, or tank appurtenances shall be performed by trained personnel and with the permission of the container owner.

7.1.7 Unauthorized Use. Compressed gas containers, cylinders, and tanks shall not be used for any purpose other than to serve as a vessel for containing the product for which it was designed.

Table 7.1.5.2 Separation of Gas Containers, Cylinders, and Tanks by Hazard Class

Gas Category	Other Gas	Unstable Reactive Class 2, Class 3, or Class 4	Corrosive	Oxidizing	Flammable	Pyrophoric	Toxic or Highly Toxic
Toxic or highly toxic	NR	6.1 m (20 ft)	6.1 m (20 ft)	6.1 m (20 ft)	6.1 m (20 ft)	6.1 m (20 ft)	—
Pyrophoric	NR	6.1 m (20 ft)	6.1 m (20 ft)	6.1 m (20 ft)	6.1 m (20 ft)	—	6.1 m (20 ft)
Flammable	NR	6.1 m (20 ft)	6.1 m (20 ft)	6.1 m (20 ft)	—	6.1 m (20 ft)	6.1 m (20 ft)
Oxidizing	NR	6.1 m (20 ft)	6.1 m (20 ft)	—	6.1 m (20 ft)	6.1 m (20 ft)	6.1 m (20 ft)
Corrosive	NR	6.1 m (20 ft)	—	6.1 m (20 ft)	6.1 m (20 ft)	6.1 m (20 ft)	6.1 m (20 ft)
Unstable reactive Class 2, Class 3, or Class 4	NR	—	6.1 m (20 ft)	6.1 m (20 ft)	6.1 m (20 ft)	6.1 m (20 ft)	6.1 m (20 ft)
Other Gas	—	NR	NR	NR	NR	NR	NR

NR = No separation required.

7.1.8 Containers, Cylinders, and Tanks Exposed to Fire. Compressed gas containers, cylinders, and tanks exposed to fire shall not be used or shipped while full or partially full until they are requalified in accordance with the pressure vessel code under which they were manufactured.

7.1.9 Leaks, Damage, or Corrosion.

7.1.9.1 Leaking, damaged, or corroded compressed gas containers, cylinders, and tanks shall be removed from service.

7.1.9.2 Leaking, damaged, or corroded compressed gas systems shall be replaced or repaired.

7.1.9.3* Handling of Containers, Cylinders, and Tanks Removed from Service. Compressed gas containers, cylinders, and tanks that have been removed from service shall be handled in an approved manner.

7.1.9.4 Leaking Systems. Compressed gas systems that are determined to be leaking, damaged, or corroded shall be repaired to a serviceable condition or shall be removed from service.

7.1.10 Surfaces.

7.1.10.1 To prevent bottom corrosion, containers, cylinders, and tanks shall be protected from direct contact with soil or surfaces where water might accumulate.

7.1.10.2 Surfaces shall be graded to prevent accumulation of water.

7.2 Storage.

7.2.1 General.

7.2.1.1 Applicability. The storage of compressed gas containers, cylinders, and tanks shall be in accordance with Section 7.2.

7.2.1.2 Upright Storage Flammable Gas in Solution and Liquefied Flammable Gas. Cylinders, containers, and tanks containing liquefied flammable gases and flammable gases in solution shall be positioned in the upright position.

7.2.1.2.1 Containers and Cylinders of Less than 5 L (1.3 Gal). Containers with a capacity of 5 L (1.3 gal) or less shall be permitted to be stored in a horizontal position.

7.2.1.2.2 Containers, Cylinders, and Tanks Designed for Horizontal Use. Containers, cylinders, and tanks designed for use in a horizontal position shall be permitted to be stored in a horizontal position.

7.2.1.2.3 Palletized Containers, Cylinders, and Tanks. Containers, cylinders, and tanks, with the exception of those containing flammable liquefied compressed gases, that are palletized for transportation purposes shall be permitted to be stored in a horizontal position.

7.2.2 Material-Specific Regulations.

7.2.2.1 Indoor Storage. Indoor storage of compressed gases shall be in accordance with the material-specific provisions of Section 7.4 through Section 7.10.

7.2.2.2 Exterior Storage.

7.2.2.2.1 General. Exterior storage of compressed gases shall be in accordance with the material-specific provisions of Section 7.4 through Section 7.10.

7.2.2.2.2 Separation. Distances from property lines, buildings, and exposures shall be in accordance with the material-specific provisions of Section 7.4 through Section 7.10.

7.3 Use and Handling.

7.3.1 General.

7.3.1.1 Applicability. The use and handling of compressed gas containers, cylinders, tanks, and systems shall be in accordance with 7.3.1.

7.3.1.2 Compressed Gas Systems. Compressed gas systems shall be designed for the intended use and shall be designed by persons competent in such design.

7.3.1.3 Controls.

7.3.1.3.1 Compressed gas system controls shall be designed to prevent materials from entering or leaving the process at an unintended time, rate, or path.

7.3.1.3.2 Automatic controls shall be designed to be fail-safe.

7.3.1.4 Piping Systems. Piping, tubing, fittings, and related components shall be designed, fabricated, and tested in accordance with the requirements of ASME B31.3, *Process Piping*, or other approved standards.

7.3.1.4.1 Integrity. Piping, tubing, pressure regulators, valves, and other apparatus shall be kept gastight to prevent leakage.

7.3.1.4.2 Backflow Prevention. Backflow prevention or check valves shall be provided when the backflow of hazardous materials could create a hazardous condition or cause the unauthorized discharge of hazardous materials.

7.3.1.5 Valves.

7.3.1.5.1 Valves utilized on compressed gas systems shall be designed for the gas or gases and pressure intended and shall be accessible.

7.3.1.5.2 Valve handles or operators for required shutoff valves shall not be removed or otherwise altered to prevent access.

7.3.1.6 Venting. Venting of gases shall be directed to an approved location.

7.3.1.7 Upright Use.

7.3.1.7.1 Compressed gas containers, cylinders, and tanks containing flammable liquefied gas, except those designed for use in a horizontal position and those compressed gas containers, cylinders, and tanks containing nonliquefied gases, shall be used in a “valve end up” upright position.

7.3.1.7.2 An upright position shall include a position in which the container, cylinder, or tank axis is inclined as much as 45 degrees from the vertical and in which the relief device is always in direct communication with the gas phase.

7.3.1.8 Inverted Use. Cylinders, containers, and tanks containing nonflammable liquefied gases shall be permitted to be used in the inverted position when the liquid phase is used.

(A) Flammable liquefied gases at processing plants shall be permitted to use this inverted position method while transfilling.

(B) The container, cylinder, or tank shall be secured, and the dispensing apparatus shall be designed for use with liquefied gas.

7.3.1.9 Containers and Cylinders of Less than 5 L (1.3 Gal). Containers or cylinders with a water volume of 5 L (1.3 gal) or less shall be permitted to be used in a horizontal position.

7.3.1.10 Transfer. Transfer of gases between containers, cylinders, and tanks shall be performed by qualified personnel using equipment and operating procedures in accordance with CGA P-1, *Safe Handling of Compressed Gases in Containers*.

7.3.1.10.1 The requirements of 7.3.1.10 shall not apply to fueling of vehicles with compressed natural gas (CNG).

7.3.1.11 Use of Compressed Gases for Inflation. Inflatable equipment, devices, or balloons shall only be pressurized or filled with compressed air or inert gases.

7.3.1.12 Emergency Shutoff Valves. Accessible manual valves, or automatic remotely activated fail-safe emergency shutoff valves shall be provided and clearly marked.

7.3.1.12.1 Emergency shutoffs shall be located at the point of use and at the tank, cylinder, or bulk source.

7.3.1.13 Excess Flow Control. Excess flow control shall be provided for compressed gases with a hazard rating in accordance with NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response*, as follows:

- (1) Health hazard Class 3 or Class 4
- (2) Flammability Class 4
- (3) Reactivity Class 3 or Class 4

7.3.1.13.1 Excess Flow Control Above 103 kPa (15 psig). Excess flow control shall be provided for pressurized gas piping systems that are pressurized above 103 kPa (15 psig) where the source of the gas exceeds the quantity threshold in Table 6.3.1.

7.3.1.13.2 Location. The location of excess flow control shall be as specified in 7.3.1.13.2(A) and 7.3.1.13.2(B).

(A) Where piping originates from a source located in a room or area, the excess flow control shall be located within the room or area.

(B) Where piping originates from a bulk source, the excess flow control shall be as close to the bulk source as possible.

7.3.1.13.3 Location Requirement Exemptions. The requirements of 7.3.1.13 shall not apply to the following:

- (1) Piping for inlet connections designed to prevent backflow
- (2) Piping for pressure relief devices
- (3) Systems containing 12.7 m³ (450 scf) of flammable gas or less

7.3.2 Material-Specific Regulations.

7.3.2.1 Indoor Use. Indoor use of compressed gases shall be in accordance with the requirements of Section 7.4 through Section 7.10.

7.3.2.2 Exterior Use.

7.3.2.2.1 General. Exterior use of compressed gases shall be in accordance with the requirements of Section 7.4 through Section 7.10.

7.3.2.2.2 Separation. Distances from property lines, buildings, and exposure hazards shall be in accordance with the material-specific provisions of Section 7.4 through Section 7.10.

7.3.3 Handling.

7.3.3.1 Applicability. The handling of compressed gas containers, cylinders, and tanks shall be in accordance with 7.3.3.

7.3.3.2 Carts and Trucks.

7.3.3.2.1 Containers, cylinders, and tanks shall be moved using an approved method.

7.3.3.2.2 Where containers, cylinders, or tanks are moved by hand cart, hand truck, or other mobile device, such carts, trucks, or devices shall be designed for the secure movement of containers, cylinders, or tanks.

7.3.3.3 Lifting Devices. Ropes, chains, or slings shall not be used to suspend compressed gas containers, cylinders, and tanks unless provisions at time of manufacture have been made on the container, cylinder, or tank for appropriate lifting attachments, such as lugs.

7.4 Medical Gas Systems. Medical gas systems for health care shall be in accordance with NFPA 99, *Standard for Health Care Facilities*.

7.5 Corrosive Gases.

7.5.1 General. The storage or use of corrosive compressed gases exceeding the quantity thresholds for gases requiring special provisions as specified in Table 6.3.1 shall be in accordance with Chapter 1 through Chapter 6, Section 7.1 through Section 7.3, and Section 7.5.

7.5.2 Distance to Exposures. The outdoor storage or use of corrosive compressed gas shall not be within 6096 mm (20 ft) of buildings, not associated with the manufacture or distribution of corrosive gases, lot lines, streets, alleys, public ways, or means of egress.

7.5.2.1 A 2-hour fire barrier wall without openings or penetrations, and extending not less than 762 mm (30 in.) above and to the sides of the storage or use area, shall be permitted in lieu of the 6096 mm (20 ft) distance.

7.5.2.1.1 The fire barrier wall shall be either an independent structure or the exterior wall of the building adjacent to the storage or use area.

7.5.2.1.2 The 2-hour fire barrier shall be located at least 1.5 m (5 ft) from any exposure.

7.5.2.1.3 The 2-hour fire barrier shall not have more than two sides at approximately 1.57-rad (90-degree) directions, or not more than three sides with connecting angles of approximately 2.36 rad (135 degrees).

7.5.3 Use of Corrosive Gases. Corrosive gases for indoor use shall be located in a gas cabinet, exhausted enclosure, or gas room.

7.6 Flammable Gases.

7.6.1 Storage, Use, and Handling.

7.6.1.1 The storage or use of flammable gases exceeding the quantity thresholds for gases requiring special provisions as specified in Table 6.3.1 shall be in accordance with Chapter 1 through Chapter 6, Section 7.1 through Section 7.3, and Section 7.6.

7.6.1.2 Storage, use, and handling of gaseous hydrogen shall be in accordance with 7.6.1 and Chapter 10.

7.6.2 Distance to Exposures. The outdoor storage or use of flammable compressed gas shall be in accordance with Table 7.6.2.

7.6.2.1 The minimum required distances shall be reduced to 1.5 m (5 ft) where protective structures having a minimum fire resistance rating of 2 hours interrupt the line of sight between the container and the exposure.

7.6.2.2 The protective structure shall be at least 1.5 m (5 ft) from the storage or use area perimeter.

7.6.2.3 The configuration of the protective structure shall be designed to allow natural ventilation to prevent the accumulation of hazardous gas concentrations.

7.6.3 Ignition Source Control. Ignition sources in areas containing flammable gases shall be in accordance with 7.6.3.

7.6.3.1 Static-Producing Equipment. Static-producing equipment located in flammable gas areas shall be grounded.

7.6.3.2 No Smoking or Open Flame. Signs shall be posted in areas containing flammable gases communicating that smoking or the use of open flame, or both, is prohibited within 7.6 m (25 ft) of the storage or use area perimeter.

Table 7.6.2 Distance to Exposures for Flammable Gases

Aggregate Quantity per Storage Area		Minimum Distance to Buildings, Streets, Alleys, Public Ways, or Lot Lines of Property That Can Be Built On		Minimum Distances Between Storage Areas	
m ³	ft ³	m	ft	m	ft
0 – 120	0 – 4,225	1.5	5	1.5	5
120.1 – 598	4,226 – 21,125	3	10	3	10
598.1 – 1435	21,126 – 50,700	4.5	15	4.5	10
1435.1 – 2393	50,701 – 84,500	6	20	4.5	10
2393.1 or greater	84,501 or greater	7.5	25	6	20

7.6.4 Electrical. Areas in which the storage or use of compressed gases exceeds the quantity thresholds for gases requiring special provisions shall be in accordance with NFPA 70, *National Electrical Code*®.

7.7 Oxidizing Gases.

7.7.1 General. The storage or use of oxidizing compressed gases exceeding the quantity thresholds for gases requiring special provisions as specified in Table 6.3.1 shall be in accordance with Chapter 1 through Chapter 6, Section 7.1 through Section 7.3, and Section 7.7.

7.7.2 Distance to Exposures. The outdoor storage or use of oxidizing compressed gas shall be in accordance with Table 7.7.2.

Table 7.7.2 Oxidizing Gases Distance from Use to Exposures

Quantity of Gas Stored (ft ³ at NTP)	Distance to a Building Not Associated with the Manufacture or Distribution of Oxidizing Gases or to a Public Way or Property Line (ft)	Distance Between Storage Areas (ft)
× 3.785 for L	× 0.3048 for m	
0 – 50,000	5	5
50,001 – 100,000	10	10
100,001 or greater	15	10

7.7.2.1 The distances shall not apply where protective structures having a minimum fire resistance of 2 hours interrupt the line of sight between the container and the exposure.

7.7.2.2 The protective structure shall be at least 1.5 m (5 ft) from the storage or use area perimeter.

7.7.2.3 The configuration of the protective structure shall allow natural ventilation to prevent the accumulation of hazardous gas concentrations.

7.8 Pyrophoric Gases.

7.8.1 General. Pyrophoric compressed gases exceeding the quantity thresholds for gases requiring special provisions as specified in Table 6.3.1 shall be stored and used in accordance with Chapter 1 through Chapter 6, Section 7.1 through Section 7.3, and Section 7.8.

7.8.2 Silane and Silane Mixtures. Silane and silane mixtures shall be stored, used, and handled in accordance with the provisions of CGA P-32, *Safe Storage and Handling of Silane and Silane Mixtures*.

7.8.3 Distance to Exposures. The outdoor storage or use of pyrophoric compressed gas shall be in accordance with Table 7.8.3.

7.8.3.1 The distances shall be allowed to be reduced to 1.5 m (5 ft) when protective structures having a minimum fire resistance of 2 hours interrupt the line of sight between the container and the exposure.

7.8.3.2 The protective structure shall be at least 1.5 m (5 ft) from the storage or use area perimeter.

7.8.3.3 The configuration of the protective structure shall allow natural ventilation to prevent the accumulation of hazardous gas concentrations.

7.9 Toxic and Highly Toxic Gases.

7.9.1 General. The storage or use of toxic and highly toxic gases exceeding the quantity thresholds for gases requiring special provisions as specified in Table 6.3.1 shall be in accordance with Chapter 1 through Chapter 6, Section 7.1 through Section 7.3, and Section 7.9.

7.9.2 Ventilation and Arrangement.

7.9.2.1 Indoors. The indoor storage or use of highly toxic gases or toxic gases shall be provided with a gas cabinet, exhausted enclosure, or gas room.

(A) Gas cabinets shall be in accordance with Section 6.18.

(B) Exhausted enclosures shall be in accordance with Section 6.19.

(C) Gas rooms shall be in accordance with Section 6.4.

7.9.2.2 Distance to Exposures. The outdoor storage or use of toxic and highly toxic compressed gases shall not be within 23 m (75 ft) of lot lines, streets, alleys, public ways or means of egress, or buildings not associated with such storage or use.

7.9.2.2.1 A 2-hour fire barrier wall without openings or penetrations, and extending not less than 762 mm (30 in.) above and to the sides of the storage or use area, that interrupts the line of sight between the storage or use and the exposure, shall be permitted in lieu of the 23-m (75-ft) distance.

7.9.2.2.1.1 The fire barrier wall shall be either an independent structure or the exterior wall of the building adjacent to the storage or use area.

7.9.2.2.1.2 The 2-hour fire barrier shall be located at least 1.5 m (5 ft) from any exposure.

7.9.2.2.1.3 The 2-hour fire barrier shall not have more than two sides at approximately 1.5-rad (90-degree) directions, or more than three sides with connecting angles of approximately 2.36 rad (135 degrees).

7.9.2.2.2 Openings in Exposed Buildings. Where the storage or use area is located closer than 23 m (75 ft) to a building not associated with the manufacture or distribution of toxic or highly toxic compressed gases, openings in the building other than for piping shall not be permitted above the height of the top of the 2-hour fire barrier wall or within 15 m (50 ft) horizontally from the storage area, regardless of whether the openings are shielded by a fire barrier.

7.9.2.3 Air Intakes. Storage and use of toxic and highly toxic compressed gases shall not be located within 23 m (75 ft) of air intakes.

7.9.3 Treatment Systems. Treatment systems, except as provided in 7.9.3.1 and 7.9.3.2, gas cabinets, exhausted enclosures, and gas rooms containing toxic or highly toxic gases shall be provided with exhaust ventilation, with all exhaust directed to a treatment system designed to process accidental release of gas.

7.9.3.1 Storage of Toxic or Highly Toxic Gases. Treatment systems shall not be required for toxic or highly toxic gases in storage where containers, cylinders, and tanks are provided with the controls specified in 7.9.3.1.1 through 7.9.3.1.3.

7.9.3.1.1 Valve Outlets Protected. Valve outlets shall be equipped with outlet plugs or caps, or both, rated for the container service pressure.

Table 7.8.3 Pyrophoric Gases Distance from Storage to Exposures

Maximum Amount per Storage Area (ft ³)	Minimum Distance between Storage Areas (ft)	Minimum Distance to Property Lines (ft)	Minimum Distance to Public Ways (ft)	Minimum Distance to Buildings on the Same Property		
				Nonrated or Openings within 25 ft	2 Hour and No Openings within 25 ft	4 Hour and No Openings within 25 ft
× 3.785 for L			× 0.3048 for m			
250	5	25	5	5	0	0
2500	10	50	10	10	5	0
7500	20	100	20	20	10	0

7.9.3.1.2 Handwheels Secured. Where provided, handwheel-operated valves shall be secured to prevent movement.

7.9.3.1.3 Containment Devices Provided. Approved cylinder containment vessels or cylinder containment systems shall be provided at an approved location.

7.9.3.2 Use of Toxic Gases. Treatment systems shall not be required for toxic gases in use where containers, cylinders, and tanks are provided with the controls specified in 7.9.3.2.1 and 7.9.3.2.2.

7.9.3.2.1 Gas Detection.

7.9.3.2.1.1 A gas detection system with a sensing interval not exceeding 5 minutes shall be provided.

7.9.3.2.1.2 The gas detection system shall monitor the exhaust system at the point of discharge from the gas cabinet, exhausted enclosure, or gas room.

7.9.3.2.2 Fail-Safe Automatic Closing Valve. An approved automatic-closing fail-safe valve shall be located immediately adjacent to and downstream of active container, cylinder, or tank valves.

(A) The fail-safe valve shall close when gas is detected at the permissible exposure limit, short-term exposure limit (STEL), or ceiling limit by the gas detection system.

(B) For attended operations a manual closing valve shall be permitted when in accordance 7.9.3.4.3.

(C) For gases used at unattended operations for the protection of public health, such as chlorine at water or wastewater treatment sites, the automatic valve shall close if the concentration of gas detected by a gas detection system reaches one-half of the IDLH.

(D) The gas detection shall also alert persons on-site and a responsible person off-site when the gas concentration in the storage/use area reaches the OSHA, PEL, OSHA ceiling limit, or STEL for the gas employed.

7.9.3.3 Treatment System Design and Performance. Treatment systems shall be capable of diluting, adsorbing, absorbing, containing, neutralizing, burning, or otherwise processing stored or used toxic or highly toxic gas, or both.

(A) Where a total containment system is used, the system shall be designed to handle the maximum anticipated pressure of release to the system when it reaches equilibrium.

(B) Treatment systems shall be capable of reducing the allowable discharge concentrations to one-half the immediately dangerous to life and health threshold at the point of discharge.

7.9.3.4 Treatment System Sizing.

7.9.3.4.1 Worst-Case Release of Gas. Treatment systems shall be sized to process the maximum worst-case release of gas based on the maximum flow rate of release from the largest vessel utilized in accordance with 7.9.3.5.

7.9.3.4.2 Largest Compressed Gas Vessel. The entire contents of the single largest compressed gas vessel shall be considered.

7.9.3.4.3 Attended Operations — Alternative Method of System Sizing.

7.9.3.4.3.1 Where source containers, cylinders, and tanks are used in attended process operations, with an operator present at the enclosure where the activity occurs, the volume of the release shall be limited to the estimated amount released from the process piping system within a period not to exceed 5 minutes.

7.9.3.4.3.2 Such process piping systems shall comply with the requirements of 7.9.3.4.3.2(A) through 7.9.3.4.3.2(E).

(A) **Local Exhaust.** All gas transfer operations shall be conducted within a zone of local exhaust that is connected to a treatment system.

(B) **Gas Detection.** Gas detection shall be used to provide a warning to alert the operators to emission of gas into the zone of local exhaust, and the following requirements also shall apply.

- (1) The system shall be capable of detecting gas at the permissible exposure limit or ceiling limit for the gas being processed.
- (2) Activation of the gas detection system shall provide a local alarm.

(C) **Process Shutdown.** Operations involving the gas detected shall be shut down and leaks repaired.

(D) **Piping System Construction.** Piping systems used to convey gases shall be of all-welded construction throughout, with the exception of fittings used to connect containers, cylinders, or tanks, or any combination thereof, to the process system.

(E) Piping systems shall be designed to provide for readily accessible manual shutdown controls.

7.9.3.5 Rate of Release. The time release shall be in accordance with Table 7.9.3.5 for the type of container indicated.

Table 7.9.3.5 Rates of Release

Container Type	Nonliquefied (minutes)	Liquefied (minutes)
Cylinders without restrictive flow orifices	5	30
Portable tanks without restrictive flow orifices	40	240
All others	Based on peak flow from maximum valve orifice	Based on peak flow from maximum valve orifice

7.9.3.6* Maximum Flow Rate of Release. For portable containers, cylinders, and tanks, the maximum flow rate of release shall be calculated based on assuming the total release from the cylinder or tank within the time specified.

7.9.3.6.1 When portable containers, cylinders, or tanks are equipped with reduced flow orifices, the worst-case rate of release

shall be determined by the maximum achievable flow from the valve determined based on the following formula:

$$\text{CFM} = (767 \times A \times P) \frac{(28.96/MW)^{1/2}}{60}$$

where:

CFM = standard cubic feet per minute of gas of concern under flow conditions.

A = area of orifice in square inches. (See Table A.7.9.3.6 for areas of typical restricted flow orifices.)

P = supply pressure of gas at NTP in pounds per square inch absolute.

MW = molecular weight. For mixtures the average of molecular weights shall be used.

7.9.4 Leaking Containers, Cylinders, and Tanks. When containers, cylinders, or tanks are used outdoors, in excess of the quantities specified in the column for unsprinklered areas (unprotected by gas cabinets or exhausted enclosures) in Table 6.3.1, a gas cabinet, exhausted enclosure, or containment vessel or system shall be provided to control leaks from leaking containers, cylinders, and tanks in accordance with 7.9.4.1 through 7.9.4.2.3.

7.9.4.1 Gas Cabinets or Exhausted Enclosures. Where gas cabinets or exhausted enclosures are provided to handle leaks from containers, cylinders, or tanks, exhaust ventilation shall be provided that is directed to a treatment system in accordance with the provisions of 7.9.3.

7.9.4.2 Containment Vessels or Systems. Where containment vessels or containment systems are provided, they shall comply with the requirements of 7.9.4.2.1 through 7.9.4.2.3.

7.9.4.2.1 Performance. Containment vessels or containment systems shall be capable of fully containing or terminating a release.

7.9.4.2.2 Personnel. Trained personnel capable of operating the containment vessel or containment system shall be available at an approved location.

7.9.4.2.3 Location. Containment vessels or systems shall be capable of being transported to the leaking cylinder, container, or tank.

7.9.5 Emergency Power.

7.9.5.1 General. Emergency power shall comply with the requirements of 7.9.5 in accordance with NFPA 70, *National Electrical Code*®.

7.9.5.2 Alternative to Emergency Power. Emergency power shall not be required where fail-safe engineering is provided for mechanical exhaust ventilation, treatment systems, and temperature control, and standby power is provided to alternative systems that utilize electrical energy.

7.9.5.3 Where Required. Emergency power shall be provided for the following systems:

- (1) Exhaust ventilation
- (2) Treatment system
- (3) Gas detection system
- (4) Temperature control system
- (5) Fire alarm system
- (6) Emergency alarm system

7.9.5.4 Level. Emergency power systems shall comply with the requirements for a Level 2 system in accordance with NFPA 110, *Standard for Emergency and Standby Power Systems*.

7.9.6 Gas Detection. Except as provided in 7.9.6.1, a continuous gas detection system in accordance with the requirements of 7.9.6.2 through 7.9.6.6 shall be provided for the indoor storage or use of toxic or highly toxic compressed gases.

7.9.6.1 Where Gas Detection Is Not Required. A gas detection system shall not be required for toxic gases where the physiological properties for the gas are at a level below the accepted permissible exposure limit or ceiling limit for the gas.

7.9.6.2 Local Alarm. The gas detection system shall initiate a local alarm that is both audible and visible.

7.9.6.3 Alarm Monitored. The gas detection system shall transmit a signal to a constantly attended control station for quantities exceeding one toxic or one highly toxic compressed gas cylinder.

7.9.6.4 Automatic Shutdown. Activation of the gas detection system shall automatically shut off the flow of gas related to the system being monitored.

7.9.6.4.1 An automatic shutdown shall not be required for reactors utilized for the production of toxic or highly toxic gases when such reactors are operated at pressures less than 103.4 kPa (15 psig) (29.7 psia), constantly attended, and provided with readily accessible emergency shutoff valves.

7.9.6.5 Detection Points. Detection shall be provided at the locations specified in 7.9.6.5.1 through 7.9.6.5.4.

7.9.6.5.1 Treatment System Discharge. Detection shall be provided at the discharge from the treatment system.

7.9.6.5.2 Point of Use. Detection shall be provided in the room or area in which the gas is used.

7.9.6.5.3 Source. Detection shall be provided at the source container, cylinder, or tank used for delivery of the gas to the point of use.

7.9.6.5.4 Storage. Detection shall be provided in the room or area in which the gas is stored.

7.9.6.6 Level of Detection. The gas detection system shall detect the presence of gas at or below the permissible exposure limit or ceiling limit of the gas for those points identified in 7.9.6.5.2 and 7.9.6.5.3, and at not less than one-half the immediately dangerous to life and health (IDLH) level for those points identified in 7.9.6.5.1.

7.9.7 Automatic Smoke Detection System. An automatic fire detection system shall be provided for the indoor storage or use of highly toxic compressed gases in accordance with NFPA 72®, *National Fire Alarm Code*®.

7.10 Unstable Reactive Gases (Nondetonable). The storage or use of unstable reactive (nondetonable) gases exceeding the quantity thresholds for gases requiring special provisions as specified in Table 6.3.1 shall be in accordance with Chapter 1 through Chapter 6, Section 7.1 through Section 7.3, and Section 7.10.

7.10.1 Distances to Exposures for Class 2. The outdoor storage or use of unstable reactive Class 2 compressed gas shall not be within 23 m (75 ft) of buildings, lot lines, streets, alleys, or public ways or means of egress.

7.10.1.1 A 2-hour fire barrier wall without openings or penetrations, and extending not less than 762 mm (30 in.) above

and to the sides of the storage or use area, shall be permitted in lieu of the 23-m (75-ft) distance.

7.10.1.1.1 The fire barrier wall either shall be an independent structure or the exterior wall of the building.

7.10.1.1.2 The 2-hour fire barrier shall be located at least 1.5 m (5 ft) from any exposure.

7.10.1.1.3 The 2-hour fire barrier shall not have more than two sides at approximately 1.57-rad (90-degree) directions, or not more than three sides with connecting angles of approximately 2.36 rad (135 degrees).

7.10.2 Distances to Exposures for Class 3. The outdoor storage or use of unstable reactive Class 3 (nondetonable) compressed gas shall not be within 23 m (75 ft) of buildings, lot lines, streets, alleys, or public ways or means of egress.

7.10.2.1 A 2-hour fire barrier wall without openings or penetrations, and extending not less than 762 mm (30 in.) above and to the sides of the storage or use area, that interrupts the line of sight between the storage or use and the exposure shall be permitted in lieu of the 23-m (75-ft) distance.

7.10.2.1.1 The fire barrier wall either shall be an independent structure or the exterior wall of the building adjacent to the storage or use area.

7.10.2.1.2 The 2-hour fire barrier shall be located at least 1.5 m (5 ft) from any exposure.

7.10.2.1.3 The 2-hour fire barrier shall not have more than two sides at approximately 1.57-rad (90-degree) directions, or more than three sides with connecting angles of approximately 2.36 rad (135 degrees).

7.10.2.1.4 The fire barrier either shall be an independent structure or the exterior wall of the building adjacent to the storage or use area.

7.10.3 Storage Configuration. Unstable reactive Class 3 compressed gases stored in cylinders, containers, or tanks shall be arranged to limit individual groups of cylinders, containers, or tanks to areas not exceeding 9.3 m² (100 ft²). Multiple areas shall be separated by aisles. Aisle widths shall not be less than the height of the cylinders, containers, or tanks or 1219 mm (4 ft), whichever is greater.

7.10.4 Basements. Unstable reactive compressed gases shall not be stored in basements.

7.10.5 Unstable Reactive Gases (Detonable).

7.10.5.1 Storage or Use. The storage or use of unstable reactive (detonable) gases exceeding the quantity thresholds for gases requiring special provisions as specified in Table 6.3.1 shall be in accordance with Chapter 1 through Chapter 6, Section 7.1 through Section 7.3, and 7.10.5.

7.10.5.2 Location. The location of storage areas shall be determined based on the requirements of the building code for explosive materials.

Chapter 8 Cryogenic Fluids

8.1 General. Storage, use, and handling of cryogenic fluids shall be in accordance with Chapter 1 through Chapter 6 and Chapter 8.

8.1.1 Containers with Residual Contents. Partially full containers having residual cryogenic fluids shall be considered as full for the purposes of the controls required.

8.2 Containers — Design and Construction. Containers employed for the storage or use of cryogenic fluids shall be designed, fabricated, tested, and marked (stamped) in accordance with regulations of DOT, Transport Canada (TC) *Transportation of Dangerous Goods Regulations*, or the ASME *Boiler and Pressure Vessel Code*, "Rules for the Construction of Unfired Pressure Vessels," Section VIII.

8.2.1 Nonstandard Containers.

8.2.1.1 Containers, equipment, and devices that are not in compliance with recognized standards for design and construction shall be permitted if approved by the authority having jurisdiction upon presentation of evidence that they are designed and constructed for safe operation.

8.2.1.2 The following data shall be submitted to the authority having jurisdiction with reference to the deviation from the standard with the application for approval:

- (1) Type and use of container, equipment, or device
- (2) Material to be stored, used, or transported
- (3) Description showing dimensions and materials used in construction
- (4) Design pressure, maximum operating pressure, and test pressure
- (5) Type, size, and setting of pressure-relief devices

8.2.2 Concrete Containers.

8.2.2.1 Concrete containers shall be built in accordance with the building code.

8.2.2.2 Barrier materials and membranes used in connection with concrete, but not functioning structurally, shall be materials prescribed by nationally recognized standards.

8.2.3 Foundations and Supports. Stationary tanks shall be provided with concrete or masonry foundations or structural steel supports on firm concrete or masonry foundations and the following requirements also shall apply.

8.2.3.1 Stationary tanks shall be supported to prevent the concentration of excessive loads on the supporting portion of the shell.

8.2.3.2 Foundations for horizontal containers shall be constructed to accommodate expansion and contraction of the container.

8.2.3.3 Foundations shall be provided to support the weight of vaporizers and/or heat exchangers.

8.2.3.4 Temperature Effects. Where drainage systems, terrain, or surfaces beneath stationary tanks are arranged in a manner that can subject stationary tank foundations or supports to temperatures below -90°C (-130°F), the foundations or supports shall be constructed of materials that are capable of withstanding the low-temperature effects of cryogenic fluid spillage.

8.2.3.5 Corrosion Protection. Portions of stationary tanks in contact with foundations or saddles shall be painted to protect against corrosion.

8.2.4 Pressure-Relief Devices.

8.2.4.1 General.

8.2.4.1.1 Pressure-relief devices shall be provided to protect containers and systems containing cryogenic fluids from rupture in the event of overpressure.

8.2.4.1.2 Pressure-relief devices shall be designed in accordance with CGA S-1.2, *Pressure Relief Device Standards – Part 2 – Cargo and Portable Tanks for Compressed Gases*, for portable tanks and CGA S-1.3, *Pressure Relief Device Standards – Part 3 – Stationary Storage Containers for Compressed Gases*, for stationary tanks.

8.2.4.2 Containers Open to the Atmosphere. Portable containers that are open to the atmosphere, and are designed to contain cryogenic fluids at atmospheric pressure shall not be required to be equipped with pressure-relief devices.

8.2.4.3 Equipment Other than Containers. Heat exchangers, vaporizers, insulation casings surrounding containers, vessels, and coaxial piping systems in which liquefied cryogenic fluids could be trapped due to leakage from the primary container shall be provided with a pressure-relief device.

8.2.4.4 Sizing.

8.2.4.4.1 Pressure-relief devices shall be sized in accordance with the specifications to which the container was fabricated.

8.2.4.4.2 The pressure-relief device shall have the capacity to prevent the maximum design pressure of the container or system from being exceeded.

8.2.4.5 Accessibility. Pressure-relief devices shall be located such that they are accessible for inspection and repair.

8.2.4.6 Arrangement.

8.2.4.6.1 Pressure-Relief Devices. Pressure-relief devices shall be arranged to discharge unobstructed to the open air in such a manner as to prevent impingement of escaping gas on personnel, containers, equipment, and adjacent structures or to enter enclosed spaces.

8.2.4.6.2 Portable Containers with Volume Less than 0.057 m³ (2 ft³).

8.2.4.6.2.1 The arrangement of the discharge from pressure-relief devices from DOT specified containers with an internal water volume of 2.0 ft³ (0.057 m³) or less shall be incorporated in the design of the container.

8.2.4.6.2.2 Additional safeguards regarding placement or arrangement shall not be required.

8.2.4.7 Shutoffs Between Pressure-Relief Devices and Containers.

8.2.4.7.1 General. Shutoff valves installed between pressure-relief devices and containers shall be in accordance with 8.2.4.7.

8.2.4.7.2 Location. Shutoff valves shall not be installed between pressure-relief devices and containers unless the valves or their use meets the requirements of 8.2.4.7.2.1 or 8.2.4.7.2.2.

8.2.4.7.2.1 Security. Shutoff valves shall be of a locking type and their use shall be limited to service-related work performed by the supplier under the requirements of the ASME *Boiler and Pressure Vessel Code*.

8.2.4.7.2.2 Multiple Pressure-Relief Devices. Shutoff valves controlling multiple pressure-relief devices on a container shall be installed so that either the type of valve installed or the arrangement provides the full required flow through the minimum number of required relief devices at all times.

8.2.4.8 Temperature Limits. Pressure-relief devices shall not be subjected to cryogenic fluid temperatures except when operating.

8.3 Pressure-Relief Vent Piping.

8.3.1 General. Pressure-relief vent piping systems shall be constructed and arranged to direct the flow of gas to a safe location and in accordance with Section 8.3.

8.3.2 Sizing. Pressure-relief device vent piping shall have a cross-sectional area not less than that of the pressure-relief device vent opening and shall be arranged so as not to restrict the flow of escaping gas.

8.3.3 Arrangement. Pressure-relief device vent piping and drains in vent lines shall be arranged so that escaping gas discharges unobstructed to the open air and does not impinge on personnel, containers, equipment, and adjacent structures or enter enclosed spaces.

8.3.4 Installation. Pressure-relief device vent lines shall be installed in a manner that excludes or removes moisture and condensation to prevent malfunction of the pressure-relief device due to freezing or ice accumulation.

8.3.5 Overfilling. Controls shall be provided to prevent overfilling of stationary containers.

8.4 Marking.

8.4.1 General. Cryogenic containers and systems shall be marked in accordance with nationally recognized standards and in accordance with Section 8.4.

8.4.1.1 Portable Containers. Portable cryogenic containers shall be marked in accordance with CGA C-7, *Guide to the Preparation of Precautionary Labeling and Marking of Compressed Gas Containers*.

8.4.1.2 Stationary Tanks. Stationary tanks shall be marked in accordance with NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response*.

8.4.1.3 Identification Signs. Visible hazard identification signs shall be provided in accordance with NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response* at entrances to buildings or areas in which cryogenic fluids are stored, handled, or used.

8.4.2 Identification of Contents. Stationary containers shall be placarded with the identity of their contents to indicate the name of the material contained.

8.4.3 Container Specification. Stationary containers shall be marked with the manufacturing specification and maximum allowable working pressure on a permanent nameplate.

(A) The nameplate shall be installed on the container in an accessible location.

(B) The nameplate shall be marked in accordance with nationally recognized standards.

8.4.4 Identification of Container Connections.

8.4.4.1 Container inlet and outlet connections, liquid-level limit controls, valves, and pressure gauges shall be identified using one of the following methods.

(A) They shall be marked with a permanent tag or label identifying their function.

(B) They shall be identified by a schematic drawing that indicates their function and designates whether they are connected to the vapor or liquid space of the container.

8.4.4.2 When a schematic drawing is provided it shall be attached to the container and maintained in a legible condition.

8.4.5 Identification of Piping Systems. Piping systems shall be identified in accordance with ASME A13.1, *Scheme for the Identification of Piping Systems*.

8.4.6 Identification of Emergency Shutoff Valves. Emergency shutoff valves on stationary containers shall be identified, visible, and indicated by means of a sign.

8.5 Security.

8.5.1 General. Cryogenic containers and systems shall be secured against accidental dislodgement and against access by unauthorized personnel in accordance with Section 8.5.

8.5.2 Security of Areas. Areas used for the storage of containers and systems shall be secured against unauthorized entry.

8.5.3 Securing of Containers. Stationary containers shall be secured to foundations in accordance with the building code.

(A) Portable containers subject to shifting or upset shall be secured.

(B) Nesting shall be permitted as a means of securing portable containers.

8.5.4 Securing of Vaporizers. Vaporizers, heat exchangers, and similar equipment shall be secured to foundations, and their connecting piping shall be designed and constructed to provide for the effects of expansion and contraction due to temperature changes.

8.5.5 Physical Protection. Containers, piping, valves, pressure-relief devices, regulating equipment, and other appurtenances shall be protected against physical damage and against tampering.

8.6 Separation from Hazardous Conditions.

8.6.1 General. Cryogenic containers and systems in storage or use shall be separated from materials and conditions that present exposure hazards to or from each other in accordance with Section 8.6.

8.6.2 Stationary Cryogenic Containers. Stationary containers located outdoors shall be separated from exposure hazards in accordance with the minimum separation distances indicated in Table 8.6.2.

8.6.2.1 Point of Fill Connections. Remote transfer points and fill connection points shall not be positioned closer to exposures than the minimum distances required for stationary containers as indicated in Table 8.6.2.

8.6.2.2 Surfaces Beneath Containers. The surface of the area on which stationary containers are placed, including the surface of the area located below the point at which connections are made for the purpose of filling such containers, shall be compatible with the fluid in the container.

8.6.3 Portable Cryogenic Containers.

8.6.3.1 Separation from Exposure Hazards. Portable containers located outdoors shall be separated from exposure hazards in accordance with Table 8.6.3.

Table 8.6.2 Minimum Separation Distance Between Stationary Cryogenic Containers and Exposures

Exposure	Minimum Distance	
	m	ft
Buildings, regardless of construction type	0.3	1
Wall openings	0.3	1
Air intakes	3.1	10
Property lines	1.5	5
Places of public assembly	15	50
Nonambulatory patient areas	15	50
Combustible materials, such as paper, leaves, weeds, dry grass, or debris	4.5	15
Incompatible hazardous materials	6.1	20

Table 8.6.3 Minimum Separation Distance Between Portable Cryogenic Containers and Exposures

Exposure	Minimum distance	
	m	ft
Building exits	3.1	10
Wall openings	3.1	10
Air intakes	3.1	10
Property lines	1.5	5
Room or area exits	0.9	3
Combustible materials, such as paper, leaves, weeds, dry grass, or debris	4.5	15
Incompatible hazardous materials	6.1	20

8.6.3.2 Surfaces Beneath Containers. The surface of the area on which portable containers are placed, including the surface of the area located below the point at which connections are made for the purpose of filling such containers, shall be compatible with the fluid in the container.

8.7 Electrical Wiring and Equipment.

8.7.1 General. Electrical wiring and equipment shall be in accordance with NFPA 70, *National Electrical Code*[®], and Section 8.7.

8.7.2 Location. Containers and systems shall not be located where they could become part of an electrical circuit.

8.7.3 Electrical Ground and Bonding. Containers and systems shall not be used for electrical grounding.

(A) When electrical grounding and bonding is required, the system shall be in accordance with NFPA 70, *National Electrical Code*[®].

(B) The grounding system shall be protected against corrosion, including corrosion caused by stray electric currents.

8.8 Service and Repair. Service, repair, modification, or removal of valves, pressure-relief devices, or other container appurtenances shall be in accordance with nationally recognized standards.

8.8.1 Containers. Containers that have been removed from service shall be handled in an approved manner.

8.8.2 Systems. Service and repair of containers or systems shall be performed by trained personnel in accordance with nationally recognized standards and with the permission of the container owner.

8.9 Unauthorized Use. Containers shall not be used for any purpose other than to serve as a vessel for containing the product for which it is designed.

8.10 Leaks, Damage, and Corrosion.

8.10.1 Leaking, damaged, or corroded containers shall be removed from service.

8.10.2 Leaking, damaged, or corroded systems shall be replaced, repaired, or removed from service.

8.11 Lighting. Where required by the authority having jurisdiction, lighting, including emergency lighting, shall be provided for fire appliances and operating facilities such as walkways, control valves, and gates ancillary to stationary containers.

8.12 Storage.

8.12.1 Indoor Storage.

8.12.1.1 Installation. Stationary containers indoors shall be installed in accordance with Chapter 9 and Chapter 11, or CGA P-18, *Standard for Bulk Inert Gas Systems at Consumer Sites*.

8.12.1.2 Stationary Containers. Stationary containers shall be in accordance with Section 8.2.

8.12.1.3 Cryogenic Fluids. Cryogenic fluids in stationary or portable containers stored indoors shall be stored in buildings, rooms, or areas constructed in accordance with the building code.

8.12.1.4 Ventilation. Ventilation shall be in accordance with Section 6.17.

8.12.2 Outdoor Storage.

8.12.2.1 General. Cryogenic fluids in stationary or portable containers stored outdoors shall be in accordance with 8.12.2.

8.12.2.2 Diked Areas Containing Other Hazardous Materials. Containers of cryogenic fluids shall not be located within diked areas with other hazardous materials.

8.12.2.3 Areas Subject to Flooding. Stationary containers located in areas subject to flooding shall be securely anchored or elevated to prevent the containers from separating from foundations or supports.

8.12.2.4 Drainage.

8.12.2.4.1 The area surrounding stationary and portable containers shall be provided with a means to prevent accidental discharge of fluids from endangering personnel, containers, equipment, and adjacent structures and from entering enclosed spaces. The stationary container shall not be placed where spilled or discharged fluids will be retained around the container.

8.12.2.4.2 The provisions of 8.12.2.4.2 shall be permitted to be altered or waived where the authority having jurisdiction determines that the container does not constitute a hazard after consideration of special features such as the following:

- (1) Crushed rock utilized as a heat sink
- (2) Topographical conditions
- (3) Nature of occupancy
- (4) Proximity to structures on the same or adjacent property
- (5) Capacity and construction of containers and character of fluids to be stored

8.13 Use and Handling.

8.13.1 General. Use and handling of containers and systems shall be in accordance with Section 8.13.

8.13.1.1 Design.

8.13.1.1.1 Cryogenic fluid systems shall be designed for the use intended.

8.13.1.1.2 Where nationally recognized good practices or standards have been established for the process employed, such practices and standards shall be followed.

8.13.1.2 Piping Systems. Piping and tubing conveying cryogenic fluids, including valves, joints, and fittings, shall be installed in accordance with nationally recognized standards and shall be in accordance with 8.13.1.2.

8.13.1.2.1 Design and Construction.

8.13.1.2.1.1 Piping systems shall be designed for the use intended through the full range of pressure and temperature to which they will be subjected.

8.13.1.2.1.2 Piping systems shall be designed and constructed to allow for expansion, contraction, vibration, settlement, and fire exposure.

8.13.1.2.2 Joints. Joints on container piping and tubing shall be threaded, welded, silver-brazed, or flanged.

8.13.1.2.3 Valves and Accessory Equipment. Valves and accessory equipment shall be acceptable for the intended use at the temperatures of the application and shall be designed and constructed to withstand the maximum pressure at the minimum temperature to which they will be subjected.

8.13.1.2.4 Shutoff Valves on Containers. Shutoff valves shall be provided on all container connections, except for pressure-relief devices.

(A) Shutoff valves for containers with multiple pressure-relief devices shall be permitted in accordance with 8.2.4.7.

(B) Shutoff valves shall be accessible and located as close as practical to the container.

8.13.1.2.5 Shutoff Valves on Piping.

8.13.1.2.5.1 Shutoff valves shall be installed in piping containing cryogenic fluids where needed to limit the volume of liquid discharged in the event of piping or equipment failure.

8.13.1.2.5.2 Pressure-relief valves shall be installed where liquid can be trapped between shutoff valves in the piping system. (See 8.2.4.)

8.13.1.2.6 Physical Protection and Support.

8.13.1.2.6.1 Aboveground piping systems shall be supported and protected from physical damage.

8.13.1.2.6.2 Piping passing through walls shall be protected from mechanical damage.

8.13.1.2.7 Corrosion Protection. Aboveground piping that is subject to corrosion shall be protected against corrosion. Belowground piping shall be protected against corrosion.

8.13.1.2.8 Testing.

8.13.1.2.8.1 Piping systems shall be tested and proven free of leaks after installation as required by the standards to which they are designed and constructed.

8.13.1.2.8.2 Test pressures shall not be less than 150 percent of the maximum allowable working pressure when hydraulic testing is conducted or 110 percent when testing is conducted pneumatically.

8.13.2 Material-Specific Requirements.

8.13.2.1 Indoor Use. Indoor use of cryogenic fluids shall be in accordance with the material-specific provisions of Chapter 9 and Chapter 11, or CGA P-18, *Standard for Bulk Inert Gas Systems at Consumer Sites*, and 8.13.2.

8.13.2.2 Outdoor Use.

8.13.2.2.1 General. Outdoor use of cryogenic fluids shall be in accordance with the material-specific provisions of Chapter 9 and Chapter 11 or CGA P-18, *Standard for Bulk Inert Gas Systems at Consumer Sites*, and 8.13.2.2.

8.13.2.2.2 Separation. Distances from property lines, buildings, and exposure hazards shall be in accordance with Table 8.6.2 and Table 8.6.3 and the material-specific provisions of Chapter 9 and Chapter 11 or CGA P-18, *Standard for Bulk Inert Gas Systems at Consumer Sites*.

8.13.2.2.3 Shutoff Valves.

8.13.2.2.3.1 Shutoff valves shall be provided to shut off the cryogenic fluid supply in case of emergency.

8.13.2.2.3.2 A shutoff valve shall be located at the source of supply and at the point where the system enters the building.

8.13.2.3 Filling and Dispensing.

8.13.2.3.1 General. Filling and dispensing of cryogenic fluids shall be in accordance with 8.13.2.3.

8.13.2.3.2 Dispensing Areas. Dispensing of cryogenic fluids associated with physical or health hazards shall be conducted in approved locations.

(A) Indoor Dispensing Areas. Dispensing indoors shall be conducted in areas constructed in accordance with the building code.

(B) Ventilation. Indoor areas in which cryogenic fluids are dispensed shall be ventilated in accordance with the requirements of Section 6.17 and the mechanical code.

(C) Piping Systems. Piping systems utilized for filling or dispensing of cryogenic fluids shall be designed and constructed in accordance with 8.13.1.2.

8.13.2.3.3 Vehicle Loading and Unloading Areas. Loading or unloading areas shall be constructed in accordance with the requirements of Chapter 9 and Chapter 11 or CGA P-18, *Standard for Bulk Inert Gas Systems at Consumer Sites*.

8.13.2.3.4 Overfilling. Controls shall be provided to prevent overfilling of stationary containers during filling operations.

8.13.2.4 Handling.

8.13.2.4.1 Applicability. Handling of cryogenic containers shall be in accordance with 8.13.2.4.

8.13.2.4.2 Carts and Trucks.

8.13.2.4.2.1 Cryogenic containers shall be moved using an approved method.

8.13.2.4.2.2 Where cryogenic containers are moved by hand cart, hand truck, or other mobile device, such a device shall be designed for the secure movement of the container.

8.13.2.4.3 Design. Carts and trucks used to transport cryogenic containers shall be designed to provide a stable base for the commodities to be transported and shall have a means of restraining containers to prevent accidental dislodgement.

8.13.2.4.4 Closed Containers.

8.13.2.4.4.1 Pressurized containers shall be closed while transported.

8.13.2.4.4.2 Containers designed for use at atmospheric conditions shall be transported with appropriate loose-fitting covers in place to prevent spillage.

Chapter 9 Bulk Oxygen Systems (Reserved for Chapters 2-4 and annex material of NFPA 50)

Chapter 10 Gaseous Hydrogen Systems (Reserved for Chapters 2-6 and annex material of NFPA 50A)

Chapter 11 Liquefied Hydrogen Systems (Reserved for Chapters 2-7 and annex material of NFPA 50B)

Annex A Explanatory Material

Annex A is not a part of the requirements of this NFPA document but is included for informational purposes only. This annex contains explanatory material, numbered to correspond with the applicable text paragraphs.

A.1.1.2(1) For regulations on the transportation of gases, see 49 CFR 100 to 179 (Transportation) and *Transportation of Dangerous Goods Regulations* of Transport Canada.

A.1.1.2(7) For information, see NFPA 52, *Compressed Natural Gas (CNG) Vehicular Fuel Systems Code*, or NFPA 58, *Liquefied Petroleum Gas Code*.

A.1.1.2(8) The storage of gases outside of laboratory work areas is covered by this standard.

A.1.2 Reference is made to other material-specific standards published by NFPA when appropriate. The material-specific standards are limited in number, and controls are focused on select materials through the use of these standards. On the other hand, NFPA 55 is intended to be a generic standard and applicable to all materials when found in the gaseous or cryogenic state.

A.3.2.1 Approved. The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

A.3.2.2 Authority Having Jurisdiction (AHJ). The phrase “authority having jurisdiction,” or its acronym AHJ, is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

A.3.2.4 Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation; some organizations do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

A.3.3.16 Exhausted Enclosure. Such enclosures include laboratory hoods, exhaust fume hoods, and similar appliances and equipment used to retain and exhaust locally the gases, fumes, vapors, and mists that could be released. Rooms or areas provided with general ventilation, in and of themselves, are not exhausted enclosures.

A.3.3.17.1 Compressed Gas. The states of a compressed gas are categorized as follows:

- (1) Nonliquefied compressed gases are gases, other than those in solution, that are in a packaging under the charged pressure and are entirely gaseous at a temperature of 20°C (68°F).
- (2) Liquefied compressed gases are gases that, in a packaging under the charged pressure, are partially liquid at a temperature of 20°C (68°F).
- (3) Compressed gases in solution are nonliquefied gases that are dissolved in a solvent.
- (4) Compressed gas mixtures consist of a mixture of two or more compressed gases contained in a packaging, the hazard properties of which are represented by the properties of the mixture as a whole.

A.3.3.17.3 Flammable Gas. The degrees of hazard are ranked according to ease, rate, and quantity of energy release of the material in pure or commercial form detailed in Table A.3.3.17.3.

A.3.3.17.13 Unstable Reactive Gas. Unstable reactive materials are subdivided into five classifications. Class 4 materials are

materials that in themselves are readily capable of detonation or explosive decomposition or explosive reaction at normal temperatures and pressures, which include the following:

- (1) Materials that are sensitive to localized thermal or mechanical shock at normal temperatures and pressures
- (2) Materials that have an instantaneous power density (product of heat of reaction and reaction rate) at 250°C (482°F) of 1000 W/mL or greater

Class 3 materials are materials that in themselves are capable of detonation or explosive decomposition or explosive reaction but require a strong initiating source or heat under confinement before initiation. Class 3 materials include the following:

- (1) Materials that have an instantaneous power density (product of heat of reaction and reaction rate) at 250°C (482°F) at or above 100 W/mL and below 1000 W/mL
- (2) Materials that are sensitive to thermal or mechanical shock at elevated temperatures and pressures
- (3) Materials that react explosively with water without requiring heat or confinement

Class 2 materials are materials that readily undergo violent chemical change at elevated temperatures and pressures, including the following:

- (1) Materials that have an instantaneous power density (product of heat of reaction and reaction rate) at 250°C (482°F) at or above 10 W/mL and below 100 W/mL
- (2) Materials that react violently with water or form potentially explosive mixtures with water

Class 1 materials are materials that in themselves are normally stable but that can become unstable at elevated temperatures and pressures, including the following:

- (1) Materials that have an instantaneous power density (product of heat of reaction and reaction rate) at 250°C (482°F) at or above 0.01 W/mL and below 10 W/mL
- (2) Materials that react vigorously with water, but not violently
- (3) Materials that change or decompose on exposure to air, light, or moisture

Class 0 materials are materials that in themselves are normally stable, even under fire conditions, including the following:

- (1) Materials that have an instantaneous power density (product of heat of reaction and reaction rate) at 250°C (482°F) below 0.01 W/mL
- (2) Materials that do not react with water
- (3) Materials that do not exhibit an exotherm at temperatures less than or equal to 500°C (932°F) when tested by differential scanning calorimetry

A.3.3.18 Gas Cabinet. Doors and access ports for exchanging cylinders and accessing pressure-regulating controls are permitted to be included as part of a gas cabinet.

A.3.3.20 Gas Room. Gas rooms must be constructed and utilized in accordance with Section 6.4.

A.3.3.22 Hazard Rating. The criteria for hazard rating are as defined in NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response*.

A.3.3.23 Immediately Dangerous to Life and Health (IDLH). This level is established by the National Institute for Occupational Safety and Health (NIOSH). If adequate data do not exist for precise establishment of IDLH data, an independent certified industrial hygienist, industrial toxicologist, or appropriate regulatory agency should make such determination.

Table A.3.3.17.3 Degrees of Instability Hazards

Degree of Hazard	Criteria
4 — Materials that in themselves are readily capable of detonation or explosive decomposition or explosive reaction at normal temperatures and pressures	Materials that are sensitive to localized thermal or mechanical shock at normal temperatures and pressures Materials that have an instantaneous power density (product of heat of reaction and reaction rate) at 250°C (482°F) of 1000 W/mL or greater
3 — Materials that in themselves are capable of detonation or explosive decomposition or explosive reaction, but that require a strong initiating source or that must be heated under confinement before initiation	Materials that have an instantaneous power density (product of heat of reaction and reaction rate) at 250°C (482°F) at or above 100 W/mL and below 1000 W/mL Materials that are sensitive to thermal or mechanical shock at elevated temperatures and pressures
2 — Materials that readily undergo violent chemical change at elevated temperatures and pressures	Materials that have an instantaneous power density (product of heat of reaction and reaction rate) at 250°C (482°F) at or above 10 W/mL and below 100 W/mL
1 — Materials that in themselves are normally stable, but that can become unstable at elevated temperatures and pressures	Materials that have an instantaneous power density (product of heat of reaction and reaction rate) at 250°C (482°F) at or above 0.01 W/mL and below 10 W/mL
0 — Materials that in themselves are normally stable, even under fire conditions	Materials that have an instantaneous power density (product of heat of reaction and reaction rate) at 250°C (482°F) below 0.01 W/mL Materials that do not exhibit an exotherm at temperatures less than or equal to 500°C (932°F) when tested by differential scanning calorimetry

A.3.3.24.2 Permissible Exposure Limit (PEL). The maximum permitted time-weighted average exposures to be utilized are those published in 29 CFR 1910.1000.

A.3.3.24.3 Short-Term Exposure Limit (STEL). STEL limits are published in 29 CFR 1910.1000.

A.3.3.33.1 Compressed Gas System. A compressed gas system can consist of a compressed gas container or containers, reactors, and appurtenances, including pumps, compressors, and connecting piping and tubing.

A.3.3.34.1 Portable Tank. A portable tank does not include any cylinder having less than 453.5-kg (1000-lb) water capacity, cargo tank, tank car tank, or trailers carrying cylinders of over 453.5-kg (1000-lb) water capacity.

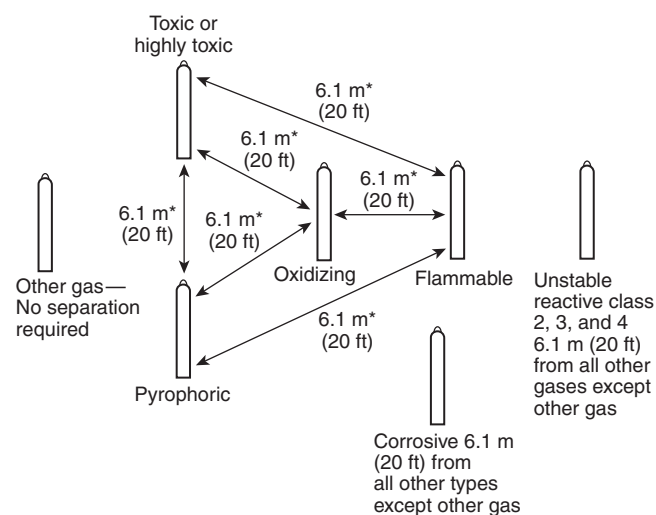
A.3.3.34.2 Stationary Tank. A stationary tank does not include a cylinder having less than 453.5-kg (1000-lb) water capacity.

A.6.10 NFPA 68, *Guide for Venting of Deflagrations*, provides information on this subject.

A.6.11 The intent of this section is to require a water-based fire extinguishing system to keep vessels containing compressed gases cool in the event of an exposure fire, thereby minimizing the likelihood of a release and associated consequences. Accordingly, alternative fire extinguishing systems, such as dry-chemical or gaseous agent systems, should not be substituted.

A.7.1.5.2 Figure A.7.1.5.2 is a schematic showing the separation distances required under 7.1.5.2.

A.7.1.9.3 The gas supplier should be consulted for advice under these circumstances.



* The 6.1-m (20-ft) distance may be reduced without limit when separated by a barrier of noncombustible materials at least 1.5 m (5 ft) high that has a fire-resistant rating of at least ½ hour.

FIGURE A.7.1.5.2 Separation of Gas Cylinders by Hazard.

A.7.9.3.6 The areas for typical restricted flow orifices are shown in Table A.7.9.3.6.

The formula has been taken from industry publications including the Airco (BOC) Special Gases and Equipment Data

Table A.7.9.3.6 Typical Orifice Areas

Orifice Diameter		Area	
cm	in.	cm ²	in. ²
0.015	0.006	1.83×10^{-4}	2.83×10^{-5}
0.025	0.010	5.06×10^{-4}	7.85×10^{-5}
0.036	0.014	9.93×10^{-4}	1.54×10^{-4}

Book. It is published by other suppliers of specialty and mixed gases, including Scott Semiconductor Gases. It is based on estimated flow rates for air at 21°C (70°F) discharging to normal atmospheric pressure through an average shape and quality orifice. It can be assumed to be ±15 percent accurate. Correction factors have been built into the formula as presented in 7.9.3.6.1 to accommodate the use of gases other than air, for example, use of specific gravity data.

Annex B Attended Operations

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

B.1 Introduction. Section 112(r) of the *Clean Air Act* (CAA) mandates that the U.S. Environmental Protection Agency (EPA) promulgate a regulatory program to prevent accidental releases of regulated toxic and flammable substances and reduce the severity of releases that do occur. The rule was published on June 20, 1996, and formally appears in the *Code of Federal Regulations* as 40 CFR 68 and is officially titled *Accidental Release Prevention Requirements: Risk Management Programs Under Clean Air Act Section 112(r)(7)*.

B.1.1 In addition to qualified judgment and expertise, the following three resources must be considered when selecting alternative release scenarios in evaluating the hazards of any system:

- (1) The five scenarios as listed in Section 68.28 of 40 CFR 68
- (2) The five-year accident history of all accidental releases from covered processes that resulted in deaths, injuries, or significant property damage on-site, or all known off-site deaths, injuries, evacuations, sheltering-in-place, or property or environmental damage
- (3) The hazard review or process hazards analysis completed as part of the required prevention program

B.1.2 The five scenarios encompassed in Section 68.28 of 40 CFR 68 of the regulation include the following:

- (1) Transfer hose releases due to splits or sudden hose uncoupling (typical of delivery operations)
- (2) Process piping releases from failures at flanges, joints, welds, valves and valve seals, and drains or bleeds
- (3) Process vessel or pump releases due to cracks, seal failure, or drain, bleed, or plug failure
- (4) Vessel overfilling and spill, or overpressurization and venting through relief valves or rupture disks
- (5) Shipping container mishandling and breakage or puncturing leading to a spill

B.1.3 Based on comparable analysis, it was determined that the most likely alternative release scenario having an off-site impact from compressed gas systems would be a process piping failure that is either outdoors, or indoors and entrained

into an unspecified exhaust system where either discharge results in a continuous emission resulting in a plume on-site or off-site. An accidental release of this type might occur due to mechanical failure, corrosion, failure of a piping component such as a joint or valve, or another cause.

B.1.4 The flow rate through a pipe during a release is computed based on the pressure of the container, cylinder, or tank, the liquid head (if a liquid is involved), the fluid density, the line's resistance to flow (based primarily on diameter, length, and number of bends), and the open area available to flow at the exit.

B.2 Parameters. Each parameter, whether selected by the user or preselected, as is typical, is explained in B.2.1 through B.2.5.

B.2.1 Container, Cylinder, or Tank Pressure. The highest normal operating pressure should be used for the tank pressure.

B.2.2 Liquid Head. The liquid head is the amount of pressure exerted by the weight of the liquid column. For most small containers and cylinders, the liquid head is normally small and can usually be ignored.

B.2.3 Fluid Density. Fluid density is the density of the fluid under consideration.

B.2.4 Line Length and Configuration. Line configuration is specific to the configuration under consideration.

B.2.5 Pipe Break Flow Area. Most piping breaks result in less than full pipe diameter being open to flow. For example, a full-guillotine break is not nearly as likely as a reduced flow area break or a small leak. It is unlikely that small leaks will have an off-site impact. Therefore, it is appropriate to select as an alternative release case, a piping failure characterized by a fraction of the full-open area that is typical of the majority of piping failures while significantly greater than that of a small leak.

For the purposes of calculation, a 20 percent flow rate versus a full bore line break should be used. Statistics indicate that piping failures of this magnitude would be expected to occur between two and ten times as often as a full-guillotine break.

B.3 Calculations to demonstrate the “maximum credible worst-case leak” must be engineered and factors to include the nature of flow must be considered, including whether the gas or vapor flowing is gaseous, or liquid, or a two-phase-type flow. Detailed air dispersion models and methods of calculation are available. The choice of the model or methodology, or both, must be established by engineering principles and applied by those versed in such matters.

Annex C Informational References

C.1 Referenced Publication. The following documents or portions thereof are referenced within this standard for informational purposes only and are thus not part of the requirements of this document unless also listed in Chapter 2.

C.1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 52, *Compressed Natural Gas (CNG) Vehicular Fuel Systems Code*, 2002 edition.

NFPA 58, *Liquefied Petroleum Gas Code*, 2001 edition.

NFPA 68, *Guide for Venting of Deflagrations*, 2002 edition.