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55

Compressed Gases and Cryogenic Fluids Code

2023

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NFPA® 55

Compressed Gases and Cryogenic Fluids Code

2023 Edition

This edition of NFPA 55, *Compressed Gases and Cryogenic Fluids Code*, was prepared by the Technical Committee on Industrial and Medical Gases. It was issued by the Standards Council on June 16, 2022, with an effective date of July 6, 2022, and supersedes all previous editions.

This document has been amended by one or more Tentative Interim Amendments (TIAs) and/or Errata. See "Codes & Standards" at www.nfpa.org for more information.

This edition of NFPA 55 was approved as an American National Standard on July 6, 2022.

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 with 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, NFPA 43C was no longer needed.

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 the requirements for installation and usage of gases in portable cylinders. The 1998 edition clarified many of the 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 was a complete revision of the document that significantly expanded its scope and introduced requirements not addressed in previous editions. For example, the 1998 edition covered only compressed and liquefied gases in portable cylinders and only at consumer (user) locations; the 2003 edition covered the use of compressed and liquefied gases in portable and stationary containers and at manufacturer and consumer sites. This expansion to manufacturer sites brought a large portion of gas usage under the scope of NFPA 55.

The 2003 edition was also restructured to comply with the *Manual of Style for NFPA Technical Committee Documents*.

The 2005 edition of NFPA 55 was a complete revision of the document. Some of the significant changes in the document included the following:

(1) Incorporation of the requirements of NFPA 50, *Standard for Bulk Oxygen Systems at Consumer Sites,* into Chapter 9
(2) Incorporation of the requirements of NFPA 50A, *Standard for Gaseous Hydrogen Systems at Consumer Sites,* into Chapter 10
(3) Incorporation of NFPA 50B, *Standard for Liquefied Hydrogen Systems at Consumer Sites,* into Chapter 11
(4) Clarification of threshold storage requirements in Chapters 6 and 7
(5) Clarification of the separation distance tables formerly in NFPA 50, NFPA 50A, and NFPA 50B, and now in Chapters 9–11
(6) Schematic drawings added to annex material to illustrate system siting requirements in Chapters 9 and 11

The 2010 edition of NFPA 55 included a change from a standard to a code. The following were some of the significant changes to the document in the 2010 edition:

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(1) Incorporation of the requirements of NFPA 560, *Standard for the Storage, Handling, and Use of Ethylene Oxide for Sterilization and Fumigation*, into Chapter 14
(2) Updated separation distances for exposure to gaseous hydrogen systems based on new research
(3) Incorporation of the requirements on medical bulk oxygen systems from NFPA 99, *Standard for Health Care Facilities*, based on joint task group recommendations
(4) Addition of a new chapter, Chapter 12, on gas generation systems
(5) Addition of a new chapter, Chapter 13, on insulated liquid carbon dioxide systems

The 2013 edition of NFPA 55 was a complete revision of the document. Significant changes to the document included the following:

(1) Incorporation of the requirements of NFPA 51A, *Standard for Acetylene Cylinder Charging Plants*, into a new chapter, Chapter 15, on acetylene cylinder charging
(2) Revisions to Chapters 10 and 11 on bulk compressed and liquefied hydrogen systems, including updates to separation distances for exposure to hydrogen systems
(3) Changes to the table in Chapter 6 regarding the maximum allowable quantity (MAQ) of hazardous materials per control area to provide clarification and consistency with the approach used to establish the requirements in *NFPA 5000, Building Construction and Safety Code*, and NFPA 1, *Fire Code*

The 2016 edition incorporated the following significant changes:

(1) Clarification and organization of the requirements in Chapter 10 for gaseous hydrogen systems into three tiers based on the quantity of hydrogen stored: less than or equal to the MAQ, greater than the MAQ but less than bulk quantity, and bulk systems
(2) Changes to the requirements in Chapter 7 for emergency isolation
(3) A complete revision of Chapter 13, with a focus on carbon dioxide beverage systems
(4) A new Chapter 16 on liquid nitrous oxide systems

The 2020 edition incorporated the following changes:

(1) A new definition was added for *Press-Connect Fittings*. The definition incorporates fitting designs with and without elastomeric seals.
(2) In Chapter 6, a code change was made to Table 6.6 involving pyrophoric gases. The change provided a safe system for the control of pyrophoric gases in high hazard gas rooms serving Protection Level 5 fabrication facilities.
(3) In Chapter 8, under Pressure Relief Devices, a new subsection, 8.2.4.1, General, was added to require that pressure relief devices involved with cryogenic fluid piping systems vent to the outdoors when the maximum allowable working pressure or maximum process operating pressure is released.
(4) New text was added to Section 11.3, Location of Bulk Liquefied Hydrogen Systems, to reflect the intentional omission of vent stacks in hydrogen storage systems as they relate to setback distances.
(5) Chapter 16, Liquid Nitrous Oxide Systems, directed the reader to Chapter 17 for medical gases applications.

The following changes have been made in the 2023 edition of this code:

(1) Chapter 6 has been updated to clarify the proper doubling allowances associated with cabinet storage.
(2) Flammable gas requirements have been expanded to include refrigerants with lower global warming potential.
(3) The definition for *flammable gas* has been expanded to include Category 1A and Category 1B flammable gases, which have been added to the MAQ of Hazardous Materials per Control Area table in Chapter 6.
(4) Requirements have been revised to reduce the risk of excessive stacking of small cylinders and to clarify the proper electrical classification of gas cabinets.
(5) Temperature extreme requirements for compressed gas cylinders have been revised to account for manufacturers with facilities that expose cylinders to subambient temperatures during filling.
(6) Requirements have been added for bulk hydrogen gas system installations in 3- and 4- walled enclosures or courts.
(7) Several definitions have been added to clarify the terminology for risk management.

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Technical Committee on Industrial and Medical Gases

Rob Early, *Chair*
Compressed Gas Association, NY [M]

John J. Anicello, Chart Industries, Inc., WA [M]
Rodney L. Barnes, US Department of Energy, TN [U]
Denise Beach, FM Global, MA [I]
Chad E. Beebe, ASHE - AHA, WA [U]
Mark David Carter, National Institutes Of Health, MD [U]
Erik W. Christiansen, Exponent, Inc., CA [SE]
Michael Ciotti, Messer North America Inc., NJ [M]
Brian Ehrhart, Sandia National Laboratories, NM [U]
Kenneth Fegley, Air Products and Chemicals, Inc., PA [IM]
Rep. Compressed Gas Association
Jef Frick, Safe Gas Systems LLC., CO [IM]
Alejandro Gonzalez, Kryogenifex, FL [M]
Bryan R. Gordon, Ivys Energy Solutions, Inc., MA [IM]
Martin T. Gresho, FP2Fire, Inc., CO [SE]
Bridget Hamilton, Linde, NY [M]
Gerald T. Hayes, Air Liquide America, AZ [IM]
Rep. Compressed Gas Association
Anthony J. Lachawiec, Jr., Versum Materials, CA [M]
Brian D. Musch, Sterigenics US, LLC, IL [IM]
Eugene Y. Ngai, Chemically Speaking LLC, NJ [SE]
Richard P. Palluzi, Richard Palluzi LLC, NJ [SE]
Josh Pringle, Co2Meter, Inc., FL [M]
April Dawn Richardson, Railroad Commission of Texas, TX [E]
David A. Rohrig, Pacific Northwest National Laboratory, WA [U]
Robert M. Sutter, B&R Compliance Associates, FL [SE]
Scott E. Swanson, Intel Corporation, OR [M]
Jonathan C. Willard, Acute Medical Gas Services, NH [SE]
Edgar Wolff-Klammer, UL LLC, IL [RT]

Alternates

Joseph M. Bablo, UL LLC, IL [RT]
(Alt. to Edgar Wolff-Klammer)
Jerome Bell, Sterigenics International, Inc., IL [IM]
(Alt. to Brian D. Musch)
Richard A. Craig, Compressed Gas Association, VA [IM]
(Alt. to Gerald T. Hayes)
Niamh Donohoe, Intel Corporation-Ireland, Ireland [M]
(Alt. to Scott E. Swanson)
David J. Farese, Air Products and Chemicals, Inc., PA [IM]
(Alt. to Kenneth Fegley)
Rick Ginn, Praxair, Inc., OH [M]
(Alt. to Bridget Hamilton)
Joseph Wayne Green, Greengas Services Inc., TX [SE]
(Alt. to Robert M. Sutter)
Alice B. Muna, Sandia National Laboratories, NM [U]
(Alt. to Brian Ehrhart)
Lisa Reiheld, Viega LLC, OH [M]
(Voting Alt.)
Larry Wagg, Matheson, CO [SE]
(Alt. to Eugene Y. Ngai)

Heath Dehn, NFPA Staff Liaison

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Committee Scope: This Committee shall have primary responsibility for documents on the storage, transfer, and use of industrial gases. Included are the storage and handling of such gases in their gaseous or liquid phases; the installation of associated storage, piping, and distribution equipment; and operating practices. The Committee also has a technical responsibility for contributions in the same areas for medical gases and clean rooms. The Committee shall coordinate the material on gaseous and liquid hydrogen storage and use with the Hydrogen Technology Committee.

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Compressed Gases and Cryogenic Fluids Code

2023 Edition

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

Chapter 1 Administration

1.1 Scope. This code shall provide fundamental safeguards for the installation, storage, use, and handling of compressed gases and cryogenic fluids in portable and stationary cylinders, containers, and tanks.

1.2* Purpose. The purpose of this code shall be to provide a reasonable degree of protection of life and property from fire through standardization of practices for the installation, storage, use, and handling of compressed gases and cryogenic fluids.

1.3* Application.

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

1.3.2 This code shall not apply to the following:

(1)* Off-site transportation of materials covered by this code
(2) Storage, use, and handling of radioactive gases in accordance with NFPA 801
(3)* Use and handling of medical compressed gases at health care facilities in accordance with NFPA 99, except as specified in Chapter 17
(4) Systems consisting of cylinders of oxygen and cylinders of fuel gas used for welding and cutting in accordance with NFPA 51
(5)* Flammable gases used as a vehicle fuel when stored on a vehicle
(6)* Storage, use, and handling of liquefied and nonliquefied compressed gases in laboratory work areas in accordance with NFPA 45
(7) Storage, use, and handling of liquefied petroleum gases in accordance with NFPA 58
(8) Storage, use, and handling of compressed gases within closed-cycle refrigeration systems complying with the mechanical code
(9) Liquefied natural gas (LNG) storage at utility plants under NFPA 59A
(10) Compressed natural gas (CNG) and LNG utilized as a vehicle fuel in accordance with NFPA 52
(11)* Compressed hydrogen gas (GH_2), or liquefied hydrogen gas (LH_2) generated, installed, stored, piped, used, or handled in accordance with NFPA 2 when there are no specific or applicable requirements in NFPA 55
(12) Nonflammable mixtures of ethylene oxide with other chemicals
(13) Ethylene oxide in chambers 10 scf (0.283 Nm^3) or less in volume or for containers holding 7.05 oz (200 g) of ethylene oxide or less

1.4 Conflicts.

1.4.1 If a requirement differs between this code and a referenced document, the requirement of this code shall apply.

1.4.2 If a conflict between a general requirement and a specific requirement occurs, the specific requirement shall apply.

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

1.5.1* Unless otherwise specified, the provisions of this code 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 code. Where specified, the provisions of this code shall be retroactive.

1.5.2 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 code deemed appropriate.

1.5.3 The retroactive requirements of this code 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.

1.6 Equivalency. Nothing in this code 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 code.

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

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

1.7 Units and Formulas.

1.7.1 The units of measure in the code shall be presented first in US customary units (inch-pound units), followed by International System (SI) units in parentheses.

1.7.2 Either system of units shall be acceptable for satisfying the requirements in this code.

1.7.3 Users of this code shall apply one system of units consistently and shall not alternate between units.

1.7.4 The values presented for measurements in this code shall be expressed with a degree of precision appropriate for practical application and enforcement. It shall not be intended that the application or enforcement of these values be more precise than the precision expressed.

1.7.5 Where extracted text contains values expressed in only one system of units, the values in the extracted text shall be retained without conversion to preserve the values established by the responsible technical committee in the source document.

1.8 Enforcement. This code shall be administered and enforced by the authority having jurisdiction designated by the governing authority. *(See Annex F for sample wording for enabling legislation.)*

Chapter 2 Referenced Publications

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

2.2 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 1, *Fire Code,* 2021 edition.

NFPA 2, *Hydrogen Technologies Code,* 2023 edition.

NFPA 10, *Standard for Portable Fire Extinguishers,* 2022 edition.

NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam,* 2021 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems,* 2022 edition.

NFPA 30, *Flammable and Combustible Liquids Code,* 2021 edition.

NFPA 45, *Standard on Fire Protection for Laboratories Using Chemicals,* 2019 edition.

NFPA 51, *Standard for the Design and Installation of Oxygen–Fuel Gas Systems for Welding, Cutting, and Allied Processes,* 2023 edition.

NFPA 52, *Vehicular Natural Gas Fuel Systems Code,* 2023 edition.

NFPA 58, *Liquefied Petroleum Gas Code,* 2020 edition.

NFPA 59A, *Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG),* 2019 edition.

NFPA 68, *Standard on Explosion Protection by Deflagration Venting,* 2018 edition.

NFPA 69, *Standard on Explosion Prevention Systems,* 2019 edition.

NFPA 70®, National Electrical Code®, 2023 edition.

NFPA 72®, National Fire Alarm and Signaling Code®, 2022 edition.

NFPA 79, *Electrical Standard for Industrial Machinery,* 2021 edition.

NFPA 99, *Health Care Facilities Code,* 2021 edition.

NFPA 110, *Standard for Emergency and Standby Power Systems,* 2022 edition.

NFPA 111, *Standard on Stored Electrical Energy Emergency and Standby Power Systems,* 2022 edition.

NFPA 259, *Standard Test Method for Potential Heat of Building Materials,* 2018 edition.

NFPA 275, *Standard Method of Fire Tests for the Evaluation of Thermal Barriers,* 2022 edition.

NFPA 318, *Standard for the Protection of Semiconductor Fabrication Facilities,* 2022 edition.

NFPA 400, *Hazardous Materials Code,* 2022 edition.

NFPA 496, *Standard for Purged and Pressurized Enclosures for Electrical Equipment,* 2021 edition.

NFPA 505, *Fire Safety Standard for Powered Industrial Trucks Including Type Designations, Areas of Use, Conversions, Maintenance, and Operations,* 2018 edition.

NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response,* 2022 edition.

NFPA 801, *Standard for Fire Protection for Facilities Handling Radioactive Materials,* 2020 edition.

2.3 Other Publications.

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

ASME A13.1, *Scheme for the Identification of Piping Systems*, 2015.

ASME B31, *Code for Pressure Piping*, 2018.

ASME B31.3, *Process Piping*, 2018.

ASME B31.12, *Hydrogen Piping and Pipelines*, 2019.

Boiler and Pressure Vessel Code, "Rules for the Construction of Unfired Pressure Vessels," Section VIII, Division 1, 2019.

2.3.2 ASSE Publications. American Society of Sanitary Engineering, 18927 Hickory Creek Drive, Suite 220, Mokena, IL 60448.

ASSE/IAPMO/ANSI 6015, *Bulk Medical Gas/Cryogenic Fluid Central Supply Systems Installers*, 2021.

ASSE/IAPMO/ANSI 6035, *Bulk Medical Gas/Cryogenic Fluid Central Supply Systems Verifiers*, 2021.

2.3.3 ASTM Publications. ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959.

ASTM B88, *Standard Specification for Seamless Copper Water Tube*, 2020.

ASTM B819, *Standard Specification for Seamless Copper Tube for Medical Gas Systems*, 2019.

ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials*, 2021.

ASTM E136, *Standard Test Method for Assessing Combustibility of Materials Using a Vertical Tube Furnace at 750°C*, 2019a.

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ASTM E681, *Standard Test Method for Concentration Limits of Flammability of Chemicals (Vapors and Gases)*, 2009, reaffirmed 2015.

ASTM E1529, *Standard Test Methods for Determining Effects of Large Hydrocarbon Pool Fires on Structural Members and Assemblies*, 2016e1.

ASTM E2652, *Standard Test Method for Assessing Combustibility of Materials Using a Tube Furnace with a Cone-shaped Airflow Stabilizer, at 750°C*, 2018.

ASTM E2965, *Standard Test Method for Determination of Low Levels of Heat Release Rate for Materials and Products Using an Oxygen Consumption Calorimeter*, 2017.

2.3.4 CGA Publications. Compressed Gas Association, 8484 Westpark Drive, Suite 220, McLean, VA 22102.

CGA C-7, *Guide to Classification and Labeling of Compressed Gases*, 2020.

CGA G-4.1, *Cleaning Equipment for Oxygen Service*, 2018.

CGA G-4.10, *Use of Nonmetallic Materials in High Pressure Oxygen Breathing Gas Applications*, 2017.

CGA G-5.5, *Hydrogen Vent Systems*, 2014.

CGA G-6.1, *Standard for Insulated Liquid Carbon Dioxide Systems at Consumer Sites*, 2013.

CGA G-8.1, *Standard for Nitrous Oxide Systems at Customer Sites*, 2013, reaffirmed 2018.

ANSI/CGA G-13, *Storage and Handling of Silane and Silane Mixtures*, 2015.

ANSI/CGA M-1, *Standard for Medical Gas Supply Systems at Health Care Facilities*, 2018.

CGA P-1, *Safe Handling of Compressed Gases in Containers*, 2015.

CGA P-18, *Standard for Bulk Inert Gas Systems*, 2020.

CGA P-23, *Standard for Categorizing Gas Mixtures Containing Flammable and Nonflammable Components*, 2015.

CGA P-74, *Standard for Tube Trailer Supply Systems at Customer Sites*, 2019.

CGA S-1.1, *Pressure Relief Device Standards — Part 1 — Cylinders for Compressed Gases*, 2019.

CGA S-1.2, *Pressure Relief Device Standards — Part 2 — Portable Containers for Compressed Gases*, 2019.

CGA S-1.3, *Pressure Relief Device Standards — Part 3 — Stationary Storage Containers for Compressed Gases*, 2020.

CGA V-6, *Standard Bulk Refrigerated Liquid Transfer Connections*, 2014.

2.3.5* TC Publications. Transport Canada, 330 Sparks Street, Ottawa, ON K1A 0N5, Canada.

Transportation of Dangerous Goods Regulations, 2020.

2.3.6 IAPMO Publications. International Association of Plumbing and Mechanical Officials, 4755 E. Philadelphia Street, Ontario, CA 91761.

Uniform Mechanical Code, 2021 edition.

2.3.7 ICC Publications. International Code Council, 500 New Jersey Avenue, NW, 6th Floor, Washington, DC 20001.

International Fuel Gas Code (IFGC), 2018.

2.3.8 ISO Publications. International Organization for Standardization, ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401 - 1214 Vernier, Geneva, Switzerland.

ISO 10156, *Gas cylinders —— Gases and gas mixtures — Determination of fire potential and oxidizing ability for the selection of cylinder valve outlets*, 2017.

ISO 10298, *Gas cylinders — Gases and gas mixtures — Determination of toxicity for the selection of cylinder valve outlets*, 2018.

2.3.9 UL Publications. Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062-2096.

UL 723, *Test for Surface Burning Characteristics of Building Materials*, 2018.

2.3.10 US Government Publications. US Government Publishing Office, 732 North Capitol Street, NW, Washington, DC 20401-0001.

Title 21, Code of Federal Regulations, Part 210, "Current Good Manufacturing Practice in Manufacturing Processing, Packing, or Holding of Drugs; General."

Title 21, Code of Federal Regulations, Part 211, "Current Good Manufacturing Practice for Finished Pharmaceuticals."

Title 29, Code of Federal Regulations, Part 1910.1200, "Hazard Communication."

Title 49, Code of Federal Regulations, Part 173, "Shippers — General Requirements for Shipments and Packages."

2.3.11 Other Publications.

Merriam-Webster's Collegiate Dictionary, 11th edition, Merriam-Webster, Inc., Springfield, MA 2003.

2.4 References for Extracts in Mandatory Sections.

NFPA 1, *Fire Code*, 2021 edition.

NFPA 30, *Flammable and Combustible Liquids Code*, 2021 edition.

NFPA 52, *Vehicular Natural Gas Fuel Systems Code*, 2023 edition.

NFPA 58, *Liquefied Petroleum Gas Code*, 2020 edition.

NFPA 99, *Health Care Facilities Code*, 2021 edition.

NFPA *101®*, *Life Safety Code®*, 2021 edition.

NFPA 318, *Standard for the Protection of Semiconductor Fabrication Facilities*, 2021 edition.

NFPA 400, *Hazardous Materials Code*, 2022 edition.

NFPA 5000®, *Building Construction and Safety Code®*, 2021 edition.

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Chapter 3 Definitions

3.1 General. The definitions contained in this chapter shall apply to the terms used in this code. Where terms are not defined in this chapter or within another chapter, they shall be defined using their ordinarily accepted meanings within the context in which they are used. *Merriam-Webster's Collegiate Dictionary*, 11th edition, shall be the source for the ordinarily accepted meaning.

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

3.2.2* Authority Having Jurisdiction (AHJ). An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

3.2.3* Code. A standard that is an extensive compilation of provisions covering broad subject matter or that is suitable for adoption into law independently of other codes and standards.

3.2.4 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.

3.2.5* 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.

3.2.6 Shall. Indicates a mandatory requirement.

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

3.3 General Definitions.

3.3.1* Absolute Pressure. Pressure based on a zero reference point, the perfect vacuum.

3.3.2* Acetylene.

3.3.2.1 ***High-Pressure Acetylene.*** Acetylene at pressures exceeding a gauge pressure of 15 psi (103 kPa), but not exceeding a gauge pressure of 400 psi (2760 kPa).

3.3.2.2 ***Low-Pressure Acetylene.*** Acetylene at a pressure not exceeding a gauge pressure of 1 psi (6.9 kPa).

3.3.2.3 ***Medium-Pressure Acetylene.*** Acetylene at gauge pressures exceeding 1 psi (6.9 kPa) but not exceeding 15 psi (103 kPa).

3.3.3 Acetylene Operations. Operations that include acetylene generation, storage, purification, compression, cylinder filling, mobile acetylene trailer systems (MATS) filling and discharge, cylinder storage, and calcium carbide storage.

3.3.4 Acetylene Plant. A facility engaged in the generation and compression of acetylene and in the filling of acetylene cylinders either as its sole operation or in conjunction with facilities for filling other compressed gas cylinders.

3.3.5 Aeration Room. A room or area with controlled temperature or airflow where ethylene oxide sterilized products are held initially for outgassing.

3.3.6 Area.

3.3.6.1 ***Control Area.*** A building or portion of a building within which hazardous materials are allowed to be stored, dispensed, used, or handled in quantities not exceeding the maximum allowable quantities (MAQ). [**5000,** 2021]

3.3.6.2 ***Indoor Area.*** An area that is within a building or structure having overhead cover, other than a structure qualifying as "weather protection."

3.3.6.3 ***Outdoor Area.*** An area that is not an indoor area.

3.3.6.4* ***Use Area.*** A location inside or outside of a building or structure where the material placed into use is situated.

3.3.7 ASME. American Society of Mechanical Engineers. [**58,** 2020]

3.3.8* Assembly Occupancy. An occupancy (1) used for a gathering of 50 or more persons for deliberation, worship, entertainment, eating, drinking, amusement, awaiting transportation, or similar uses; or (2) used as a special amusement building, regardless of occupant load. [***101***, 2021]

3.3.9 ASTM. American Society for Testing and Materials, now known as "ASTM International."

3.3.10 Atmospheric Vents. All points where pipes, stacks, or ducts are open to the atmosphere, including discharge points from emissions control devices, vent pipes from safety valves, vent pipes from filters or pumps, and other vents.

3.3.11 Authorized Cylinder Requalifier. A facility approved by US Department of Transportation (DOT) or Transport Canada (TC) to perform cylinder requalification, inspection, testing, certification, or repair required by transportation regulations.

3.3.12 Back-Vent System. An exhaust vent system designed to transport residual vapors from a sterilization chamber to a designated point of termination outside of the building.

3.3.13 Building. Any structure used or intended for supporting or sheltering any use or occupancy. [***101,*** 2021]

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

3.3.15* Cathodic Protection. A technique to resist the corrosion of a metal surface by making the surface the cathode of an electrochemical cell.

3.3.16 Cathodic Protection Tester. A person who demonstrates an understanding of the principles and measurements of all common types of cathodic protection systems applicable to metal piping and container systems and who has education and experience in soil resistivity, stray current, structure-to-soil potential, and component electrical isolation measurements of metal piping and container systems.

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3.3.17 CFR. The Code of Federal Regulations of the United States Government. [**1,** 2021]

3.3.18 CGA. Compressed Gas Association. [**1,** 2021]

3.3.19* Chime Ring. The two raised rings circling the outer shell of UN 1A1 ethylene oxide drums.

3.3.20* Cleaning Media. Materials used to clean piping systems.

3.3.21 Combustible Liquid. A liquid having a closed-cup flash point at or above 100°F (37.8°C), subdivided as follows: (a) Class II liquids include those having a flash point at or above 100°F (37.8°C) and below 140°F (60°C); (b) Class IIIA liquids include those having a flash point at or above 140°F (60°C) and below 200°F (93.4°C); (c) Class IIIB liquids include those having a flash point at or above 200°F (93.4°C).

3.3.22* Compressed Medical Gases (CMG). Any liquefied or vaporized gas alone or in combination with other gases that is classified as a drug.

3.3.23 Compressor. A mechanical device used to increase the pressure and the resultant density of a gas through the act of compression.

3.3.24 Constantly Monitored Control Station. A facility where alarm or supervisory signals are monitored and the means are provided to notify emergency services.

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

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

3.3.26 Corrosion Expert. A person who, by reason of knowledge of the physical sciences and the principles of engineering acquired through professional education and related practical experience, is qualified to engage in the practice of corrosion control of container systems.

3.3.27 Corrosion Protection. Protecting a container, piping, or system to resist degradation of the metal through oxidation or reactivity with the environment in which it is installed.

3.3.28 Court. An open, uncovered, unoccupied space, unobstructed to the sky, bounded on three sides by walls.

3.3.28.1 ***Enclosed Court.*** A court bounded on all sides by walls.

3.3.29 Cryogenic Fluid. A fluid with a boiling point lower than –130°F (–90°C) at an absolute pressure of 14.7 psi (101.3 kPa).

3.3.30 Cryogenic Fluid Central Supply System. An assembly of equipment for supplying compressed gas, including, but not limited to, a stationary tank(s) that is permanently installed through anchoring to a foundation, pressure regulators, pressure relief devices, vaporizers, manifolds, and interconnecting piping that is designed to be filled at the health care facility with a cryogenic fluid and that terminates at the source valve. [**99,** 2021]

3.3.30.1 ***Bulk Cryogenic Fluid Central Supply System.*** A cryogenic fluid central supply system with a storage capacity of more than 566 m^3 [20,000 ft^3 (scf)].

3.3.30.2 ***Micro-Bulk Cryogenic Fluid Central Supply System.*** A cryogenic fluid central supply system with a storage capacity of less than or equal to 566 m^3 [20,000 ft^3 (scf)].

3.3.31 Cylinder. A pressure vessel designed for absolute pressures higher than 40 psi (276 kPa) and having a circular cross-section. It does not include a portable tank, multiunit tank car tank, cargo tank, or tank car.

3.3.32 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.

3.3.33* Cylinder Pack. An arrangement of cylinders into a cluster where the cylinders are confined into a grouping or arrangement with a strapping or frame system and connections are made to a common manifold. The frame system is allowed to be on skids or wheels to permit movement.

3.3.34 Detached Building. A separate single-story building, without a basement or crawl space, used exclusively for the storage or use of hazardous materials and located an approved distance from other structures.

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

3.3.36 DOT. US Department of Transportation. [**52,** 2023]

3.3.37 Emergency Shutoff Valve. A designated valve designed to shut off the flow of gases or liquids.

3.3.37.1 ***Automatic Emergency Shutoff Valve.*** A designated fail-safe automatic closing valve designed to shut off the flow of gases or liquids that is initiated by a control system where the control system is activated by either manual or automatic means.

3.3.37.2 ***Manual Emergency Shutoff Valve.*** A designated valve designed to shut off the flow of gases or liquids that is manually operated.

3.3.38 Ethylene Oxide Drum. For the purposes of this code, containers built to UN specification 1A1.

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

3.3.40* 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.

3.3.41 Exit Access. That portion of a means of egress that leads to an exit. [***101,*** 2021]

3.3.42* Explosion Control. A means of either preventing an explosion through the use of explosion suppression, fuel reduction, or oxidant reduction systems or a means to prevent the structural collapse of a building in the event of an explosion through the use of deflagration venting, barricades, or related construction methods.

3.3.43 Fail-Safe. A design arrangement incorporating one or more features that automatically counteracts the effect of an

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anticipated source of failure or which includes a design arrangement that eliminates or mitigates a hazardous condition by compensating automatically for a failure or malfunction. [**1,** 2021]

3.3.44* Fire Barrier. A continuous membrane or a membrane with discontinuities created by protected openings with a specified fire protection rating, where such membrane is designed and constructed with a specified fire resistance rating to limit the spread of fire. [**5000,** 2021]

3.3.45 Fire Code. The fire prevention code adopted by the jurisdiction.

3.3.46 Fixed Natural Ventilation. The movement of air into and out of a space through permanent openings that are arranged in such a way that the required ventilation cannot be reduced by operating windows, doors, louvers, or similar devices.

3.3.47 Flammable Cryogenic Fluid. A cryogenic fluid that forms flammable mixtures in air when in its vapor state.

3.3.48* Flammable Liquid (Class I). Any liquid having a closed-cup flash point not exceeding 100°F (37.8°C).

3.3.49 Full Trycock Valve. A manual valve used to indicate when the container is filled to maximum design capacity.

3.3.50 Gallon. A standard US gallon.

3.3.51 Gas.

3.3.51.1* ***Compressed Gas.*** A material, or mixture of materials, that (1) is a gas at 68°F (20°C) or less at an absolute pressure of 14.7 psi (101.3 kPa) and (2) has a boiling point of 68°F (20°C) or less at an absolute pressure of 14.7 psi (101.3 kPa) 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 40.6 psi (280 kPa) at 68°F (20°C).

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

3.3.51.3* ***Flammable Gas.*** A material that is a gas at 68°F (20°C) or less at an absolute pressure of 14.7 psi (101.3 kPa).

3.3.51.3.1* ***Category 1A Flammable Gas.*** A flammable gas that is ignitible at an absolute pressure of 14.7 psi (101.3 kPa) when in a mixture of 13 percent or less by volume with air or that has a flammable range at an absolute pressure of 14.7 psi (101.3 kPa) with air of at least 12 percent regardless of the lower limit.

3.3.51.3.2 ***Category 1B Flammable Gas.*** A non-pyrophoric or non-chemically unstable Category 1A flammable gas that has either a lower flammability limit of more than 6 percent by volume of air or a fundamental burning velocity of less than 3.9 in./s (10 cm/s).

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

3.3.51.5 ***Highly Toxic Gas.*** A chemical that has a median lethal concentration (LC_{50}) in air of 200 ppm by volume or less of gas or vapor, or 2 mg/L 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 0.44 lb and 0.66 lb (200 g and 300 g) each.

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

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

3.3.51.8* ***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.

3.3.51.9 ***Oxidizing Cryogenic Fluid.*** An oxidizing gas in the cryogenic state.

3.3.51.10 ***Oxidizing Gas.*** A gas that can support and accelerate combustion of other materials more than air does.

3.3.51.11 ***Pyrophoric Gas.*** A gas with an autoignition temperature in air at or below 130°F (54.4°C).

3.3.51.12 ***Toxic Gas.*** A gas with a median lethal concentration (LC_{50}) 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 0.44 lb and 0.66 lb (200 g and 300 g) each.

3.3.51.13* ***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.

3.3.51.13.1 ***Class 1 Unstable Reactive Gas.*** Materials that in themselves are normally stable, but that can become unstable at elevated temperatures and pressures.

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

3.3.51.13.3 ***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.

3.3.51.13.4 ***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.

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

3.3.53 Gas Generator System. An assembly of equipment that may consist of, but not be limited to, storage containers, pressure regulators, pressure relief devices, membranes, absorption material, and piping. The gas generating system terminates at the point where the gas supply, at service pressure, first enters the supply line.

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

3.3.55 Gas Room. A separately ventilated, fully enclosed room in which only compressed gases, cryogenic fluids, associated equipment, and supplies are stored or used.

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

3.3.57* Hazard Rating. The numerical rating of the health, flammability, self-reactivity, and other hazards of the material, including its reaction with water.

3.3.58* Health Care Facilities. Buildings, portions of buildings, or mobile enclosures in which medical, dental, psychiatric, nursing, obstetrical, or surgical care is provided. [**99,** 2021]

3.3.59* 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.

3.3.60 Inert Cryogenic Fluid. A cryogenic fluid that vaporizes to produce an inert gas when in its vapor state.

3.3.61* ISO Module. An assembly of tanks or tubular cylinders permanently mounted in a frame conforming to International Organization for Standardization (ISO) requirements.

3.3.62 Large Insulated Liquid Carbon Dioxide System. An assembly of equipment consisting of one or more insulated carbon dioxide containers, interconnecting piping, pressure regulators, and pressure relief devices, where the capacity of one or more of the individual containers is greater than 1000 pounds of carbon dioxide.

3.3.63 Limit.

3.3.63.1* ***Ceiling Limit.*** The maximum concentration of an airborne contaminant to which one can be exposed. [**5000,** 2021]

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

3.3.63.3* ***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).

3.3.64 Limited-Combustible. See 4.12.2.

3.3.65 Material.

3.3.65.1 ***Incompatible [Hazardous] Material.*** Materials that, when in contact with each other, have the potential to react in a manner that generates heat, fumes, gases, or by-products that are hazardous to life or property. [**400,** 2022]

3.3.65.2 ***Limited-Combustible Material.*** See 4.12.2.

3.3.65.3 ***Noncombustible Material.*** See 4.12.1.

3.3.66 MATS Building. A single-story detached building, without an attic, basement, crawl space, or false ceiling, used for acetylene trailer(s) or mobile acetylene trailer system (MATS) operations located indoors and with the balance of the building used exclusively for acetylene operations including storage and use of hazardous materials.

3.3.67 MATS Fill Valve. A shutoff valve on the charging system for MATS where the acetylene supply first enters the charging connection.

3.3.68 MATS Fire Area. The area or footprint occupied by the individual mobile acetylene trailer(s) to include the control system up to the point of the MATS source valve for MATS being discharged or to the point of the fill valve for MATS being charged.

3.3.69 MATS Source Valve. A shutoff valve on the piping system serving MATS where the acetylene supply first enters the user's supply line.

3.3.70 Maximum Allowable Quantity per Control Area (MAQ). A threshold quantity of hazardous material in a specific hazard class that once exceeded requires the application of additional administrative procedures, construction features, or engineering controls.

3.3.71 Mechanical Code. The mechanical or mechanical construction code adopted by the jurisdiction.

3.3.72 Metal Hydride. A generic name for compounds composed of metallic element(s) and hydrogen.

3.3.73 Metal Hydride Storage System. A closed system consisting of a group of components assembled as a package to contain metal–hydrogen compounds for which there exists an equilibrium condition where the hydrogen-absorbing metal alloy(s), hydrogen gas, and the metal–hydrogen compound(s) coexist and where only hydrogen gas is released from the system in normal use.

3.3.74* Mobile Acetylene Trailer System (MATS). A manifolded group of cylinders held together as a unit on a transport vehicle for the purpose of containing and transporting large quantities of acetylene.

3.3.75* Mobile Supply Unit. Any supply source that is equipped with wheels so it is able to be moved around.

3.3.76 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 (e.g., a wall or railing).

3.3.77 Noncombustible Material. See 4.12.1.

3.3.78 Normal Cubic Meter (Nm^3) of Gas. A cubic meter of gas at an absolute pressure of 14.7 psi (101.3 kPa) and a temperature of 70°F (21°C).

3.3.79* Normal Temperature and Pressure (NTP). A temperature of 70°F (21°C) at an absolute pressure of 14.7 psi (101.3 kPa).

3.3.80 OSHA. The Occupational Safety and Health Administration of the US Department of Labor.

3.3.81 Outgassing. Release of adsorbed or absorbed ethylene oxide after sterilization.

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3.3.82* Piping System. Interconnected piping consisting of mechanical components suitable for joining or assembly into pressure-tight fluid-containing system. Components include pipe, tubing, fittings, flanges, bolting, valves, and devices such as expansion joints, flexible joints, pressure hoses, in-line portions of instruments, and wetted components other than individual pieces or stages of equipment.

3.3.83* Press-Connect Fittings. Nonseparable connection for joining piping or tubing by radially compressing and mechanically deforming the fitting with a pressing tool.

3.3.84 Pressure Relief Device. A device designed to open to prevent a rise of internal pressure in excess of a specified value.

3.3.85* Protection Level. A tier of building safety that exceeds the construction requirements for control areas to accommodate quantities of hazardous materials in excess of those permitted using the control area concept.

3.3.86 Purging. A method used to free the internal volume of a piping system of unwanted contents that results in the existing contents being removed or replaced.

3.3.87 Qualified Individual. An individual knowledgeable in the hazards of compressed gases and cryogenic fluids through training and work experience.

3.3.88 Remotely Located, Manually Activated Shutdown Control. A control system that is designed to initiate shutdown of the flow of gas or liquid that is manually activated from a point located some distance from the delivery system.

3.3.89 Risk Management Terminology.

3.3.89.1 ***Harm.*** Injury or damage to the health of people, or damage to property or the environment.

3.3.89.2 ***Hazard.*** A potential source of harm.

3.3.89.3 ***Level of Risk.*** The magnitude of a risk or combination of risks, expressed in terms of the combination of consequences and their likelihood.

3.3.89.4 ***Likelihood.*** The chance of something happening.

3.3.89.5 ***Risk.*** The combination of the probability of occurrence of harm and the severity of that harm.

3.3.89.6 ***Risk Analysis.*** The process of comprehending the nature of risk and determining the level of risk.

3.3.89.7 ***Risk Assessment.*** The overall process of risk identification, risk analysis, and risk evaluation.

3.3.89.8 ***Risk Evaluation.*** The process of comparing the results of a risk analysis with risk criteria, to determine whether the risk and/or its magnitude is acceptable or tolerable.

3.3.89.9 ***Risk Identification.*** The process of finding, recognizing, and describing risks.

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

3.3.91* Secondary Containment. That level of containment that is external to and separate from primary containment. [**400,** 2022]

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

3.3.93 Small Insulated Liquid Carbon Dioxide System. An assembly of equipment consisting of one or more insulated carbon dioxide containers, interconnecting piping, pressure regulators, and pressure relief devices. The capacity of individual containers is 1000 pounds of carbon dioxide or less.

3.3.94* Source Valve. A shutoff valve on the piping system serving a bulk gas supply system where the gas supply, at service pressure, first enters the supply line.

3.3.95 Special Provisions. Controls required when the maximum allowable quantity in the control area is exceeded.

3.3.96 Standard Cubic Foot (scf) of Gas. An amount of gas that occupies one cubic foot at an absolute pressure of 14.7 psi (101 kPa) and a temperature of 70°F (21°C).

3.3.97* Sterilization Building. A detached building that contains all ancillary systems and rooms supporting the sterilization process.

3.3.98 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.

3.3.99 Subatmospheric Gas Source (SAGS).

3.3.99.1 ***Subatmospheric Gas Storage and Delivery Source (Type 1 SAGS).*** A gas source package that stores and delivers gas at subatmospheric pressure and includes a container that stores and delivers gas at a pressure of less than the absolute pressure of 14.7 psi (101.3 kPa) at 68°F (20°C).

3.3.99.2 ***Subatmospheric Gas Delivery Source (Type 2 SAGS).*** A gas source package that stores compressed gas and delivers gas at subatmospheric pressure and includes a container that stores gas at a pressure greater than the absolute pressure of 14.7 psi (101.3 kPa) at 68°F (20°C) and delivers gas at a pressure less than the absolute pressure of 14.7 psi (101.3 kPa) at 68°F (20°C).

3.3.100 System.

3.3.100.1 ***Bulk Gas System.*** A system in which compressed gas is delivered, stored, and discharged in the gaseous form to a piping system. The threshold quantity used to define a bulk gas system is determined based on material-specific requirements. The compressed gas system terminates at the source valve.

3.3.100.2* ***Bulk Inert Gas System.*** An assembly of equipment that consists of, but is not limited to, storage containers, pressure regulators, pressure relief devices, vaporizers, manifolds, and piping, with a storage capacity of more than 20,000 scf (566 Nm^3) of inert gas, and that terminates at the source valve.

3.3.100.3* ***Bulk Oxygen System.*** An assembly of equipment, such as oxygen storage containers, pressure regulators, pressure relief devices, vaporizers, manifolds, and interconnecting piping, that has a storage capacity of more than 20,000 scf (566 Nm^3) of oxygen and that terminates at the source valve.

3.3.100.4* ***Compressed Gas System.*** An assembly of equipment designed to contain, distribute, or transport compressed gases. [**318,** 2021]

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3.3.100.5 ***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.

3.3.100.6 ***Cryogenic Fluid System.*** An assembly of equipment designed to contain, distribute, or transport cryogenic fluids.

3.3.100.7 ***Cylinder Containment System.*** A gastight recovery system comprising 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.

3.3.100.8* ***Fast-Acting Fire Detection System.*** A detection system designed to detect a fire more rapidly than standard smoke or heat detectors.

3.3.100.9* ***Gaseous Hydrogen (GH_2) System.*** An assembly of equipment that consists of, but is not limited to, storage containers, pressure regulators, pressure relief devices, compressors, manifolds, and piping and that terminates at the source valve.

3.3.100.9.1* ***Bulk Hydrogen Compressed Gas System.*** A gaseous hydrogen (GH_2) system with a storage capacity of more than 5000 scf (141.6 Nm^3) of compressed hydrogen gas.

3.3.100.10 ***Liquefied Hydrogen (LH_2) System.*** An assembly of equipment that consists of, but is not limited to, storage containers, pressure regulators, pressure relief devices, compressors, manifolds, and piping and that terminates at the source valve.

3.3.100.10.1* ***Bulk Liquefied Hydrogen System.*** A liquefied hydrogen (LH_2) system with a storage capacity of more than 39.7 gal (150 L) of liquefied hydrogen.

3.3.100.11* ***Non-Bulk Flammable Gas System.*** A system consisting of cylinders or other storage systems, with each individual cylinder and each individual set of connected cylinders having less than 5000 scf (141.6 Nm^3).

3.3.100.12 ***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.

3.3.101 Tank.

3.3.101.1* ***Portable Tank.*** Any packaging over 60 US gal (227.1 L) 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.

3.3.101.2* ***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.

3.3.102 TC. Transport Canada.

3.3.103* Tube Trailer. A truck or semitrailer on which a number of very long compressed gas tubular cylinders have been mounted and manifolded into a common piping system.

3.3.104 Unpierced Wall. A wall that is allowed to have pipes or conduits passing through it, or unopenable windows, glazed with safety glass or wired glass, set in it, but such openings are sealed to prevent the flow of air between adjacent rooms.

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

3.3.106 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.

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

3.3.108* Vent System. A system that provides a means of depressurizing or relieving excess gas pressure and directs the venting gas to a safe location.

Chapter 4 General Requirements

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

4.2 Emergency Plan.

4.2.1 Emergency Plan Requirements.

4.2.1.1 An emergency plan shall be prepared and updated wherever compressed gases or cryogenic fluids are produced, handled, stored, or used in amounts exceeding the maximum allowable quantity (MAQ) per control area or where required by the authority having jurisdiction (AHJ).

4.2.1.2 The plan shall be available for inspection by the AHJ 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) The location of posted emergency procedures
(5) A safety data sheet (SDS) or equivalent 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 SDSs
    (d) Knowing the site emergency procedures
(7) A list of the types and quantities of compressed gases and cryogenic fluids and their locations

4.3 Facility Closure.

4.3.1 Facilities Temporarily Out of Service. Facilities that are temporarily out of service shall continue to maintain a permit and be monitored and inspected. [**400:**1.9.3.1]

4.3.2 Facilities Permanently Out of Service. 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 perma-

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nently out of service and shall be closed in accordance with 4.3.3. [**400:**1.9.3.2]

4.3.3 Closure Plan.

4.3.3.1 Where required by the AHJ, the permit holder or applicant shall submit a closure plan to the fire department to terminate storage, dispensing, handling, or use of hazardous materials at least 30 days prior to facility closure. [**400:**1.9.4.1]

4.3.3.2 The plan shall demonstrate that hazardous materials that were stored, dispensed, handled, or used in the facility have been transported, disposed of, or reused in a manner that eliminates the need for further maintenance and any threat to public health and safety. [**400:**1.9.4.2]

4.3.3.3 The plan shall be submitted with a permit application for facility closure in accordance with Section 4.1.

4.4* Out-of-Service Stationary Bulk Gas Systems. Installed bulk gas systems no longer in use that remain in place shall be removed from service by the supplier or shall be safeguarded in accordance with the following:

(1) Required permits shall be maintained.
(2) The source and fill valves shall be closed to prevent the intrusion of air or moisture.
(3) Cylinders, containers, and tanks shall be maintained in serviceable condition.
(4) Security shall be maintained in accordance with 7.1.8.

4.5 Management Plan and Hazardous Materials Documentation.

4.5.1 Hazardous Materials Management Plan. Where required by the AHJ, a hazardous materials management plan (HMMP) shall be submitted to the AHJ.

4.5.1.1 The HMMP shall comply with the requirements of the fire code.

4.5.2 Hazardous Materials Inventory Statement. Where required by the AHJ, permit applications shall include a hazardous materials inventory statement (HMIS) in accordance with the fire code.

4.5.3 Safety Data Sheets (SDS). Safety data sheets (SDS) shall be available on the premises for hazardous materials regulated by this code. When approved, SDSs shall be permitted to be retrievable by electronic access. [**400:**6.1.2]

4.6 Release of Hazardous Materials.

4.6.1 Prohibited Releases. Hazardous materials shall not be released into a sewer, storm drain, ditch, drainage canal, lake, river, or tidal waterway; upon the ground, a sidewalk, a street, or a highway; or into the atmosphere, unless such release is permitted by the following:

(1) Federal, state, or local governing regulations
(2) Permits of the jurisdictional air quality management board
(3) National Pollutant Discharge Elimination System permit
(4) Waste discharge requirements established by the jurisdictional water quality control board
(5) Sewer pretreatment requirements for publicly or privately owned treatment works

[**400:**6.1.3.1]

4.6.2 Control and Mitigation of Unauthorized Releases. Provisions shall be made for controlling and mitigating unauthorized releases. [**400:**6.1.3.2]

4.6.3 Records of Unauthorized Releases. Accurate records of the unauthorized release of hazardous materials shall be kept by the permittee. [**400:**6.1.3.3]

4.6.4* Notification of Unauthorized Releases. The fire department shall be notified immediately or in accordance with approved emergency procedures when an unauthorized release becomes reportable under state, federal, or local regulations. [**400:**6.1.3.4]

4.6.5 Container Failure. When an unauthorized release due to primary container failure is discovered, the involved primary container shall be repaired or removed from service. [**400:**6.1.3.5]

4.6.5.1 Overpack Containers. Overpack containers shall be permitted to be used as a means to provide protection for primary containers to be transported for repair or removal from service. [**400:**6.1.3.6]

4.6.6 Responsibility for Cleanup of Unauthorized Discharges.

4.6.6.1 The person, firm, or corporation responsible for an unauthorized release shall institute and complete all actions necessary to remedy the effects of such unauthorized release, whether sudden or gradual, at no cost to the AHJ. [**400:**6.1.3.7.1]

4.6.6.2 When deemed necessary by the AHJ, cleanup of an unauthorized release shall be permitted to be initiated by the fire department or by an authorized individual or firm, and costs associated with such cleanup shall be borne by the owner, operator, or other person responsible for the unauthorized release. [**400:**6.1.3.7.2]

4.7* Personnel Training. Persons in areas where hazardous materials are stored, dispensed, handled, or used shall be trained in the hazards of the materials employed and actions required by the emergency plan. The level of training to be conducted shall be consistent with the responsibilities of the persons to be trained in accordance with 4.7.1 through 4.7.4.4. [**400:**6.1.4]

4.7.1 Awareness. The training provided for persons designated in Section 4.7 shall include awareness training in accordance with 4.7.1.1 through 4.7.1.3. [**400:**6.1.4.1]

4.7.1.1 Completion. Initial training shall be completed prior to beginning work in the work area. [**400:**6.1.4.1.1]

4.7.1.2 Hazard Communications. Training shall be provided prior to beginning work in the work area to enable personnel to recognize and identify hazardous materials stored, dispensed, handled, or used on site and where to find safety information pertaining to the hazards of the materials employed. [**400:**6.1.4.1.2]

4.7.1.3 Emergency Plan. Training shall be provided prior to beginning work in the work area to enable personnel to implement the emergency plan. [**400:**6.1.4.1.3]

4.7.2 Operations Personnel. Persons engaged in storing, using, or handling hazardous materials shall be designated as operations personnel and shall be trained in accordance with 4.7.1 and 4.7.2.1 through 4.7.2.6. [**400:**6.1.4.2]

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4.7.2.1 Physical and Health Hazard Properties. Operations personnel shall be trained in the chemical nature of the materials, including their physical hazards and the symptoms of acute or chronic exposure as provided by the safety data sheet (SDS) furnished by the manufacturer or other authoritative sources. [**400:**6.1.4.2.1]

4.7.2.2 Dispensing, Using, and Processing. Operations personnel shall be trained in the use of specific safeguards applicable to the dispensing, processing, or use of the materials and equipment employed. [**400:**6.1.4.2.2]

4.7.2.3 Storage. Operations personnel shall be trained in the application of storage arrangements and site-specific limitations on storage for the materials employed. [**400:**6.1.4.2.3]

4.7.2.4 Transport (Handling). Operations personnel involved in materials handling shall be trained in the requirements for on-site transport of the materials employed. [**400:**6.1.4.2.4]

4.7.2.5 Actions in an Emergency. Operations personnel shall be trained in the necessary actions to take in the event of an emergency, including the operation and activation of emergency controls prior to evacuation. [**400:**6.1.4.2.5]

4.7.2.6 Changes. Training shall be provided whenever a new hazardous material is introduced into the work area that presents a new physical or health hazard, or when new information is obtained pertaining to physical or health hazards of an existing hazardous material that has not been included in previous training, and when there are changes in any of the following:

(1) Equipment
(2) Operations
(3) Hazardous materials

[**400:**6.1.4.2.6]

4.7.3 Emergency Response Liaison. [400:6.1.4.3]

4.7.3.1 Responsible persons shall be designated and trained to be emergency response (ER) liaison personnel. [**400:**6.1.4.3.1]

4.7.3.2 Emergency response liaison personnel shall do the following:

(1) Aid emergency responders in preplanning responses to emergencies
(2) Identify locations where hazardous materials are located
(3) Have access to safety data sheets
(4) Be knowledgeable in the site emergency response procedures

[**400:**6.1.4.3.2]

4.7.4* Emergency Responders. Emergency responders shall be trained to be competent in the actions to be taken in an emergency event. [**400:**6.1.4.4]

4.7.4.1* Emergency Response Team Leader. Persons acting as ER team leaders shall be trained under the Incident Command System concept or equivalent. [**400:**6.1.4.4.1]

4.7.4.2* Response to Incipient Events. Responses to incidental releases of hazardous materials where the material can be absorbed, neutralized, or otherwise controlled at the time of release by employees in the immediate release area, or by maintenance personnel, shall not be considered emergency responses as defined within the scope of this code. [**400:**6.1.4.4.2]

4.7.4.3* On-Site Emergency Response Team. When an on-site emergency response team is provided, emergency responders shall be trained in accordance with the requirements of the specific site emergency plan or as required by federal, state, or local governmental agencies. [**400:**6.1.4.4.3]

4.7.4.4 Training Mandated by Other Agencies. Training required by federal, state, or local regulations that is required based on the quantity or type of hazardous materials stored, dispensed, handled, or used shall be conducted in accordance with the requirements of and under the jurisdiction of the governing agency. [**400:**6.1.4.5]

4.7.4.5 Documentation. Training shall be documented and the documentation made available to the AHJ upon written request. [**400:**6.1.4.6]

4.8 Emergency Response Liaison.

4.8.1 Responsible persons shall be designated and trained to be emergency response (ER) liaison personnel. [**400:**6.1.4.3.1]

4.8.2 Emergency response liaison personnel shall do the following:

(1) Aid emergency responders in preplanning responses to emergencies
(2) Identify locations where hazardous materials are located
(3) Have access to safety data sheets
(4) Be knowledgeable in the site emergency response procedures

[**400:**6.1.4.3.2]

4.9 Ignition Source Controls.

4.9.1 Smoking. Smoking shall be prohibited in the following locations:

(1) Within 25 ft (7.6 m) of outdoor storage areas, dispensing areas, or open use areas
(2) In rooms or areas where hazardous materials are stored or dispensed or used in open systems in amounts requiring a permit in accordance with Section 4.1

[**400:**6.1.5.1]

4.9.2 Open Flames and High-Temperature Devices. Open flames and high-temperature devices shall not be used in a manner that creates a hazardous condition. [**400:**6.1.5.2]

4.9.3 Energy-Consuming Equipment. Energy-consuming equipment with the potential to serve as a source of ignition shall be listed or approved for use with the hazardous materials stored or used. [**400:**6.1.5.3]

4.9.3.1* Powered Industrial Trucks. Powered industrial trucks shall be operated and maintained in accordance with NFPA 505. [**1:**10.18]

4.9.4 Static Producing Equipment. Equipment that can develop a static charge in flammable gas storage and use areas shall be grounded.

4.10 Signs.

4.10.1 General.

4.10.1.1 Design and Construction. Signs shall be durable, and the size, color, and lettering of signs shall be in accordance with nationally recognized standards. [**400:**6.1.8.1.1]

4.10.1.2 Language. Signs shall be in English as the primary language or in symbols permitted by this code. [**400:**6.1.8.1.2]

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4.10.1.3 Maintenance. Signs shall meet the following criteria:

(1) They shall not be obscured.
(2) They shall be maintained in a legible condition.
(3) They shall not be removed, unless for replacement.
[**400:**6.1.8.1.3]

4.10.2 Hazard Identification Signs.

4.10.2.1 General. Visible hazard identification signs in accordance with NFPA 704 shall be placed at the following, locations except where the AHJ has received a hazardous materials management plan and a hazardous materials inventory statement in accordance with 4.5.1 through 4.5.2 and has determined that omission of such signs is consistent with safety:

(1) On stationary aboveground tanks
(2) On stationary aboveground containers
(3) At entrances to locations where hazardous materials are stored, dispensed, used, or handled in quantities requiring a permit
(4) At other entrances and locations designated by the AHJ
[**400:**6.1.8.2.1]

4.10.2.2 Identification of Containers, Cartons, and Packages. Individual containers, cartons, or packages shall be conspicuously marked or labeled in accordance with nationally recognized standards. [**400:**6.1.8.2.2]

4.10.2.3 Identification of Gas Rooms and Cabinets. Rooms or cabinets containing compressed gases shall be conspicuously labeled as follows:

COMPRESSED GAS

4.10.3 No Smoking Signs. Signs prohibiting smoking shall be provided where smoking is prohibited by 4.9.1 or where required by 6.13.2.2 for an entire site or building.

4.11 Protection from Vehicular Damage.

4.11.1 Where required, guard posts or other approved means shall be provided to protect against physical damage in accordance with 4.11.1.1 and 4.11.1.2.

4.11.1.1 Guard posts or other approved means shall be provided to protect the following where subject to vehicular damage:

(1) Storage tanks and connected piping, valves, and fittings
(2) Storage areas containing tanks or portable containers except where the exposing vehicles are powered industrial trucks used for transporting the hazardous materials
(3) Use areas
[**400:**6.1.9.1]

4.11.1.2 Where guard posts are installed, the posts shall meet the following criteria:

(1) They shall be constructed of steel not less than 4 in. (102 mm) in diameter and concrete filled.
(2) They shall be spaced not more than 4 ft (1.2 m) between posts on center.
(3) They shall be set not less than 3 ft (0.9 m) deep in a concrete footing of not less than a 15 in. (381 mm) diameter.
(4) They shall be set with the top of the posts not less than 3 ft (0.9 m) above ground.
(5) They shall be located not less than 3 ft (0.9 m) from the tank.
[**400:**6.1.9.2]

4.12* Building Construction Materials.

4.12.1* Noncombustible Material. A material that complies with any one of the following shall be considered a noncombustible material:

(1)* The material, in the form in which it is used, and under the conditions anticipated, will not ignite, burn, support combustion, or release flammable vapors, when subjected to fire or heat.
(2) The material is reported as passing ASTM E136, *Standard Test Method for Assessing Combustibility of Materials Using a Vertical Tube Furnace at 750°C.*
(3) The material is reported as complying with the pass/fail criteria of ASTM E136 when tested in accordance with the test method and procedure in ASTM E2652, *Standard Test Method for Assessing Combustibility of Materials Using a Tube Furnace with a Cone-shaped Airflow Stabilizer, at 750°C.*

[**5000:**7.1.4.1.1]

4.12.2* Limited-Combustible Material. A material shall be considered a limited-combustible material where one of the following is met:

(1) The conditions of 4.12.2.1 and 4.12.2.3, and the conditions of either 4.12.2.4 or 4.12.2.5 shall be met.
(2) The conditions of 4.12.2.6 shall be met.
[***101:***4.6.14]

4.12.2.1 The material shall not comply with the requirements for a noncombustible material, in accordance with 4.12.1. [**5000:**7.1.4.2.1]

4.12.2.2 Where the term *limited-combustible* is used in this *Code*, it shall also include the term *noncombustible*. [**5000**:7.1.4.1.2]

4.12.2.3 The material, in the form in which it is used, shall exhibit a potential heat value not exceeding 3500 Btu/lb (8141 kJ/kg), when tested in accordance with NFPA 259. [**5000:**7.1.4.2.2]

4.12.2.4 The material shall have the structural base of a noncombustible material with a surfacing not exceeding a thickness of ⅛ in. (3.2 mm) where the surfacing exhibits a flame spread index not greater than 50 when tested in accordance with ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials*, or UL 723, *Test for Surface Burning Characteristics of Building Materials*. [**5000:**7.1.4.2.3]

4.12.2.5 The material shall be composed of materials that in the form and thickness used neither exhibit a flame spread index greater than 25 nor exhibit evidence of continued progressive combustion when tested in accordance with ASTM E84 or UL 723, and are of such composition that all surfaces that would be exposed by cutting through the material on any plane would neither exhibit a flame spread index greater than 25 nor exhibit evidence of continued progressive combustion when tested in accordance with ASTM E84 or UL 723. [**5000:**7.1.4.2.4]

4.12.2.6 Materials shall be considered limited-combustible materials where tested in accordance with ASTM E2965, *Standard Test Method for Determination of Low Levels of Heat Release Rate for Materials and Products Using an Oxygen Consumption Calorimeter*, at an incident heat flux of 75 kW/m^2 for a 20-minute exposure and both of the following conditions are met:

(1) The peak heat release rate shall not exceed 150 kW/m^2 for longer than 10 seconds.

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(2) The total heat released shall not exceed 8 MJ/m^2. [**5000:**7.1.4.2.5]

4.12.2.7 Where the term *limited-combustible* is used in this *Code*, it shall also include the term *noncombustible*. [**5000:**7.1.4.2.6]

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) Flammable cryogenic fluid
- (c) Oxidizing gas
- (d) Oxidizing cryogenic fluid
- (e) Pyrophoric gas
- (f) Unstable reactive (detonable) gas, Class 3 or Class 4
- (g) Unstable reactive (nondetonable) gas, Class 3
- (h) Unstable reactive gas, Class 1 or Class 2

(2) Health hazards, which shall include the following:
- (a) Corrosive gas
- (b) Cryogenic fluids
- (c) Highly toxic gas
- (d) Toxic 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 code 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 of Gas Mixtures. The toxicity of gas mixtures shall be classified in accordance with NFPA 400 or with the requirements of 29 CFR 1910.1200, 49 CFR 173.115, or ISO 10298, *Gas cylinders — Gases and gas mixtures — Determination of toxicity for the selection of cylinder valve outlets.*

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 E681, *Standard Test Method for Concentration Limits of Flammability of Chemicals (Vapors and Gases),* or ISO 10156, *Gas Cylinders — 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.

6.1.1 Occupancy.

6.1.1.1 Occupancy Requirements. Occupancies that contain compressed gases or cryogenic fluids shall comply with this chapter in addition to other applicable requirements of this code.

6.1.1.2 Occupancy Classification. The occupancy of a building or structure, or portion of a building or structure, shall be classified in accordance with the building code.

6.2 Control Areas.

6.2.1 Construction Requirements. Control areas shall be separated from each other by fire barriers in accordance with Table 6.2.1. [**400:**5.2.2.3]

6.2.2 Number of Control Areas. The maximum number of control areas within a building shall be in accordance with Table 6.2.1. [**400:**5.2.2.1]

6.2.3 Where only one control area is present in a building, no special construction provisions shall be required. [**400:**5.2.2.2]

6.2.4 Quantities Less Than or Equal to the MAQ. Indoor control areas with compressed gases or cryogenic fluids stored or used in quantities less than or equal to those shown in Table 6.3.1.1 shall be in accordance with 6.3.1.6 and 6.3.1.7 and Sections 6.1, 6.8, 6.9, 6.13, 6.16, and 6.17, and the applicable provisions of Chapters 1 through 5 and Chapters 7 through 16.

6.3 Occupancy Protection Levels.

6.3.1 Quantity Thresholds for Compressed Gases and Cryogenic Fluids Requiring Special Provisions.

6.3.1.1* Threshold Exceedances. Where the quantities of compressed gases or cryogenic fluids stored or used within an indoor control area exceed those shown in Table 6.3.1.1, the area shall meet the requirements for Protection Levels 1 through 5 in accordance with the building code based on the requirements of 6.3.2.

Table 6.2.1 Design and Number of Control Areas

Floor Level	Maximum Allowable Quantity per Control Area (%)*	Number of Control Areas per Floor	Fire Resistance Rating for Fire Barriers† (hr)
Above grade			
>9	5.0	1	2
7–9	5.0	2	2
4–6	12.5	2	2
3	50.0	2	1
2	75.0	3	1
1	100.0	4	1
Below grade			
1	75.0	3	1
2	50.0	2	1
Lower than 2	NP	NP	N/A

NP: Not Permitted.
N/A: Not Applicable.
*Percentages represent the applicable MAQ per control area shown in Table 6.3.1.1, with all the increases permitted in the footnotes of that table.
†Fire barriers are required to include floors and walls, as necessary, to provide a complete separation from other control areas.
[**400:**Table 5.2.2.1]

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Table 6.3.1.1 Maximum Allowable Quantity (MAQ) of Hazardous Materials per Control Area

			Storage			Use — Closed Systems			Use — Open Systems	
Material	Class	High Hazard Protection Level	Solid Pounds	Liquid Gallons	Gas[a] scf (lb)	Solid Pounds	Liquid Gallons	Gas[a] scf (lb)	Solid Pounds	Liquid Gallons
Cryogenic fluid	Flammable	2	NA	45[b, c]	NA	NA	45[b,c]	NA	NA	45[b,c]
	Oxidizing	3	NA	45[d, e]	NA	NA	45[d,e]	NA	NA	45[d,e]
	Inert	NA	NA	NL	NA	NA	NL	NA	NA	NL
Flammable, gas[f]	Gaseous Category 1A and 1B (High BV)[l]	2	NA	NA	1000[d,e]	NA	NA	1000[d,e]	NA	NA
	Gaseous Category 1B (Low BV)[l]	2	NA	NA	162,500[d,e]	NA	NA	162,500[d,e]	NA	NA
	Liquefied Category 1A and 1B (High BV)[l]	2	NA	NA	(150)[d,e]	NA	NA	(150)[d,e]	NA	NA
	Liquefied Category 1B (Low BV)[l]	2	NA	NA	(10,000)[d,e,i]	NA	NA	(10,000)[d,e]	NA	NA
	LP	2	NA	NA	(300)[g,h,i]	NA	NA	(300)[g]	NA	NA
Inert gas	Gaseous	NA	NA	NA	NL	NA	NA	NL	NA	NA
	Liquefied	NA	NA	NA	NL	NA	NA	NL	NA	NA
Oxidizing gas	Gaseous	3	NA	NA	1500[d,e]	NA	NA	1500[d,e]	NA	NA
	Liquefied	3	NA	NA	(150)[d,e]	NA	NA	(150)[d,e]	NA	NA
Pyrophoric gas	Gaseous	2	NA	NA	50[d,j]	NA	NA	50[d,j]	NA	NA
	Liquefied	2	NA	NA	(4)[d,j]	NA	NA	(4)[d,j]	NA	NA
Unstable (reactive) gas	Gaseous									
	4 or 3 detonable	1	NA	NA	10[d,j]	NA	NA	10[d,j]	NA	NA
	3 nondetonable	2	NA	NA	50[d,e]	NA	NA	50[d,e]	NA	NA
	2	3	NA	NA	750[d,e]	NA	NA	750[d,e]	NA	NA
	1	NA	NA	NA	NL	NA	NA	NL	NA	NA
Unstable (reactive) gas	Liquefied									
	4 or 3 detonable	1	NA	NA	(1)[d,j]	NA	NA	(1)[d,j]	NA	NA
	3 nondetonable	2	NA	NA	(2)[d,e]	NA	NA	(2)[d,e]	NA	NA
	2	3	NA	NA	(150)[d,e]	NA	NA	(150)[d,e]	NA	NA
	1	NA	NA	NA	NL	NA	NA	NL	NA	NA
Corrosive gas	Gaseous	4	NA	NA	810[d,e]	NA	NA	810[d,e]	NA	NA
	Liquefied		NA	NA	(150)[d,e]	NA	NA	(150)[d,e]	NA	NA
Highly toxic gas	Gaseous	4	NA	NA	20[e,k]	NA	NA	20[e,k]	NA	NA
	Liquefied		NA	NA	(4)[e,k]	NA	NA	(4)[e,k]	NA	NA
Toxic gas	Gaseous	4	NA	NA	810[d,e]	NA	NA	810[d,e]	NA	NA
	Liquefied		NA	NA	(150)[d,e]	NA	NA	(150)[d,e]	NA	NA

NA: Not applicable within the context of NFPA 55 (refer to the applicable building or fire code for additional information on these materials).
NL: Not limited in quantity.
Notes:
(1) For use of control areas (see Section 6.2.)
(2) Table values in parentheses or brackets correspond to the unit name in parentheses or brackets at the top of the column.
(3) The aggregate quantity in use and storage is not permitted to exceed the quantity listed for storage. In addition, quantities in specific occupancies are not permitted to exceed the limits in the building code.
[a]Measured at NTP [70°F (20°C) and 14.7 psi (101.3 kPa)].
[b]None allowed in unsprinklered buildings unless stored or used in gas rooms or in approved gas cabinets or exhausted enclosures as specified in this code.
[c]With pressure-relief devices for stationary or portable containers vented directly outdoors or to an exhaust hood.
[d]Quantities are permitted to be increased 100 percent where stored or used in approved cabinets, gas cabinets, exhausted enclosures, or gas rooms as appropriate for the material stored. Where Footnote e also applies, the increase for the quantities in both footnotes is permitted to be applied accumulatively.
[e]Maximum quantities are permitted to be increased 100 percent in buildings equipped throughout with automatic sprinkler systems in accordance with NFPA 13. Where Footnote d also applies, the increase for the quantities in both footnotes is permitted to be applied accumulatively.
[f]Flammable gases in the fuel tanks of mobile equipment or vehicles are permitted to exceed the MAQ where the equipment is stored and operated in accordance with the applicable fire code.
[g]See NFPA 58 for requirements for liquefied petroleum gas (LP-Gas). LP-Gas is not within the scope of NFPA 55.
[h]Additional storage locations are required to be separated by a minimum of 300 ft (92 m).
[i]In mercantile occupancies, storage of LP-Gas is limited to a maximum of 200 lb (91 kg) in nominal 1 lb (0.45 kg) LP-Gas containers.
[j]Permitted only in buildings equipped throughout with automatic sprinkler systems in accordance with NFPA 13.
[k]Allowed only where stored or used in gas rooms or in approved gas cabinets or exhausted enclosures as specified in this code.
[l]High BV Category 1B flammable gas has a burning velocity greater than 3.9 in./s (10 cm/s). Low BV Category 1B flammable gas has a burning velocity 3.9 in./s (10 cm/s) or less.

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6.3.1.2 Quantities Greater Than the MAQ. Building-related controls in areas with compressed gases or cryogenic fluids stored or used within an indoor area in quantities greater than those shown in Table 6.3.1.1 shall be in accordance with the requirements of Chapter 6.

6.3.1.3 Aggregate Allowable Quantities. The aggregate quantity in use and storage shall not exceed the quantity listed for storage.

6.3.1.4 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, provided the area is constructed to meet the requirements of the most restrictive protection level and that the incompatible materials are separated as required by 7.1.10.2.

6.3.1.5 Multiple Hazards. When 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.

6.3.1.6 Flammable and Oxidizing Gases.

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

6.3.1.6.2 Cylinders, containers, or tanks not exceeding 250 scf (7.1 Nm^3) content at normal temperature and pressure (NTP) and used for maintenance purposes, patient care, or operation of equipment shall be permitted.

6.3.1.6.3 Hydrogen gas systems located in a hydrogen gas room that meet the requirements of Section 6.5 shall be permissible in quantities up to those allowed by Table 6.3.1.1 in assembly, educational, institutional, residential, or business occupancies.

6.3.1.7 Toxic and Highly Toxic Compressed Gases. Except for containers or cylinders not exceeding 20 scf (0.6 Nm^3) 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. Where a gas room is used to increase the threshold quantity for a gas requiring special provisions or where otherwise required by the material or application specific requirements of Chapters 7 through 16, the room 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.

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 Hydrogen Gas Rooms.

6.5.1 Floors, walls, and ceilings shall be constructed of noncombustible or limited-combustible materials in accordance with the requirements of the building code.

6.5.1.1 Interior walls or partitions shall have a fire resistance rating of not less than 2 hours, shall be continuous from floor to ceiling, and shall be anchored to resist movement.

6.5.1.2 Not less than 25 percent of the perimeter wall shall be an exterior wall.

6.5.1.3 Openings to other parts of the building shall not be permitted.

6.5.1.4 Windows and doors shall be in exterior walls only.

6.5.2 Ventilation shall be as provided in Section 6.17.

6.5.3 Explosion control shall be provided in accordance with the requirements of Section 6.10.

6.5.4 There shall be no sources of ignition from open flames, electrical equipment, or heating equipment.

6.5.5 Electrical equipment shall be in accordance with Article 501 of *NFPA 70* for Class I, Division 2 locations.

6.5.6 Heating, if provided, shall be by steam, hot water, or indirect means except that electrical heating shall be permitted to be used if in compliance with 6.5.5.

6.6* Detached Buildings. Occupancies used for the storage or use of compressed gases, including individual bulk hydrogen compressed gas systems in quantities exceeding those specified in Table 6.6, shall be in detached buildings constructed in accordance with the provisions of the building code.

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Table 6.6 Detached Buildings Required Where Quantity of Material Exceeds Amount Shown

Gas Hazard	Class	Quantity of Material	
		scf	Nm^3
Individual bulk hydrogen compressed gas systems	N/A	15,000	425
Unstable reactive (detonable)	4 or 3	Quantity thresholds for gases requiring special provisions*	
Unstable reactive (nondetonable)	3	2,000	57
Unstable reactive (nondetonable)	2	10,000	283
Pyrophoric gas†	N/A	2,000	57

N/A: Not applicable.
*See Table 6.3.1.1.
†Detached buildings are not required for gases in high-hazard gas rooms that support Protection Level 5 fabrication facilities separated from other areas by a fire barrier with a fire resistance rating of not less than 2 hours, where the gas is located in internally sprinklered gas cabinets equipped with continuous leak detection and automatic shutdown, where the supply is from cylinders that do not exceed 125 lb (57 kg) water capacity per 49 CFR 173.192 for Hazard Zone A toxic gases, and where the gas cabinets are not manifolded upstream of pressure control devices.

6.7 Weather Protection.

6.7.1 For other than explosive materials and hazardous materials presenting a detonation hazard, a weather protection structure shall be permitted to be used for sheltering outdoor storage or use areas, without requiring such areas to be classified as indoor storage or use.

6.7.2 Weather protected areas constructed in accordance with 6.7.3 shall be regulated as outdoor storage or use.

6.7.2.1 Weather protected areas that are not constructed in accordance with 6.7.3 shall be regulated as indoor storage or use.

6.7.3 Buildings or structures used for weather protection shall be in accordance with the following:

(1) The building or structure shall be constructed of noncombustible materials.
(2) Walls shall not obstruct more than one side of the structure.
(3) Walls shall be permitted to obstruct portions of multiple sides of the structure, provided that the obstructed area does not exceed 25 percent of the structure's perimeter area.
(4) The building or structure shall be limited to a maximum area of 1500 ft^2 (140 m^2), with increases in area allowed by the building code based on occupancy and type of construction.
(5) The distance from the structure constructed as weather protection to buildings, lot lines, public ways, or means of egress to a public way shall not be less than the distance required for an outside hazardous material storage or use area without weather protection based on the hazard classification of the materials contained.
(6) Reductions in separation distance shall be permitted based on the use of fire barrier walls where permitted for specific materials in accordance with the requirements of Chapters 7 through 11.

6.8* Electrical Equipment. Electrical wiring and equipment shall be in accordance with Section 6.8, *NFPA 70*, and NFPA 79, as applicable.

6.8.1 Standby Power.

6.8.1.1 Where the following systems are required by this code for 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*:

(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 6.8.2 and *NFPA 70*.

6.8.1.3 When standby power is required, the system shall meet the requirements for a Level 2 system in accordance with NFPA 111.

6.8.2 Emergency Power. When emergency power is required, the system shall meet the requirements for a Level 2 system in accordance with NFPA 110 or NFPA 111.

6.9* Employee Alarm System. Where required by government regulations, an employee alarm system shall be provided to allow warning for necessary emergency action as called for in the emergency action plan required by 4.2.1.1, or for reaction time for safe egress of employees from the workplace or the immediate work area, or both.

6.10 Explosion Control. Explosion control shall be provided as required by Table 6.10 in accordance with NFPA 68, or NFPA 69, where amounts of compressed gases in storage or use exceed the quantity thresholds requiring special provisions.

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.

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.

6.11.2.1 Where sprinkler protection is required, 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 11.2.3.1.1 of NFPA 13 for the Ordinary Hazard Group 2 density/area curve.

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Table 6.10 Explosion Control Requirements

Material	Class	Explosion Control Methods	
		Barricade Construction	Explosion Venting or Prevention Systems
Flammable cryogenic fluid	—	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

6.11.2.2 Where sprinkler protection is required, 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 11.2.3.1.1 of NFPA 13 for the Extra Hazard Group 1 density/area curve.

6.12 Lighting. Approved lighting by natural or artificial means shall be provided for areas of storage or use.

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 in accordance with NFPA 704.

6.13.1.1 Ratings shall be assigned in accordance with NFPA 704.

6.13.1.2 The authority having jurisdiction shall be permitted to waive 6.13.1 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 25 ft (7.6 m) 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 Shelves and containers shall be secured from overturning.

6.16 Vent Pipe Termination. The termination point for piped vent systems serving cylinders, containers, tanks, and gas systems used for the purpose of operational or emergency venting shall be located to prevent impingement exposure on the system served and to minimize the effects of high temperature thermal radiation or the effects of contact with the gas from the escaping plume to the supply system, personnel, adjacent structures, and ignition sources.

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 fixed natural ventilation, where natural ventilation is shown to be acceptable for the material as stored.

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

6.17.2 Ventilation Systems. In addition to the requirements of Section 6.17, ventilation systems shall be designed and installed in accordance with the requirements of the mechanical code.

6.17.3 Mechanical Exhaust Ventilation. Where mechanical exhaust ventilation is provided, the system shall be operational during the time the building or space is occupied.

6.17.3.1 Continuous Operation. When operation of ventilation systems is required, systems shall operate continuously unless an alternative design is approved by the AHJ.

6.17.3.2 Ventilation Rate. Mechanical exhaust or fixed natural ventilation shall be provided at a rate of not less than 1 scf/min/ft^2 (0.0051 m^3/sec/m^2) of floor area over the area of storage or use.

6.17.3.3 Shutoff Controls. Where powered ventilation is provided, a manual shutoff switch shall be provided outside the room in a position adjacent to the principal access door to the room or in an approved location.

6.17.3.3.1 Manual Shutoff Switch. The switch shall be the breakglass or equivalent type and shall be labeled as follows:

WARNING:

VENTILATION SYSTEM EMERGENCY SHUTOFF

6.17.4 Exhaust System.

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

6.17.4.2* For gases that are heavier than air, exhaust shall be taken from a point within 12 in. (305 mm) of the floor. The use of supplemental inlets shall be allowed to be installed at points above the 12 in. (305 mm) threshold level.

6.17.4.3* For gases that are lighter than air, exhaust shall be taken from a point within 12 in. (305 mm) of the ceiling. The

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use of supplemental inlets shall be allowed to be installed at points below the 12 in. (305 mm) threshold level.

6.17.4.4 The location of both the exhaust and inlet air openings shall be designed to provide air movement across all portions of the floor or ceiling of the room or area to prevent the accumulation of vapors within the ventilated space.

6.17.5 Recirculation of Exhaust. Exhaust ventilation shall not be recirculated.

6.17.6 Ventilation Discharge. Ventilation discharge systems shall terminate at a point not less than 50 ft (15 m) from intakes of air-handling systems, air-conditioning equipment, and air compressors.

6.17.7 Air Intakes. Storage and use of compressed gases shall be located not less than 20 ft (6 m) from air intakes. *(See Sections 7.5 through 7.11 for material-specific requirements.)*

6.18 Gas Cabinets. 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 through 6.18.5.

6.18.1 Construction.

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

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

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

6.18.2 Ventilation Requirements.

6.18.2.1 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 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 200 ft/min (61 m/min) average, with not less than 150 ft/min (46 m/min) at any single point.

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

6.18.4 Quantity Limits.

6.18.4.1 Gas cabinets shall contain not more than three cylinders, containers, or tanks, where each contains greater than or equal to 10 scf (0.28 m^3).

6.18.4.2 Gas cabinets shall contain not more than 30 cylinders, containers, or tanks, where the capacity of each is less than 10 scf (0.28 m^3) in place of a cylinder, container, or tank containing greater than or equal to 10 scf (0.28 m^3).

6.18.5 Separation of Incompatibles. Incompatible gases, as defined by Table 7.1.10.2, shall be stored or used within separate gas cabinets.

6.18.6* All cylinders in gas cabinets shall be individually secured to prevent falling or rolling and designed to allow exhaust airflow around the cylinders.

6.18.7* The interior of gas cabinets handling flammable gases or flammable liquefied gases shall be electrically classified as determined by a qualified individual in accordance with the requirements of *NFPA 70*.

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 200 ft/min (61 m/min) average, with not less than 150 ft/min (46 m/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 7.1.10.2.

6.19.1.3 Fire Protection. Exhausted enclosures shall be internally sprinklered.

6.19.2 Separation. Incompatible gases, as defined by Table 7.1.10.2, shall be stored or used within separate exhausted enclosures.

6.20* Source Valve. Bulk gas systems shall be provided with a source valve.

6.20.1 The source valve shall be marked.

6.20.2 The source valve shall be designated on the design drawings for the installation.

Chapter 7 Compressed Gases

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

7.1.1 Where the primary supply of compressed gas is stored in a bulk liquid form, the provisions of Chapter 8 shall apply to piping and other gaseous system components downstream of the liquid vaporizer and upstream of the source valve.

7.1.2 Compressed Gas Systems.

7.1.2.1 Design. Compressed gas systems shall be designed for the intended use and shall be designed by persons competent in such design.

7.1.2.2 Installation. Installation of bulk compressed gas systems shall be supervised by personnel knowledgeable in the application of the standards for their construction and use.

7.1.2.3 Tube trailers used as gas supply systems shall comply with the mandatory requirements of CGA P-74, *Standard for Tube Trailer Supply Systems at Customer Sites.*

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7.1.3 Insulated Liquid Carbon Dioxide Systems. Insulated liquid carbon dioxide systems shall be in accordance with Chapter 13.

7.1.4 Insulated Liquid Nitrous Oxide Systems. Insulated liquid nitrous oxide systems shall be in accordance with Chapter 16.

7.1.5 Cylinders, Containers, and Tanks.

7.1.5.1 Design and Construction. Cylinders, containers, and tanks shall be designed, fabricated, tested, and marked (i.e., stamped) in accordance with Department of Transportation (DOT) regulations, Transport Canada's (TC) *Transportation of Dangerous Goods Regulations*, or the ASME *Boiler and Pressure Vessel Code*.

7.1.5.2 Defective Cylinders, Containers, and Tanks.

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

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

7.1.5.2.3 Suppliers shall ensure that defective cylinders, containers, and tanks that have been repaired are evaluated by qualified individuals to verify that the needed repairs and any required testing has been performed and that those repaired or tested are in a serviceable condition before returning them to service.

7.1.5.3 Supports. Stationary cylinders, containers, and tanks shall be provided with engineered supports of noncombustible material on noncombustible foundations.

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

7.1.5.5 Pressure Relief Devices.

7.1.5.5.1 When required by 7.1.5.5.2, pressure relief devices shall be provided to protect containers and systems containing compressed gases from rupture in the event of overpressure from thermal exposure.

7.1.5.5.2 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 — Portable Containers 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 or in accordance with applicable equivalent requirements in the country of use.

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

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

7.1.5.5.5 Pressure relief devices shall be arranged to discharge unobstructed to the open air in such a manner as to prevent any impingement of escaping gas upon the container, adjacent structures, or personnel. This requirement shall not apply to DOT specification containers having an internal volume of 2.0 scf (0.057 Nm^3) or less.

7.1.5.5.6 Pressure relief devices or vent piping shall be designed or located so that moisture cannot collect and freeze in a manner that would interfere with operation of the device.

7.1.5.5.7 Shutoffs Between Pressure Relief Devices and Containers.

7.1.5.5.7.1 General. Shutoff valves installed between pressure relief devices and containers shall be in accordance with 7.1.5.5.7.2 through 7.1.5.5.7.4.

7.1.5.5.7.2 Location. Shutoff valves shall not be installed between pressure relief devices and containers unless the valves or their use meet the requirements of 7.1.5.5.7.3 or 7.1.5.5.7.4.

7.1.5.5.7.3* Security. Shutoff valves, where used, shall be locked in the open position, 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*.

7.1.5.5.7.4 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 relief devices at all times.

7.1.6 Cathodic Protection. Where required, cathodic protection shall be in accordance with 7.1.6.

7.1.6.1 Operation. Where installed, cathodic protection systems shall be operated and maintained to continuously provide corrosion protection.

7.1.6.2 Inspection. Container systems equipped with cathodic protection shall be inspected for the intended operation by a cathodic protection tester. The frequency of inspection shall be determined by the designer of the cathodic protection system.

7.1.6.2.1 The cathodic protection tester shall be certified as being qualified by the National Association of Corrosion Engineers, International (NACE).

7.1.6.3 Impressed Current Systems. Systems equipped with impressed current cathodic protection systems shall be inspected in accordance with the requirements of the design and 7.1.6.2.

7.1.6.3.1 The design limits of the cathodic protection system shall be available to the AHJ upon request.

7.1.6.3.2 The system owner shall maintain the following records to demonstrate that the cathodic protection is in conformance with the requirements of the design:

(1) The results of inspections of the system
(2) The results of testing that has been completed

7.1.6.4 Repairs, maintenance, or replacement of a cathodic protection system shall be under the supervision of a corrosion expert certified by NACE.

7.1.6.4.1 The corrosion expert shall be certified by NACE as a senior corrosion technologist, a cathodic protection specialist, or a corrosion specialist or shall be a registered engineer with registration in a field that includes education and experience in corrosion control.

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7.1.7 Labeling Requirements.

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

7.1.7.2 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.

7.1.7.3 Stationary Compressed Gas Cylinders, Containers, and Tanks.

7.1.7.3.1 Stationary compressed gas cylinders, containers, and tanks shall be marked in accordance with NFPA 704.

7.1.7.3.2 Markings shall be visible from any direction of approach.

7.1.7.4 Piping Systems.

7.1.7.4.1 Except as provided in 7.1.7.4.2, piping systems shall be marked in accordance with ASME A13.1, *Scheme for the Identification of Piping Systems,* or other applicable approved 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 20 ft (6.1 m) or fraction thereof throughout the piping run

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

7.1.8 Security.

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

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

7.1.8.2.1 Administrative controls shall be allowed to be used to control access to individual storage, use, and handling areas located in secure facilities not accessible by the general public.

7.1.8.3 Physical Protection.

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

7.1.8.3.2 Guard posts or other means shall be provided to protect compressed gas cylinders, containers, tanks, and systems indoors and outdoors from vehicular damage in accordance with Section 4.11.

7.1.8.4 Securing Compressed Gas Cylinders, Containers, and Tanks. Compressed gas cylinders, containers, and tanks in use or in storage shall be secured to prevent them from falling or being knocked over by corralling them and securing them to a cart, framework, or fixed object by use of a restraint, unless otherwise permitted by 7.1.8.4.1 and 7.1.8.4.2.

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

7.1.8.4.2 At cylinder-filling plants, authorized cylinder requalifier's facilities, and distributors' warehouses, the nesting of cylinders shall be permitted as a means to secure cylinders.

7.1.9 Valve Protection.

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

7.1.9.1.1 Valve protection of individual valves shall not be required to be installed on individual cylinders, containers, or tanks installed on tube trailers or similar transportable bulk gas systems equipped with manifolds that are provided with a means of physical protection that will protect the valves from physical damage when the equipment is in use. Protective systems required by DOT for over the road transport shall provide an acceptable means of protection.

7.1.9.1.1.1 Valve protection of individual valves shall not be required on cylinders, containers, or tanks that comprise bulk or non-bulk gas systems where the containers are stationary, or portable equipped with manifolds, that are provided with physical protection in accordance with Section 4.11 and 7.1.8.3 or other approved means. Protective systems required by DOT for over the road transport shall provide an acceptable means of protection.

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

7.1.9.3 Valve Outlet Caps or Plugs.

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

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

7.1.10 Separation from Hazardous Conditions.

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

7.1.10.2* Incompatible Materials. Gas cylinders, containers, and tanks shall be separated in accordance with Table 7.1.10.2.

7.1.10.2.1 Subparagraph 7.1.10.2 shall not apply to gases contained within closed piping systems.

7.1.10.2.2 The distances shown in Table 7.1.10.2 shall be permitted to be reduced without limit where compressed gas cylinders, containers, and tanks are separated by a barrier of noncombustible construction that has a fire resistance rating of

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Table 7.1.10.2 Separation of Gas Cylinders, Containers, 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	
		ft	m	ft	m	ft	m	ft	m	ft	m	ft	m
Toxic or highly toxic	NR	20	6.1	20	6.1	20	6.1	20	6.1	20	6.1	—	—
Pyrophoric	NR	20	6.1	20	6.1	20	6.1	20	6.1	—	—	20	6.1
Flammable	NR	20	6.1	20	6.1	20	6.1	—	—	20	6.1	20	6.1
Oxidizing	NR	20	6.1	20	6.1	—	—	20	6.1	20	6.1	20	6.1
Corrosive	NR	20	6.1	—	—	20	6.1	20	6.1	20	6.1	20	6.1
Unstable reactive Class 2, Class 3, or Class 4	NR	—	—	20	6.1	20	6.1	20	6.1	20	6.1	20	6.1
Other gas	—	NR		NR		NR		NR		NR		NR	

NR: No separation required.

at least 0.5 hour and interrupts the line of sight between the containers.

7.1.10.2.3* The distances shown in Table 7.1.10.2 shall be permitted to be reduced without limit where it has been determined that compressed gas cylinders, containers, and tanks are not incompatible.

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

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

7.1.10.2.6* Spatial separation shall not be required between cylinders deemed to be incompatible in gas production facilities where cylinders are connected to manifolds for the purposes of filling, analysis of compressed gases, or manufacturing procedures, assuming the prescribed controls for the manufacture of gas mixtures are in place.

7.1.10.3* Clearance from Combustibles and Vegetation. Combustible waste, vegetation, and similar materials shall be kept a minimum of 10 ft (3.1 m) from compressed gas cylinders, containers, tanks, and systems.

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

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

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

7.1.10.5 Temperature Extremes. Compressed gas cylinders, containers, and tanks, whether full or partially full, shall not be exposed to temperatures exceeding 125°F (52°C) or subambient (low) temperatures unless one of the following apply:

(1) The compressed gas cylinders, containers, or tanks are designed for use under such exposure
(2) The compressed gas cylinders, containers, or tanks are located at compressed gas manufacturing facilities where all of the following apply:
    (a) Temperatures above 125°F (52°C) and below subambient (low) temperatures are permitted for the purposes of filling, analysis, and other related procedures
    (b) Engineering controls are employed to prevent any hazards
    (c) The temperature extremes will not degrade the original mechanical properties of the containers, cylinders, or tanks

7.1.10.5.1 Compressed gas cylinders, containers, and tanks that have not been designed for use under elevated temperature conditions shall not be exposed to direct sunlight outdoors where ambient temperatures exceed 125°F (52°C).

7.1.10.5.2 The use of a weather protection structure or shaded environment for storage or use shall be permitted as a means to protect against direct exposure to sunlight.

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

7.1.10.7 Heating. Compressed gas cylinders, containers, 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 125°F (52°C).

7.1.10.7.1 Electrically Powered Heating Devices. Electrical heating devices shall be in accordance with *NFPA 70*.

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

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

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

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7.1.10.9.1 Compressed gas cylinders shall not be located where they could be exposed to spills of flammable and combustible liquids.

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

7.1.10.10.1* Electrical devices mounted on compressed gas piping, cylinders, containers, or tanks shall be installed, grounded, and bonded in accordance with the methods specified in *NFPA 70* (NEC).

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

7.1.12 Unauthorized Use. Compressed gas cylinders, containers, 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.

7.1.13 Cylinders, Containers, and Tanks Exposed to Fire. Compressed gas cylinders, containers, 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.

7.1.14 Leaks, Damage, or Corrosion.

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

7.1.14.2 Replacement and Repair. Leaking, damaged, or corroded compressed gas systems shall be replaced or repaired.

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

7.1.14.4 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.

7.1.15 Surfaces.

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

7.1.15.2 Surfaces shall be graded to prevent accumulation of water.

7.1.16 Storage Area Temperature.

7.1.16.1 Compressed Gas Containers. Storage area temperatures shall not exceed 125°F (52°C).

7.1.17 Underground Piping.

7.1.17.1 Underground piping shall be of welded construction without valves, unwelded mechanical joints, or connections installed underground.

7.1.17.1.1 Valves or connections located in boxes or enclosures shall be permitted to be installed underground where such boxes or enclosures are accessible from above ground and where the valves or connections contained are isolated from direct contact with earth or fill.

7.1.17.1.1.1 Valve boxes or enclosures installed in areas subject to vehicular traffic shall be constructed to resist uniformly distributed and concentrated live loads in accordance with the building code for areas designated as vehicular driveways and yards, subject to trucking.

7.1.17.1.2* Piping installed in trench systems located below grade where the trench is open to above shall not be considered to be underground.

7.1.17.2 Gas piping in contact with earth or other material that could corrode the piping shall be protected against corrosion in an approved manner.

7.1.17.2.1 When cathodic protection is provided, it shall be in accordance with 7.1.6.

7.1.17.3 Underground piping shall be installed on at least 6 in. (150 mm) of well-compacted bedding material. [**30:**27.6.5.1]

7.1.17.4 In areas subject to vehicle traffic, the pipe trench shall be deep enough to permit a cover of at least 18 in. (450 mm) of well-compacted backfill material and pavement. [**30:**27.6.5.2]

7.1.17.5 In paved areas where a minimum 2 in. (50 mm) of asphalt is used, backfill between the pipe and the asphalt shall be permitted to be reduced to 8 in. (200 mm) minimum. [**30:**27.6.5.3]

7.1.17.6 In paved areas where a minimum 4 in. (100 mm) of reinforced concrete is used, backfill between the pipe and the concrete shall be permitted to be reduced to 4 in. (100 mm) minimum. **[30:**27.6.5.4]

7.1.17.7 In areas not subject to vehicle traffic, the pipe trench shall be deep enough to permit a cover of at least 12 in. (300 mm) of well-compacted backfill material.

7.1.17.8 A greater burial depth shall be provided when required by the manufacturer's instructions or where frost conditions are present. [**30:**27.6.5.6]

7.1.17.9 Piping within the same trench shall be separated horizontally by at least two pipe diameters. Separation need not exceed 9 in. (230 mm). [**30:**27.6.5.7]

7.1.17.10 Two or more levels of piping within the same trench shall be separated vertically by a minimum 6 in. (150 mm) of well-compacted bedding material. [**30:**27.6.5.8]

7.1.18 Cleaning and Purging of Gas Piping Systems.

7.1.18.1 General.

7.1.18.1.1 Piping systems shall be cleaned and purged in accordance with the requirements of 7.1.18 when one or more of the following conditions exist:

(1) The system is installed and prior to being placed into service
(2) There is a change in service
(3)* There are alterations or repair of the system involving the replacement of parts or addition to the piping system and prior to returning the system to service
(4)* The design standards or written procedures specify cleaning and purging

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7.1.18.1.2 Cleaning and purging of the internal surfaces of piping systems shall be conducted by qualified individuals trained in cleaning and purging operations and procedures, including the recognition of potential hazards associated with cleaning and purging.

7.1.18.1.3* A written cleaning or purging procedure shall be provided to establish the requirements for the cleaning and purging operations to be conducted.

7.1.18.1.3.1* An independent or third-party review of the written procedure shall be conducted after the procedure has been written and shall accomplish the following:

(1) Evaluate hazards, errors, and malfunctions related to each step in the procedure
(2) Review the measures prescribed in the procedure for applicability
(3) Make recommendations for additional hazard mitigation measures if deemed necessary

7.1.18.1.3.2 The completed written procedure shall be as follows:

(1) Maintained on site by the facility owner/operator
(2) Provided to operating personnel engaged in cleaning or purging operations
(3) Made available to the AHJ upon request

7.1.18.1.3.3 Where generic cleaning or purging procedures have been established, a job-specific operating procedure shall not be required.

7.1.18.1.3.4 Generic procedures shall be reviewed when originally published or when the procedure or operation is changed.

7.1.18.1.4 Written procedures to manage a change in process materials, technology, equipment, procedures, and facilities shall be established by the facility owner/operator.

7.1.18.1.4.1 The management-of-change procedures shall ensure that the following topics are addressed prior to any change in the configuration or design of the piping system:

(1) The technical basis for the proposed change
(2) The safety and health implications
(3) Whether the change is permanent or temporary
(4) Whether modifications to the cleaning and purging procedures are required as a result of the identified changes

7.1.18.1.4.2 When modifications to the cleaning and purging procedures are required, the written procedure shall be updated to incorporate any elements identified by the management-of-change procedures.

7.1.18.1.5 Prior to cleaning or purging, piping systems shall be inspected and tested to determine that the installation, including the materials of construction, and method of fabrication, comply with the requirements of the design standard used and the intended application for which the system was designed.

7.1.18.1.5.1 Inspection and testing of piping systems shall not be required to remove a system from service.

7.1.18.1.5.2 Purging of piping systems shall not be required for systems that are utilized for operations designated by written operating procedures in accordance with the requirements of the cleaning or purging procedure specified in 7.1.18.1.1.

7.1.18.1.5.3* Personnel in the affected area(s), as determined by the cleaning or purging procedure, shall be informed of the hazards associated with the operational activity and notified prior to the initiation of any such activity.

7.1.18.2* Cleaning. Piping system designs shall be documented to specify the requirements for the internal cleaning of the piping system prior to installation and initial use.

7.1.18.2.1 The internal surfaces of gas piping systems shall be cleaned to ensure that the required standard of cleanliness specified by the design is met prior to placing the gas piping system into service.

7.1.18.2.2* When piping systems are cleaned in stages during installation or assembly, the interior of the cleaned piping shall be protected against the infiltration of unwanted contaminants.

7.1.18.3* Purging. Piping systems used to contain gases with a physical or health hazard in any of the categories specified by Section 5.1 shall be purged prior to being placed into service for initial use.

7.1.18.3.1 Piping systems shall be purged to remove the internal contents preceding the following activities or operations:

(1) Activating or placing a piping system into service
(2) Deactivating or removing a piping system from service
(3) Changing the service of a piping system from one gas to another, except when such gas is supplied to a manifold or piping system designed for the purpose of filling or otherwise processing cylinders, containers, or tanks in a process with established procedures
(4) Performing service, maintenance, or modifications on a system where personnel or designated areas will potentially be exposed to the internal contents of the piping system
(5) Performing hot work, including but not limited to, welding, cutting, or brazing on the piping system

7.1.18.3.2 The termination point for the release of purged gases shall be in accordance with Section 6.16.

7.1.18.3.2.1 The release of purged gases or mixtures containing any quantity of corrosive, toxic, or highly toxic gases shall be through a treatment system in accordance with the applicable requirements of 7.6.3.4 or 7.10.3.

7.1.18.3.2.2 The termination point for the release of purged gases resultant from the purging of piping systems out of service, other than those in accordance with 7.1.18.3.2.1, shall not be required to be in accordance with Section 6.16 where the contained volume of the piping system (when released to indoor areas) does not result in a concentration in the room or area that will reduce the oxygen concentration in the room or area below a level of 19.5 percent or that exceeds any of the following limits:

(1) Ceiling limit
(2) Permissible exposure limit
(3) Short-term exposure limit
(4) Twenty-five percent of the lower flammable limit

7.2 Subatmospheric Gas Sources (SAGS).

7.2.1 The storage and use of subatmospheric gas sources (type 1 or 2) with compatible gases shall meet all the requirements of this code based on the assigned hazard categories listed in Section 5.1.

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7.2.2 SAGS cylinders with incompatible gases shall meet the requirements of 17.14.2.1 through 17.14.2.6 in NFPA 318.

7.3 Storage.

7.3.1 General.

7.3.1.1 Applicability. The storage of compressed gas cylinders, containers, and tanks shall be in accordance with Section 7.3.

7.3.1.2 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.

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

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

7.3.1.2.3 Palletized Cylinders, Containers, and Tanks. Cylinders, containers, 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.

7.3.1.3 Classification of Weather Protection as an Indoor Versus an Outdoor Area. For other than explosive materials and hazardous materials presenting a detonation hazard, a weather protection structure shall be permitted to be used for sheltering outdoor storage or use areas without requiring such areas to be classified as indoor storage.

7.3.2 Material-Specific Regulations.

7.3.2.1 Indoor Storage. Indoor storage of compressed gases shall be in accordance with the material-specific provisions of Sections 7.5 through 7.11.

7.3.2.2 Exterior Storage.

7.3.2.2.1 General. Exterior storage of compressed gases shall be in accordance with the material-specific provisions of Sections 7.5 through 7.11.

7.3.2.2.2 Separation. Distances from property lines, buildings, and exposures shall be in accordance with the material-specific provisions of Sections 7.5 through 7.11.

7.4 Use and Handling.

7.4.1 General.

7.4.1.1 Applicability. The use and handling of compressed gas cylinders, containers, tanks, and systems shall be in accordance with 7.4.1.

7.4.1.2 Controls.

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

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

7.4.1.3 Piping Systems. Piping, tubing, fittings, and related components shall be designed, fabricated, and tested in accordance with the requirements of the applicable parts in ASME B31.3, *Process Piping*.

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

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

7.4.1.4 Valves.

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

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

7.4.1.5 Vent Pipe Termination.

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

7.4.1.5.2 The termination point for piped vent systems serving cylinders, containers, tanks, and gas systems used for the purpose of operational or emergency venting shall be in accordance with Section 6.16.

7.4.1.6 Upright Use.

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

7.4.1.6.2 An upright position shall include a position in which the cylinder, container, 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.

7.4.1.7 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.

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

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

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

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

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

7.4.1.11 Emergency Shutoff Valves.

7.4.1.11.1 Accessible manual or automatic emergency shutoff valves shall be provided to shut off the flow of gas in case of emergency.

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7.4.1.11.1.1* Manual emergency shutoff valves or the device that activates an automatic emergency shutoff valve on a bulk source or piping system serving the bulk supply shall be identified by means of a sign.

7.4.1.11.2 Emergency shutoffs shall be located at the point of use and at the tank, cylinder, or bulk source, and at the point where the system piping enters the building.

7.4.1.12 Emergency Isolation.

7.4.1.12.1 Where compressed gases from sources in excess of the quantity thresholds in Table 6.3.1.1 having a hazard ranking in one or more of the following hazard classes in accordance with NFPA 704 are carried in pressurized piping above a gauge pressure of 15 psi (103 kPa), an approved method of emergency isolation shall be provided:

(1) Health hazard Class 3 or Class 4
(2) Flammability Class 4
(3) Instability Class 3 or Class 4

7.4.1.12.2 Approved means of meeting the requirements for emergency isolation shall include any of the following:

(1) Automatic shutoff valves, located as close to the bulk source as practical, tied to leak detection systems
(2) Attended control stations where trained personnel can monitor alarms or supervisory signals and can trigger emergency responses
(3) A constantly monitored control station with an alarm and remote shutoff of the gas supply system
(4) Excess flow valves at the bulk source

7.4.1.12.3 The requirements of 7.4.1.12 shall not be required for the following:

(1) Piping for inlet connections designed to prevent backflow at the source
(2) Piping for pressure relief devices

7.4.1.12.4 Location Exemptions. The requirements of 7.4.1.12 shall not apply to the following:

(1) Piping for inlet connections designed to prevent backflow
(2) Piping for pressure relief devices
(3) Systems containing 430 scf (12.7 Nm^3) or less of flammable gas

7.4.2 Material-Specific Regulations.

7.4.2.1 Indoor Use. Indoor use of compressed gases shall be in accordance with the requirements of Sections 7.5 through 7.11.

7.4.2.2 Exterior Use.

7.4.2.2.1 General. Exterior use of compressed gases shall be in accordance with the requirements of Sections 7.5 through 7.11.

7.4.2.2.2 Separation. Distances from property lines, buildings, and exposure hazards shall be in accordance with the material-specific provisions of Sections 7.5 through 7.11.

7.4.3 Handling.

7.4.3.1 Applicability. The handling of compressed gas cylinders, containers, and tanks shall be in accordance with 7.4.3.

7.4.3.2 Carts and Trucks.

7.4.3.2.1 Cylinders, containers, and tanks shall be moved using an approved method.

7.4.3.2.2 Where cylinders, containers, and 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 cylinders, containers, and tanks.

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

7.5 Medical Gas Systems. Medical gas systems for health care shall be in accordance with NFPA 99.

7.6 Corrosive Gases.

7.6.1 General. The storage or use of corrosive compressed gases exceeding the quantity thresholds for gases requiring special provisions as specified in Table 6.3.1.1 shall be in accordance with Chapters 1 through 6 and Sections 7.1 through 7.4 and 7.6.

7.6.2 Distance to Exposures. The outdoor storage or use of corrosive compressed gas shall not be within 20 ft (6.1 m) of buildings not associated with the manufacture or distribution of corrosive gases, lot lines, streets, alleys, public ways, or means of egress.

7.6.2.1 A 2-hour fire barrier wall without openings or penetrations and that extends not less than 30 in. (762 mm) above and to the sides of the storage or use area shall be permitted in lieu of the 20 ft (6.1 m) distance.

7.6.2.1.1* Where a fire barrier is used to protect compressed gas systems, the system shall terminate downstream of the source valve.

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

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

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

7.6.3 Indoor Use. The indoor use of corrosive gases shall be provided with a gas cabinet, exhausted enclosure, or gas room.

7.6.3.1 Gas Cabinets. Gas cabinets shall be in accordance with Section 6.18.

7.6.3.2 Exhausted Enclosures. Exhausted enclosures shall be in accordance with Section 6.19.

7.6.3.3 Gas Rooms. Gas rooms shall be in accordance with Section 6.4.

7.6.3.4 Treatment Systems. Treatment systems, except as provided for in 7.6.3.4.1, gas cabinets, exhausted enclosures, and gas rooms containing corrosive gases in use shall be provided with exhaust ventilation, with all exhaust directed to a

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treatment system designed to process the accidental release of gas.

7.6.3.4.1 Treatment systems shall not be required for corrosive gases in use where provided with the following:

(1) Gas detection in accordance with 7.10.3.2.1.1
(2) Fail-safe automatic closing valves in accordance with 7.10.3.2.2

7.6.3.4.2 Treatment systems shall be capable of diluting, adsorbing, absorbing, containing, neutralizing, burning, or otherwise processing the release of corrosive gas in accordance with 7.10.3.4.1.

7.6.3.4.3 Treatment system sizing shall be in accordance with 7.10.3.4.

7.7 Flammable Gases.

7.7.1 Storage, Use, and Handling.

7.7.1.1* The storage or use of flammable gases exceeding the quantity thresholds for gases requiring special provisions as specified in Table 6.3.1.1 shall be in accordance with Chapters 1 through 6 and Sections 7.1 through 7.4 and Section 7.7.

7.7.1.2 Storage, use, and handling of gaseous hydrogen shall be in accordance with 7.7.1 and Chapter 10.

7.7.1.3 Storage, use, and handling of compressed natural gas shall be in accordance with 7.7.1.

7.7.2 Distance to Exposures. The outdoor storage or use of non-bulk flammable compressed gas shall be located from lot lines, public streets, public alleys, public ways, or buildings not associated with the manufacture or distribution of such gases in accordance with Table 7.7.2.

7.7.2.1 Bulk hydrogen gas installations shall be in accordance with Chapter 10.

7.7.2.1.1* Where a protective structure is used to protect compressed gas systems, the system shall terminate downstream of the source valve.

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

7.7.2.2* Bulk gas systems for flammable gases shall be in accordance with Table 10.4.2.2.1(a), Table 10.4.2.2.1(b), or Table 10.4.2.2.1(c) where the quantity of flammable compressed gas exceeds 5000 scf (141.6 Nm^3).

7.7.2.2.1 Where fire barriers are used as a means of distance reduction, fire barriers shall be in accordance with 10.4.2.2.4.

7.7.2.2.2 Mobile acetylene trailer systems (MATS) shall be located in accordance with 15.2.3.

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

7.7.2.4 Storage and use of flammable compressed gases shall not be located within 50 ft (15.2 m) of air intakes or the minimum distance from a hydrogen bulk storage system as specified in Table 10.4.2.2.1(a), Table 10.4.2.2.1(b), or Table 10.4.2.2.1(c), whichever is less.

7.7.2.5 Storage and use of flammable gases outside of buildings shall also be separated from building openings by 25 ft (7.6 m) or the minimum distance from a hydrogen bulk storage system as specified in Table 10.4.2.2.1(a), Table 10.4.2.2.1(b), or Table 10.4.2.2.1(c), whichever is less.

7.7.2.5.1 Fire barriers shall be permitted to be used as a means to separate storage areas from openings or a means of egress used to access the public way.

7.7.2.6 Vents from tube trailers and fixed storage systems under weather protection shall discharge outside the weather protection.

7.7.3 Ignition Source Control. Ignition sources in areas containing flammable gases shall be in accordance with 7.7.3.

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

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

7.7.3.3 Heating. Heating, where provided, shall be by indirect means. Equipment used for heating applications in rooms or areas where flammable gases are stored or used shall be listed and labeled for use in hazardous environments established by

Table 7.7.2 Distance to Exposures for Non-Bulk Flammable Gases

Maximum Amount per Storage Area (scf)	Minimum Distance Between Storage Areas (ft)	Minimum Distance to Lot Lines of Property That Can Be Built Upon (ft)	Minimum Distance to Public Streets, Public Alleys or Public Ways (ft)	Minimum Distance to Buildings on the Same Property		
				Less Than 2-Hour Construction	2-Hour Construction	4-Hour Construction
0–4225	5	5	5	5	0	0
4226–21,125	10	10	10	10	5	0
21,126–50,700	10	15	15	20	5	0
50,701–84,500	10	20	20	20	5	0
84,501–200,000	20	25	25	20	5	0

For SI units, 1 ft = 304.8 mm; 1 scf = 0.02832 Nm^3.

Note: The minimum required distances does not apply where fire barriers without openings or penetrations having a minimum fire-resistive rating of 2 hours interrupt the line of sight between the storage and the exposure. The configuration of the fire barriers shall be designed to allow natural ventilation to prevent the accumulation of hazardous gas concentrations.

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the gases present and shall be installed in accordance with the conditions of the listing and the manufacturer's installation instructions.

7.7.4 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*.

7.7.5 Maintenance of Piping Systems.

7.7.5.1 Maintenance of flammable gas system piping and components shall be performed annually by a qualified representative of the equipment owner.

7.7.5.2 This maintenance shall include inspection for physical damage, leak tightness, ground system integrity, vent system operation, equipment identification, warning signs, operator information and training records, scheduled maintenance and retest records, alarm operation, and other safety-related features.

7.7.5.3 Scheduled maintenance and retest activities shall be formally documented, and records shall be maintained a minimum of 3 years.

7.8 Oxidizing Gases.

7.8.1 General. The storage or use of oxidizing compressed gases exceeding the quantity thresholds for gases requiring special provisions as specified in Table 6.3.1.1 shall be in accordance with Chapters 1 through 6 and Sections 7.1 through 7.4 and 7.8.

7.8.2 Distance to Exposures. The outdoor storage or use of oxidizing compressed gas shall be in accordance with Table 7.8.2.

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

7.8.2.1.1* Where a fire barrier is used to protect compressed gas systems, the system shall terminate downstream of the source valve.

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

7.8.2.2 The fire barrier shall be at least 5 ft (1.5 m) from the storage or use area perimeter.

7.8.2.3 The configuration of the fire barrier shall allow natural ventilation to prevent the accumulation of hazardous gas concentrations.

7.9 Pyrophoric Gases.

7.9.1 General. Pyrophoric compressed gases exceeding the quantity thresholds for gases requiring special provisions as specified in Table 6.3.1.1 shall be stored and used in accordance with Chapters 1 through 6 and Sections 7.1 through 7.4 and Section 7.9.

7.9.2 Silane and Silane Mixtures. Silane and silane mixtures shall be stored, used, and handled in accordance with the provisions of ANSI/CGA G-13, *Storage and Handling of Silane and Silane Mixtures*.

7.9.3 Distance to Exposures. The outdoor storage or use of pyrophoric compressed gas shall be in accordance with Table 7.9.3.

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

7.9.3.1.1* Where a fire barrier is used to protect compressed gas systems, the system shall terminate downstream of the source valve.

Table 7.8.2 Distance to Exposures for Oxidizing Gases

Quantity of Gas Stored (at NTP)		Distance to a Building Not Associated with the Manufacture or Distribution of Oxidizing Gases or to a Public Way or Property Line		Minimum Distance Between Storage Areas	
scf	Nm^3	ft	m	ft	m
0–50,000	0–1416	5	1.5	5	1.5
50,001–100,000	1417–2832	10	3.0	10	3.0
≥100,001	≥2833	15	4.6	15	4.6

Table 7.9.3 Distance to Exposures for Pyrophoric Gases

Maximum Amount per Storage Area		Minimum Distance Between Storage Areas		Minimum Distance to Property Lines		Minimum Distance to Public Ways		Minimum Distance to Buildings on the Same Property: Less Than 2-Hour Construction		Minimum Distance to Buildings on the Same Property: 2-Hour Construction		Minimum Distance to Buildings on the Same Property: 4-Hour Construction	
scf	Nm^3	ft	m	ft	m	ft	m	ft	m	ft	m	ft	m
250	7.1	5	1.5	25	7.6	5	1.5	5	1.5	0	0	0	0
>250 to 2500	>7.1 to 71.0	10	3.0	50	15.2	10	3.0	10	3.0	5	1.5	0	0
>2500 to 7500	>71.0 to 212.4	20	6.0	100	30.5	20	6.0	20	6.0	10	3.0	0	0

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

7.9.3.1.3 The fire barrier shall be at least 5 ft (1.5 m) from the storage or use area perimeter.

7.9.3.1.4 The configuration of the fire barrier shall allow natural ventilation to prevent the accumulation of hazardous gas concentrations.

7.9.3.2 Storage and use of pyrophoric gases outside buildings shall be separated from building openings by 25 ft (7.6 m).

7.9.3.2.1 Fire barriers shall be permitted to be used as a means to separate storage areas from building openings that are used to access the public way.

7.10 Toxic and Highly Toxic Gases.

7.10.1 General. The storage or use of toxic or highly toxic gases exceeding the quantity thresholds for gases that require special provisions as specified in Table 6.3.1.1 shall be in accordance with Chapters 1 through 6 and Sections 7.1 through 7.4 and Section 7.10.

7.10.2 Ventilation and Arrangement.

7.10.2.1 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.

7.10.2.1.1 Gas cabinets shall be in accordance with Section 6.18.

7.10.2.1.2 Exhausted enclosures shall be in accordance with Section 6.19.

7.10.2.1.3 Gas rooms shall be in accordance with Section 6.4.

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

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

7.10.2.2.1.1* Where a fire barrier is used to protect compressed gas systems, the system shall terminate downstream of the source valve.

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

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

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

7.10.2.2.1.5 The minimum distance requirement for exposures shall be reduced to 5 ft (1.5 m) from buildings and 25 ft (7.6 m) from exit discharges where gases are stored in gas cabinets as specified in this code.

7.10.2.2.2 Where the storage or use area is located closer than 75 ft (23 m) 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 50 ft (15 m) horizontally from the storage area, regardless of whether the openings are shielded by a fire barrier.

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

7.10.3 Treatment Systems. Except as provided in 7.10.3.1 and 7.10.3.2, 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.

7.10.3.1 Storage of Toxic or Highly Toxic Gases. Treatment systems shall not be required for toxic or highly toxic gases in storage where cylinders, containers, and tanks are provided with the controls specified in 7.10.3.1.1 through 7.10.3.1.3.

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

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

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

7.10.3.2 Use of Toxic Gases. Treatment systems shall not be required for toxic gases in use where cylinders, containers, and tanks are provided with the controls specified in 7.10.3.2.1 and 7.10.3.2.2.

7.10.3.2.1 Gas Detection.

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

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

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

7.10.3.2.2.1 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.

7.10.3.2.2.2 For attended operations, a manual closing valve shall be permitted when in accordance with 7.10.3.4.3.

7.10.3.2.2.3 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.

7.10.3.2.2.4 The gas detection system 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 OSHA STEL for the gas employed.

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7.10.3.3 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.

7.10.3.3.1 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.

7.10.3.3.2 Treatment systems shall be capable of reducing the allowable discharge concentrations to one-half the IDLH threshold at the point of discharge.

7.10.3.4 Treatment System Sizing.

7.10.3.4.1 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 7.10.3.4.2.

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

7.10.3.4.3 Attended Operations — Alternative Method of System Sizing.

7.10.3.4.3.1 Where source cylinders, containers, 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.

7.10.3.4.3.2 Such process piping systems shall comply with the requirements of 7.10.3.4.3.2(A) through 7.10.3.4.3.2(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 PEL or the 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 cylinders, containers, or tanks, or any combination thereof, to the process system.

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

7.10.3.5 Rate of Release. The time release shall be in accordance with Table 7.10.3.5 for the type of container indicated.

7.10.3.6* Maximum Flow Rate of Release.

7.10.3.6.1 For portable cylinders, containers, 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.

Table 7.10.3.5 Rate of Release

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

7.10.3.6.2* When portable cylinders, containers, 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 based on the following formula:

[7.10.3.6.2]

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

where:
CFM = standard cubic feet per minute of gas of concern under flow conditions
A = area of orifice in square inches *(See Table A.7.10.3.6 for areas of typical restricted flow orifices.)*
P = supply pressure of gas at NTP in pounds per square inch absolute
MW = molecular weight

7.10.3.6.3 For mixtures, the average of the molecular weights shall be used.

7.10.4 Leaking Cylinders, Containers, and Tanks. When cylinders, containers, or tanks are used outdoors in excess of the quantities specified in Table 6.3.1.1 in the column for unsprinklered areas (unprotected by gas cabinets or exhausted enclosures), a gas cabinet, exhausted enclosure, or containment vessel or system shall be provided to control leaks from leaking cylinders, containers, and tanks in accordance with 7.10.4.1 through 7.10.4.2.3.

7.10.4.1 Gas Cabinets or Exhausted Enclosures. Where gas cabinets or exhausted enclosures are provided to handle leaks from cylinders, containers, or tanks, exhaust ventilation shall be provided that is directed to a treatment system in accordance with the provisions of 7.10.3.

7.10.4.2 Containment Vessels or Systems. Where containment vessels or containment systems are provided, they shall comply with the requirements of 7.10.4.2.1 through 7.10.4.2.3.

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

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

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

7.10.5 Emergency Power.

7.10.5.1 General. Emergency power shall comply with the requirements of 7.10.5 in accordance with *NFPA 70*.

7.10.5.2 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.

7.10.5.3 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) Required alarm systems

7.10.5.4 Level. Emergency power systems shall comply with the requirements for a Level 2 system in accordance with NFPA 110.

7.10.6 Gas Detection. Except as provided in 7.10.6.1, a continuous gas detection system in accordance with the requirements of 7.10.6.2 through 7.10.6.6 shall be provided for the indoor storage or use of toxic or highly toxic compressed gases.

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

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

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

7.10.6.4 Automatic Shutdown.

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

7.10.6.4.2 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 gauge pressures less than 15 psi (103.4 kPa), constantly attended, and provided with readily accessible emergency shutoff valves.

7.10.6.5 Detection Points. Detection shall be provided at the locations specified in 7.10.6.5.1 through 7.10.6.5.4.

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

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

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

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

7.10.6.6 Level of Detection. The gas detection system shall detect the presence of gas at or below the PEL or the ceiling limit of the gas for those points identified in 7.10.6.5.2 and 7.10.6.5.3 and at not less than one-half the IDLH level for points identified in 7.10.6.5.1.

7.10.7 Automatic Smoke Detection System. An automatic smoke detection system shall be provided for the indoor storage or use of highly toxic compressed gases in accordance with *NFPA 72*.

7.11 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 6.3.1.1 shall be in accordance with Chapters 1 through 6 and Sections 7.1 through 7.4 and Section 7.11.

7.11.1 Distances to Exposures for Class 2.

7.11.1.1 The outdoor storage or use of unstable reactive Class 2 compressed gas shall not be within 20 ft (6 m) of buildings, lot lines, streets, alleys, or public ways or means of egress.

7.11.1.2 A 2-hour fire barrier wall without openings or penetrations shall be permitted in lieu of the 20 ft (6 m) distance required by 7.11.1.1.

7.11.1.2.1* Where a fire barrier wall is used to protect compressed gas systems, the system shall terminate downstream of the source valve.

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

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

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

7.11.2 Distances to Exposures for Class 3.

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

7.11.2.2 A 2-hour fire barrier wall without openings or penetrations, extending not less than 30 in. (762 mm) 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 75 ft (23 m) distance specified in 7.11.2.1.

7.11.2.2.1* Where a fire barrier wall is used to protect compressed gas systems, the system shall terminate downstream of the source valve.

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

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

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

7.11.3 Storage Configuration.

7.11.3.1 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 100 ft^2 (9.3 m^2).

7.11.3.2 Multiple areas shall be separated by aisles.

7.11.3.3 Aisle widths shall not be less than the height of the cylinders, containers, or tanks or 4 ft (1.2 m), whichever is greater.

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

7.11.5 Unstable Reactive Gases (Detonable).

7.11.5.1 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 6.3.1.1 shall be in accordance with Chapters 1 through 6, Sections 7.1 through 7.4, and 7.11.5.

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

7.12 Subatmospheric Gas (Type 1 and Type 2) Sources.

7.12.1 General. The storage and use of subatmospheric gas (type 1 and type 2) sources shall meet the requirements of 7.14.2.1 through 7.14.2.6 in NFPA 318.

7.12.1.1 Where the storage and use of subatmospheric gas (type 1 and type 2) sources do not meet the requirement in 7.11.1, the storage and use of subatmospheric gas (type 1 and type 2) shall meet all the requirements of this standard based on the assigned hazard categories listed in Section 5.1.

Chapter 8 Cryogenic Fluids

8.1 General. This chapter shall apply to all cryogenic fluids, including those fluids regulated elsewhere in this code, except that where specific requirements are provided in other chapters, those specific requirements shall apply in accordance with the applicable chapter.

8.1.1 Storage, use, and handling of cryogenic fluids shall be in accordance with Chapters 1 through 6 and Chapter 8 as applicable.

8.1.2 Storage, use, and handling of inert cryogenic fluids shall be in accordance with CGA P-18, *Standard for Bulk Inert Gas Systems*.

8.1.3 Storage, use, and handling of inert cryogenic fluids in medical gas applications shall be in accordance with Chapter 17 and ANSI/CGA M-1, *Standard for Medical Gas Supply Systems at Health Care Facilities*, in addition to the provisions stated herein.

8.2* Containers — Design, Construction, and Maintenance. Containers employed for the storage or use of cryogenic fluids shall be designed, fabricated, tested, marked (i.e., stamped), and maintained in accordance with Department of Transportation (DOT) regulations, Transport Canada's (TC) *Transportation of Dangerous Goods Regulations*, the ASME *Boiler and Pressure Vessel Code*, or regulations of other administering agencies.

8.2.1 Aboveground Tanks. Aboveground tanks for the storage of cryogenic fluids shall be in accordance with 8.2.1.

8.2.1.1 Construction of the Inner Vessel. The inner vessel of storage tanks in cryogenic fluid service shall be designed and constructed in accordance with the ASME *Boiler and Pressure Vessel Code* and shall be vacuum jacketed in accordance with 8.2.1.2.

8.2.1.2 Construction of the Vacuum Jacket (Outer Vessel).

8.2.1.2.1 The vacuum jacket used as an outer vessel for storage tanks in cryogenic fluid service shall be designed to withstand the maximum internal and external pressure to which it will be subjected under operating conditions, including emergency pressure relief of the annular space between the inner vessel and the outer vessel.

8.2.1.2.2 The jacket shall be designed to withstand a minimum collapsing pressure differential of 30 psi (207 kPa).

8.2.1.2.3 Vacuum Level Monitoring.

8.2.1.2.3.1 A connection shall be provided on the exterior of the vacuum jacket to allow measurement of the pressure within the annular space between the inner vessel and the outer vessel.

8.2.1.2.3.2 The connection shall be fitted with a bellows-sealed or diaphragm-type valve equipped with a vacuum gauge tube that is shielded to protect against damage from impact.

8.2.2 Nonstandard Containers.

8.2.2.1 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.

8.2.2.2 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

8.2.3 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 requirements of 8.2.3.1 through 8.2.3.5 also shall apply.

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

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

8.2.3.3* Support of Ancillary Equipment.

8.2.3.3.1 Foundations shall be provided to support the weight of vaporizers or heat exchangers.

8.2.3.3.2 Foundations shall be designed to withstand soil and frost conditions as well as the anticipated seismic, snow, wind, and hydrostatic loading under operating conditions.

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 –130°F (–90°C), 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 Where a bulk gas source system is connected to an indoor cryogenic fluid piping system protected by a pressure relief device that is designed to protect against exceeding the maximum allowable working pressure or maximum process operating pressure, releases shall be directed to a safe location outdoors to the open air.

8.2.4.1.2 Pressure relief devices shall be provided to protect containers and piping systems containing cryogenic fluids from damage due to overpressure.

8.2.4.1.3 Pressure relief devices shall be designed in accordance with CGA S-1.1, *Pressure Relief Device Standards — Part 1 — Cylinders for Compressed Gases*, and CGA S-1.2, *Pressure Relief Device Standards — Part 2 — Portable Containers 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.

8.2.4.5.1* ASME pressure relief valves shall be made to be tamper resistant in order to prevent adjusting of the set pressure by other than authorized personnel.

8.2.4.5.2 Non-ASME pressure relief valves shall not be field adjusted.

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 its entrance into enclosed spaces.

8.2.4.6.2 Portable Containers with Volume Less Than 2.0 scf (0.057 Nm^3).

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 scf (0.057 Nm^3) 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 meet 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 locked in the open position, 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 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

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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.

8.4.1.1.1 Portable cryogenic containers shall be marked in accordance with CGA C-7, *Guide to Classification and Labeling of Compressed Gases.*

8.4.1.1.2* All DOT-4L/TC-4LM liquid cylinders shall have product identification visible from all directions with minimum 2 in. (51 mm) high letters.

8.4.1.2 Stationary Tanks. Stationary tanks shall be marked in accordance with NFPA 704.

8.4.1.3 Identification Signs. Visible hazard identification signs shall be provided in accordance with NFPA 704 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.

8.4.3.1 The nameplate shall be installed on the container in an accessible location.

8.4.3.2 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 methods prescribed by 8.4.4.1.1 through 8.4.4.1.2.

8.4.4.1.1 They shall be marked with a permanent tag or label identifying their function.

8.4.4.1.2 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.

8.4.4.1.2.1 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.

8.5.2.1 Administrative controls shall be allowed to be used to control access to individual storage areas located in secure facilities not accessible by the general public.

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

8.5.3.1 Portable containers subject to shifting or upset shall be secured.

8.5.3.2 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 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.

Table 8.6.2 Minimum Separation Distance Between Stationary Cryogenic Containers and Exposures

Exposure	Minimum Distance ft	Minimum Distance m
(1) Buildings, regardless of construction type	1	0.3
(2) Wall openings	1	0.3
(3) Air intakes	10	3.1
(4) Property lines	5	1.5
(5) Places of public assembly (assembly occupancies)	50	15
(6) Nonambulatory patient areas	50	15
(7) Combustible materials, (e.g., paper, leaves, weeds, dry grass, debris)	15	4.5
(8) Incompatible hazardous materials	20	6.1
(9) Building exits	10	3.1

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8.6.2.1 Fire Barriers. A 2-hour fire barrier wall shall be permitted in lieu of the distances specified in Table 8.6.2 for items 1, 4, 7, 8, and 9, where in accordance with the provisions of 8.6.2.1.1 through 8.6.2.1.4.

8.6.2.1.1 The fire barrier wall shall be without openings or penetrations.

8.6.2.1.1.1 Penetrations of the fire barrier wall by conduit or piping shall be permitted provided that the penetration is protected with a firestop system in accordance with the building code.

8.6.2.1.2 The fire barrier wall shall be either an independent structure or the exterior wall of the building adjacent to the storage system.

8.6.2.1.3 The fire barrier wall shall be located not less than 5 ft (1.5 m) from any exposure.

8.6.2.1.4 The fire barrier wall shall not have more than two sides at 90 degree (1.57 rad) directions or not more than three sides with connecting angles of 135 degrees (2.36 rad).

8.6.2.1.4.1* The connecting angles between fire barrier walls shall be permitted to be reduced to less than 135 degrees (2.36 rad) for installations consisting of three walls when in accordance with 8.12.2.7.2.

8.6.2.1.5 Where the requirement of 8.6.2.1.4 is met, the bulk system shall be a minimum distance of 1 ft (0.3 m) from the fire barrier wall.

8.6.2.2 Point-of-Fill Connections. Point-of-fill connections serving stationary containers filled by mobile transport equipment shall not be positioned closer to exposures than the minimum distances in Table 8.6.2.

8.6.2.3 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. Portable containers used for cryogenic fluids located outdoors shall be separated from exposure hazards in accordance with Table 8.6.3.

Table 8.6.3 Minimum Separation Distance Between Portable Cryogenic Containers and Exposures

Exposure	Minimum Distance ft	Minimum Distance m
(1) Building exits	10	3.1
(2) Wall openings	1	0.3
(3) Air intakes	10	3.1
(4) Property lines	5	1.5
(5) Room or area exits	3	0.9
(6) Combustible materials, (e.g., paper, leaves, weeds, dry grass, debris)	15	4.5
(7) Incompatible hazardous materials	20	6.1

8.6.3.1 Non-bulk portable containers of liquefied hydrogen shall be separated from exposure hazards in accordance with Table 8.6.3.1.

8.6.3.2 Fire Barriers. A 2-hour fire barrier wall shall be permitted in lieu of the distances specified by Table 8.6.3 or Table 8.6.3.1 when in accordance with the provisions of 8.6.3.2.1 through 8.6.3.2.4.

8.6.3.2.1 The fire barrier wall shall be without openings or penetrations.

8.6.3.2.1.1 Penetrations of the fire barrier wall by conduit or piping shall be permitted provided that the penetration is protected with a firestop system in accordance with the building code.

8.6.3.2.2 The fire barrier wall shall be either an independent structure or the exterior wall of the building adjacent to the storage system.

8.6.3.2.3 The fire barrier wall shall be located not less than 5 ft (1.5 m) from any exposure.

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

Table 8.6.3.1 Distance to Exposures for Non-Bulk Liquefied Hydrogen (LH_2)

Maximum Amount per Storage Area (gal)	Minimum Distance Between Storage Areas (ft)	Minimum Distance to Lot Lines of Property That Can Be Built Upon (ft)	Minimum Distance to Public Streets, Public Alleys, or Public Ways (ft)	Minimum Distance to Buildings on the Same Property: Less than 2-Hour Construction	2-Hour Construction	4-Hour Construction
0–39.7	5	5	5	5	0	0
39.8–186.9	10	10	10	10	5	0
187–448.7	10	15	15	20	5	0
448.8–747.8	10	20	20	20	5	0
>747.8	20	25	25	20	5	0

For SI units: 1 ft = 305 mm.

Notes:

(1) For requirements on minimum distance to air intakes, see 7.7.2.4.

(2) For requirements on minimum distance to building openings including exits, see 7.7.2.5.

(3) When 8.6.3.2 is used as a means of distance reduction, the configuration of the fire barriers should be designed to allow natural ventilation to prevent the accumulation of hazardous gas concentrations.

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8.7 Electrical Wiring and Equipment.

8.7.1 General. Electrical wiring and equipment shall be in accordance with *NFPA 70* and NFPA 79, as applicable, 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 Grounding and Bonding. Containers and systems shall not be used for electrical grounding.

8.7.3.1 When electrical grounding and bonding are required, the system shall be in accordance with *NFPA 70*.

8.7.3.2 The grounding system shall be protected against corrosion, including corrosion caused by stray electrical 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 codes and standards.

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

8.8.1.1 Testing. Containers out of service in excess of 1 year shall be inspected and tested as required in 8.8.1.2.

8.8.1.2 Pressure Relief Device Testing. The pressure relief devices shall be tested for operability and to determine if they are set at the relief pressure required by the tank design.

8.8.1.3 Containers that have previously been used for flammable cryogenic fluids and have been removed from service shall be purged with an inert gas to remove residual flammable gas and stored with all valves closed and the valve outlets plugged.

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 designated.

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 Chapters 9 and 11 or with CGA P-18, *Standard for Bulk Inert Gas Systems*.

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 Access. Stationary containers shall be located to provide access by mobile supply equipment and authorized personnel.

8.12.2.2.1 Where exit access is provided to serve areas in which equipment is installed, the minimum width shall be not less than 28 in. (710 mm).

8.12.2.3 Physical Protection. Cryogenic fluid containers, cylinders, tanks, and systems that could be exposed to physical damage shall be protected.

8.12.2.3.1 Guard posts or other means shall be provided to protect cryogenic fluid containers, cylinders, tanks, and systems indoors and outdoors from vehicular damage. *(See Section 4.11.)*

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

8.12.2.5* Areas Subject to Flooding. Stationary containers located in flood hazard areas shall be anchored to prevent flotation during conditions of the design flood as designated by the building code.

8.12.2.5.1 Elevated Tanks. Structures supporting elevated tanks and tanks that are supported at a level above that designated in the design flood shall be anchored to resist lateral shifting due to flood and other hydrostatic effects.

8.12.2.5.2 Underground Tanks. Underground tanks in flood hazard areas shall be anchored to prevent flotation, collapse, or lateral movement resulting from hydrostatic loads, including the effects of buoyancy, during conditions of the design flood.

8.12.2.6 Drainage.

8.12.2.6.1 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 in accordance with NFPA 1.

8.12.2.6.2 The stationary container shall not be placed where spilled or discharged fluids will be retained around the container.

8.12.2.6.3 The provisions of 8.12.2.5.2 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

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8.12.2.6.4 The grade for a distance of not less than 50 ft (15.2 m) from where cryogenic fluid storage or delivery systems are installed shall be higher than the grade on which flammable or combustible liquids are stored or used.

8.12.2.6.4.1* Drainage Control.

(A) Where the grade differential between the storage or delivery system and the flammable or combustible liquids storage or use area is not in accordance with 8.12.2.6.4, diversion curbs or other means of drainage control shall be used to divert the flow of flammable or combustible liquids away from the cryogenic system.

(B) The means of drainage control shall prevent the flow of flammable or combustible liquid to a distance not less than 50 ft (15.2 m) from all parts of the delivery system.

8.12.2.7 Outdoor Installations.

8.12.2.7.1* Enclosed Courts. Stationary containers shall not be installed within enclosed courts.

8.12.2.7.2* Courts. Stationary containers shall be sited so that they are open to the surrounding environment except that encroachment by building walls of unlimited height shall be permitted when in accordance with the distances specified by Table 8.6.2 or the material-specific tables in Chapters 9, 11, 13, and 16.

8.12.2.7.2.1* Where exterior building walls encroach on the system to form a court, the system shall be located at a distance not less than the height of the wall from at least two court walls.

8.12.2.7.2.2 The required distance between the exterior walls of the building forming the court and the container shall be determined independently without regard to fire barrier walls used to allow encroachment by fire exposure hazards.

8.12.2.7.3 Fire Department Access. Fire department access roadways or other approved means shall be in accordance with NFPA 1.

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 Operating Instructions. Operating instructions shall be provided for installations that require the operation of equipment.

8.13.1.2 Attended Delivery. A qualified individual shall be in attendance at all times cryogenic fluid is transferred from mobile supply units to a storage system.

8.13.1.3 Cleaning and Purging of Gas Piping Systems. Cleaning and purging of piping systems shall be in accordance with 7.1.18.

8.13.1.4 Inspection.

8.13.1.4.1 Cryogenic fluid storage systems shall be inspected and maintained by a qualified representative of the equipment owner as required by the material-specific requirements of Chapters 9, 11, 13, and 16.

8.13.1.4.1.1* The interval between inspections other than those specified by material-specific requirements shall be based on nationally recognized good practices or standards.

8.13.1.4.2 A record of the inspection shall be prepared and provided to the user or the authority having jurisdiction upon request.

8.13.1.5 Design.

8.13.1.5.1 Nationally Recognized Good Practices. Where nationally recognized good practices or standards have been established for the process employed, such practices and standards shall be followed.

8.13.1.5.2 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 and shall be in accordance with 8.13.2.

8.13.2 Piping and Appurtenances.

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

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

8.13.3 Joints. Joints in piping and tubing shall be in accordance with the requirements of ASME B31.3, *Process Piping*, or other approved standards.

8.13.4 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.

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

8.13.5.1 Shutoff valves for containers with multiple pressure relief devices shall be permitted in accordance with 8.2.4.7.

8.13.5.2 Shutoff valves shall be accessible and located as close as practical to the container.

8.13.6 Shutoff Valves on Piping.

8.13.6.1 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.

8.13.6.2 Pressure relief valves shall be installed where liquid or cold gas can be trapped between shutoff valves in the piping system. *(See 8.2.4.)*

8.13.7 Physical Protection and Support.

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

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

8.13.8 Corrosion Protection.

8.13.8.1 Aboveground piping that is subject to corrosion shall be protected against corrosion.

8.13.8.2 Belowground piping shall be protected against corrosion.

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8.13.9 Cathodic Protection. Where required, cathodic protection shall be in accordance with 8.13.9.

8.13.9.1 Operation. Where installed, cathodic protection systems shall be operated and maintained to continuously provide corrosion protection.

8.13.9.2 Inspection.

8.13.9.2.1 Container systems equipped with cathodic protection shall be inspected for the intended operation by a cathodic protection tester.

8.13.9.2.1.1 The examinations shall be documented.

8.13.9.2.1.2 A record of the examination history shall be maintained by the owner and shall be available to the authority having jurisdiction upon request.

8.13.9.2.2 The cathodic protection tester shall be certified as being qualified by the National Association of Corrosion Engineers, International (NACE).

8.13.9.3 Impressed Current Systems.

8.13.9.3.1 Systems equipped with impressed current cathodic protection systems shall be inspected in accordance with the requirements of the design and 8.13.9.2.

8.13.9.3.2 The design limits shall be available to the AHJ upon request.

8.13.9.3.3 The system owner shall maintain the following records to demonstrate that the cathodic protection is in conformance with the requirements of the design:

(1) The results of inspections of the system
(2) The results of testing that has been completed

8.13.9.4 Repairs, maintenance, or replacement of a cathodic protection system shall be under the supervision of a corrosion expert certified by NACE.

8.13.9.4.1 The corrosion expert shall be certified by NACE as a senior corrosion technologist, a cathodic protection specialist, or a corrosion specialist or shall be a registered engineer with registration in a field that includes education and experience in corrosion control.

8.13.10 Testing.

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

8.13.10.2 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.

8.13.11 Material-Specific Requirements.

8.13.11.1 Indoor Use. Indoor use of cryogenic fluids shall be in accordance with the material-specific provisions of Chapters 9, 11, 13, and 16 or with CGA P-18, *Standard for Bulk Inert Gas Systems,* and 8.13.2.

8.13.11.2 Outdoor Use.

8.13.11.2.1 General. Outdoor use of cryogenic fluids shall be in accordance with the material-specific provisions of Chapters 9, 11, 13, and 16 or with CGA P-18, *Standard for Bulk Inert Gas Systems,* and 8.13.2.

8.13.11.2.2 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 Chapters 9, 11, 13, and 16 or with CGA P-18, *Standard for Bulk Inert Gas Systems.*

8.13.11.2.3 Emergency Shutoff Valves.

8.13.11.2.3.1* Accessible manual or automatic emergency shutoff valves shall be provided to shut off the cryogenic fluid supply in case of emergency.

(A) Manual emergency shutoff valves or the device that activates an automatic emergency shutoff valve on a bulk source or piping systems serving the bulk supply shall be identified by means of a sign.

8.13.11.2.3.2 Emergency shutoff valves shall be located at the point of use, at the source of supply, and at the point where the system piping enters the building.

8.13.11.3 Filling and Dispensing.

8.13.11.3.1 General. Filling and dispensing of cryogenic fluids shall be in accordance with 8.13.1.2.

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

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

8.13.11.3.2.2 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.

8.13.11.3.2.3 Piping Systems. Piping systems utilized for filling or dispensing of cryogenic fluids shall be designed and constructed in accordance with 8.13.2.

8.13.11.3.3 Vehicle Loading and Unloading Areas. Loading and unloading areas shall be constructed in accordance with the requirements of Chapter 9 for liquid oxygen, Chapter 11 for liquid hydrogen, Chapter 13 for liquid carbon dioxide, and Chapter 16 for liquid nitrous oxide or CGA P-18, *Standard for Bulk Inert Gas Systems,* for inert cryogenic fluids, as applicable.

8.13.11.3.4* A noncombustible, delivery vehicle spill pad shall be provided when required by the material-specific requirements of Chapter 9 for liquid oxygen, Chapter 11 for liquid hydrogen, and Chapter 16 for liquid nitrous oxide.

8.13.11.3.4.1* A noncombustible spill pad shall be provided for delivery areas where bulk liquid helium is transferred from delivery vehicles.

8.13.11.3.5 Filling Controls. A pressure gauge and full trycock valve shall be provided and shall be visible from the delivery point to allow the delivery operator to monitor the internal pressure and liquid level of stationary containers during filling.

8.13.11.3.5.1 When the containers being filled are remote from the delivery point and pressure gauges or full trycock valves are not visible, redundant gauges and valves shall be installed at the filling connection.

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8.13.11.4 Handling.

8.13.11.4.1 Applicability. Handling of cryogenic containers shall be in accordance with 8.13.11.4.

8.13.11.4.2 Carts and Trucks.

8.13.11.4.2.1 Cryogenic containers shall be moved using an approved method.

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

8.13.11.4.3 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.

8.13.11.4.4 Closed Containers.

8.13.11.4.4.1 Pressurized containers shall be closed while being transported.

8.13.11.4.4.2 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

9.1* General. The storage, use, and handling of oxygen in bulk oxygen systems shall be in accordance with the provisions of Chapters 1 through 9, as applicable.

9.1.1 Application.

9.1.1.1* This chapter shall not apply to oxygen storage systems having capacities less than those stated in 3.3.100.3, Bulk Oxygen System.

9.1.1.2 An oxygen cryogenic fluid central supply system used in medical gas applications shall be in accordance with Chapter 17 and ANSI/CGA M-1, *Standard for Medical Gas Supply Systems at Health Care Facilities*, in addition to the requirements of this chapter.

9.2 Materials of Construction.

9.2.1* Oxygen system components, including, but not limited to, containers, valves, valve seats, lubricants, fittings, gaskets, and interconnecting equipment including hoses, shall be compatible with oxygen under the conditions of temperature and pressure to which the components are exposed in the containment and use of oxygen.

9.2.2 The use of ignitible materials shall be prohibited unless they are parts of equipment or systems that are approved, listed, or proved suitable by tests or by past experience.

9.3 Location of Bulk Oxygen Systems. Bulk oxygen systems shall be located in accordance with one of the following:

(1) Above ground and out of doors
(2) In a building of fire-resistive or noncombustible/limited-combustible construction, ventilated to prevent the accumulation of oxygen vapors, and equipped with protection level controls in accordance with the requirements of the building code

9.3.1 Rooftop Installation. Bulk oxygen systems shall not be located on rooftops of buildings or other structures.

9.3.2* Separation from Exposure Hazards. Oxygen systems located outdoors shall be separated from exposure hazards in accordance with the requirements of Table 9.3.2 as applicable.

9.3.2.1* The distances shown in items 2, 4, 5, 8, and 10 through 14 of Table 9.3.2 shall not apply where a fire barrier wall having a minimum fire resistance of 2 hours interrupts the line of sight between uninsulated portions of the bulk storage system and the exposure.

9.3.2.1.1 Fire barrier walls shall comply with the requirements of 8.6.2.1.1 through 8.6.2.1.5.

9.3.2.2 The distances shown shall be permitted to be reduced to 15 ft (4.6 m) for Class IIIB combustible liquids.

9.3.2.3 The area of noncombustible surfacing provided under liquid mobile supply equipment shall have a width not less than the 12 ft (3.7 m) and a length not less than 12 ft (3.7 m) in the direction of the vehicle axis.

9.4 System Fabrication.

9.4.1 Piping, Tubing, and Fittings.

9.4.1.1 System Design. Piping, tubing, valves, and fittings shall be designed, installed, and tested in accordance with the requirements of ASME B31.3, *Process Piping*.

9.4.1.2 Operating Conditions. Piping systems shall be designed for the most severe condition of coincident internal or external pressures and temperatures expected during service.

9.4.1.3* Low-Temperature Service. Piping or tubing operating at temperatures below –20°F (–28.9°C) shall be fabricated from materials meeting the impact test requirements of Chapter III of ASME B31.3, *Process Piping*, when tested at the minimum operating temperature to which the piping could be subjected when in service.

9.4.1.4 Requirements for Piping Joints.

9.4.1.4.1 Joints in piping and tubing shall be permitted to be made by welding or brazing or by use of flanged, threaded, socket, slip, compression, or press-connect fittings.

9.4.1.4.2 Gaskets or thread sealants shall be designed for oxygen service. Brazing materials shall have a melting point above 1000°F (538°C).

9.4.1.5 Accessory Equipment. Valves, gauges, regulators, and other accessories shall be designed for oxygen service.

9.4.1.6 Leak Testing.

9.4.1.6.1 After installation, all field-erected piping shall be tested and proved gastight in accordance with the requirements of ASME B31.3, *Process Piping*.

9.4.1.6.2 Any medium used for testing shall be oil-free and nonflammable.

9.4.1.7 Underground Piping System for Gaseous Systems. Underground piping systems for gaseous systems shall be in accordance with 7.1.17.

9.4.1.8 Underground Piping Systems for Liquid Oxygen Systems. (Reserved)

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Table 9.3.2 Minimum Separation Distances Between Bulk Liquid Oxygen Systems and Exposure Hazards

Type of Exposure	Distance *(See 9.3.2.1.)* ft	m
(1) Buildings of Type I and II construction as defined by the building code	1	0.3
(2) Buildings of Type III, IV, or V construction as defined by the building code	50	15
(3) Wall openings as measured from high-pressure gas or liquefied gas regulators, pressure relief devices, vaporizers, manifolds, and interconnected piping	10	3
(4) Property lines	5	1.5
(5) Public sidewalks	10	3
(6) Public assembly	50	15
(7) Areas occupied by nonambulatory patients as measured from the primary pressure relief device discharge vent and from filling and vent connections	50	15
(8) Parked vehicles	10	3
(9) Exterior walls that encroach on the container to form a court with three or more sides	*See 8.12.2.7*	
(10) All classes of flammable and combustible liquids above ground *(See 9.3.2.2.)*		
(a) 0 gal to 1000 gal (0 to 3785 L)	25	7.5
(b) Over 1000 gal (3785 L)	50	15
(11) All classes of flammable and combustible liquids in belowground tanks or vaults		
(a) Horizontal distance from oxygen storage container to tank or vault	15	4.6
(b) Horizontal distance from oxygen storage container to filling and vent connections or other openings to tank or vault	25	7.5
(12) Flammable gases aboveground		
(a) Liquefied hydrogen (any quantity)	75	22.5
(b) Other liquefied gas, 0 gal to 1000 gal (0 L to 3785 L)	25	7.5
(c) Other liquefied gas, over 1000 gal (3785 L)	50	15
(d) Nonliquefied or dissolved gases, 0 scf to 25,000 scf (0 Nm^3 to 708 Nm^3)	25	7.5
(e) Nonliquefied or dissolved gases, over 25,000 scf (708 Nm^3)	50	15
(13) Rapidly burning solids, including, but not limited to, excelsior, paper, or combustible waste	50	15
(14) Slowly burning solids, including, but not limited to, heavy timber or coal	25	7.5
(15) Inlets to underground sewer or drainage systems from liquid delivery connections, pressure relief device outlets, mobile supply equipment, and liquid withdrawal connections	8	2.5
(16) Areas below connections where liquid can fall during loading or unloading operations and system operation from combustible surfaces, including, but not limited to, asphalt or bitumastic paving and expansion joint fillers *(See 9.3.2.3.)*	3	1
(17) Encroachment by overhead utilities		
(a) Horizontal distance from the vertical plane below the nearest overhead wire of an electric trolley, train, or bus line	50	15
(b) Horizontal distance from the vertical plane below the nearest overhead electrical wire other than those noted in (a)	5	1.5
(c) Piping containing other hazardous materials	15	4.6
(18) Aboveground exposed piping and piping components of flammable gas systems	15	4.6

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9.4.1.9 Cleaning and Purging of Gas Piping Systems. Cleaning and purging of piping systems shall be in accordance with 7.1.18.

9.4.1.9.1 Cleaning of oxygen systems used in medical gas service shall be in accordance with NFPA 99. *(See also 9.4.3.1.)*

9.4.2 Liquid Oxygen Vaporizers. In addition to the requirements in Chapter 8, vaporizers used in liquid oxygen service shall be in accordance with the requirements of 9.4.2.1 and 9.4.2.1.1.

9.4.2.1 Heating. Heat used in an oxygen vaporizer shall be supplied indirectly through mediums such as steam, air, water, or materials that do not react with oxygen.

9.4.2.1.1 Electric Heating. If electric heaters are used to provide the primary source of heat to vaporizers, the vaporizing system shall be electrically grounded in accordance with the requirements of *NFPA 70*.

9.4.3 Equipment Assembly and Installation.

9.4.3.1 Oxygen Cleaning. Equipment used in a bulk oxygen system shall be cleaned in accordance with the requirements of CGA G-4.1, *Cleaning Equipment for Oxygen Service*, before placing the system in service in order to remove oil, grease, solvents, particulates, or other oxidizable materials.

9.4.3.2 Venting of Enclosures. Any enclosure containing oxygen control or operating equipment shall be vented to the atmosphere.

9.4.4 Signage. The bulk oxygen storage location shall be permanently placarded to read as follows:

OXYGEN

NO SMOKING — NO OPEN FLAMES

9.4.5* Electrical Wiring and Equipment. Electrical wiring and equipment shall be installed in accordance with the applicable provisions of *NFPA 70*.

9.5 Inspection.

9.5.1 Cryogenic oxygen storage systems shall be inspected annually and maintained by a qualified representative of the equipment owner.

9.5.2 A record of the inspection shall be prepared and provided to the user or the AHJ upon request.

Chapter 10 Gas Hydrogen Systems

10.1 Applicability. The storage, use, and handling of hydrogen in hydrogen compressed gas systems shall be in accordance with the applicable provisions of Chapters 1 through 7 and Chapter 10.

10.1.1 Quantities Less Than or Equal to the MAQ. The storage, use, and handling of hydrogen in gaseous hydrogen systems in quantities less than or equal to the MAQ shall be in accordance with Sections 10.1 and 10.2.

10.1.2 Quantities Greater Than the MAQ. The storage, use, and handling of hydrogen in gaseous hydrogen systems in quantities greater than the MAQ shall be in accordance with Sections 10.1, 10.2, and 10.3.

10.1.3* Quantities Greater Than 5000 scf (141.6 Nm^3). The storage, use, and handling of hydrogen in gaseous hydrogen systems (bulk gaseous hydrogen systems) in quantities greater than 5000 scf (141.6 Nm^3) shall be in accordance with Sections 10.1, 10.2, 10.3, and 10.4.

10.2 General.

10.2.1 Marking.

10.2.1.1 Hazard identification signs shall be provided in accordance with Section 6.13.

10.2.1.2 In addition, the area in which a hydrogen system is located shall be permanently placarded as follows:

WARNING: HYDROGEN — FLAMMABLE GAS
NO SMOKING — NO OPEN FLAMES

10.2.2* Piping Systems. Piping, tubing, valves, and fittings shall be designed and installed in accordance with applicable sections of ASME B31, *Code for Pressure Piping*, and Sections 704.1.2.3, 704.1.2.4, and 704.1.2.5 of the ICC *International Fuel Gas Code (IFGC)*. Cast, ductile, malleable, or high-silicon iron pipe, valves, and fittings shall not be used.

10.2.2.1 Prior to acceptance and initial operation, all piping installations shall be inspected and pressure tested in accordance with ASME B31, *Code for Pressure Piping*, and Section 705 of the ICC *International Fuel Gas Code (IFGC)*.

10.2.2.2 Brazing materials used for joints in piping and tubing systems shall have a melting point above 1000°F (538°C).

10.2.2.3 Underground piping systems shall be in accordance with 7.1.17.

10.2.3 Hydrogen-Venting Systems. Hydrogen-venting systems serving pressure relief devices discharging hydrogen to the atmosphere shall be in accordance with CGA G-5.5, *Hydrogen Vent Systems*.

10.2.3.1 Venting from the relief vents from the hydrogen supply piping serving listed fuel cell systems shall be permitted to be discharged into an enclosure integral to the fuel cell system where the concentration of hydrogen is diluted below 25 percent of the lower flammable limit (LFL) at the outlet of the enclosure.

10.2.3.1.1 The hydrogen supply piping system shall be designed to isolate the source of hydrogen from the relief vent in the event of loss of dilution ventilation or power.

10.2.3.2 Cleaning and purging of piping systems shall be in accordance with 7.1.18.

10.2.4 Equipment Assembly.

10.2.4.1 Valves, gauges, regulators, and other accessories used for hydrogen compressed gas systems shall be specified for hydrogen service by the manufacturer or the hydrogen supplier.

10.2.4.1.1 Storage containers, piping, valves, regulating equipment, and other appurtenances serving hydrogen compressed gas systems shall be accessible and shall be protected against physical damage and tampering.

10.2.4.2 Cabinets or enclosures containing hydrogen control or operating equipment shall be ventilated to prevent the accumulation of hydrogen.

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