Report of the Committee on

Industrial and Medical Gases

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.

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

The Report of the Technical Committee on Industrial and Medical Gases is presented for adoption.

This Report was prepared by the Technical Committee on Industrial and Medical Gases and proposes for complete revision to NFPA 55, Standard for the Storage, Use, and Handling of **Compressed and Liquefied Gases in Portable Cylinders,** 1998 edition. NFPA 55-1998 is published in Volume 3 of the 2001 National Fire Codes and in separate pamphlet form.

This Report has been submitted to letter ballot of the **Technical Committee on Industrial and Medical Gases,** which consists of 18 voting members. The results of the balloting, after circulation of any negative votes, can be found in the report.

(Log #CP2)

55-1-(1) : Accept
SUBMITTER: Technical Committee on Industrial and Medical Gases,
RECOMMENDATION: Restructure entire document to comply with the NFPA Manual of Style as follows:
1. Chapter 1 to contain administrative text only.
2. Chapter 2 to contain only referenced publications cited in the mandatory portions of the document.
3. Chapter 3 to contain only definitions.
4. All mandatory sections of the document must be evaluated for usability, adoptability, and enforceability language. Generate necessary committee proposals.
5. All units of measure in document are converted to SI units with inch/pound units in parentheses.
6. Appendices restructured and renamed as "Annexes."
SUBSTANTIATION: Editorial restructuring, to conform with the 2000 edition of the NFPA Manual of Style.
COMMITTEE ACTION:Accept
NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE:18
VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 14
NOT RETURNED: 4 Barlen, Bender, Trojak, Viscomi

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(Log #12)

55-2-(Table 1-1.2(a)) : Accept in Principle
SUBMITTER: Jim Everitt,
RECOMMENDATION: Clarify the requirement for a cabinet in the table.
SUBSTANTIATION: It is unclear in the standard and table if it is the intent of the committee to have these cabinets comply with 7-4. If so it should be stated in the table.
COMMITTEE ACTION:Accept in Principle
See Committee Action on Proposal 55-16 (Log #CP4).
COMMITTEE STATEMENT: Proposal 55-16 (Log #CP4) would present a clearer statement of this requirement.
NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE:18
VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 14
NOT RETURNED: 4 Barlen, Bender, Trojak, Viscomi

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(Log #CP1)

55-3-(1-4 Definitions (GOT)) : Accept
SUBMITTER: Technical Committee on Industrial and Medical Gases,
RECOMMENDATION: Adopt the preferred definition from the NFPA Glossary of Terms for the following term:
CFR (preferred) NFPA 1, 2000 ed.
The Code of Federal Regulations of the United States Government.
SUBSTANTIATION: Adoption of preferred definitions will assist the user by providing consistent meaning of defined terms throughout the National Fire Codes.
COMMITTEE ACTION:Accept
NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE:18
VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 14
NOT RETURNED: 4 Barlen, Bender, Trojak, Viscomi

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(Log #3)

55-4-(1-4 CFR) : Accept in Principle
SUBMITTER: Stanley Kaufman, Rob van Zanen, Lucent Technologies
RECOMMENDATION: Revise the definition of CFR to read as follows:
United States Code of Federal Regulations
SUBSTANTIATION: NFPA codes are used throughout the world. Users need to know unambiguously that CFR refers to United States of America law.
COMMITTEE ACTION:Accept in Principle
See Committee Action on Proposal 55-3 (Log #CP1). This proposal would address this proposal.
COMMITTEE STATEMENT: Proposal 55-3 (Log #CP1) accomplishes what this proposal requests.
NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE:18
VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 14
NOT RETURNED: 4 Barlen, Bender, Trojak, Viscomi

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(Log #4)

55-5-(1-4 Cylinder) : Reject
SUBMITTER: Stanley Kaufman, Rob van Zanen, Lucent Technologies
RECOMMENDATION: Revise the definition of Cylinder as follows:
Cylinder. A portable compressed gas container, fabricated to or authorized for use by the U.S. Department of Transportation (DOT), or fabricated to Transport Canada (TC) or the "Rules for the Construction of Unfired Pressure Vessels," Section VIII, ASME Boiler & Pressure Vessel Code, or satisfy the requirements of Directive 97/23/EC concerning pressure equipment.
SUBSTANTIATION: Gas cylinders are used throughout the world. The revised definition has broadened to include Europe.
The April 2000 Edition of Manual of Style of NFPA Technical Committee Documents, Section 2.5.1.1 states "Documents shall be written to enhance their international acceptance and adaptability."
COMMITTEE ACTION:Reject
COMMITTEE STATEMENT: No information was provided to show that Directive 97/23/EC is equivalent to the existing reference standard.
NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE:18
VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 14
NOT RETURNED: 4 Barlen, Bender, Trojak, Viscomi

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(Log #5)

55-6-(1-4 MSDS) : Accept in Principle
SUBMITTER: Stanley Kaufman, Rob van Zanen, Lucent Technologies
RECOMMENDATION: Revise the definition of MSDS as follows:
Material Safety Data Sheet (MSDS) or Chemical Safety Data Sheet (SDS) is a fact sheet that summarizes safety information on chemicals. These documents describe the hazards of a material and provides information on how the material can be safely handled, used, and stored. The specific content of a MSDS or SDS is governed by national requirements.
In general, these documents contain information on: material and manufacturer identification; hazardous ingredients; health, environment, fire, and physical hazards; first aid; chemical reactivity, spill and disposal procedures; personal protective equipment; and regulatory requirements.
SUBSTANTIATION: Material Safety Data Sheets are used throughout the world. The existing definition is specific to the United States. The revised definition is generic and not specific to any country. Use of a generic definition will facilitate the use of this standard globally.
This proposal is being offered as an alternate to another proposal that broadens the definition of MSDS to include the European definition.
The April 2000 Edition of Manual of Style of NFPA Technical Committee Documents, Section 2.5.1.1 states "Documents shall be written to enhance their international acceptance and adaptability."
COMMITTEE ACTION:Accept in Principle
See Committee Action on Proposal 55-16 (Log #CP4), Chapter 4.
COMMITTEE STATEMENT: Proposal 55-16 (Log #CP4) addresses this proposal by putting forth a similar definition.
NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE:18
VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 14
NOT RETURNED: 4 Barlen, Bender, Trojak, Viscomi

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(Log #6)

55-7-(1-4 MSDS) : Accept in Principle
SUBMITTER: Stanley Kaufman, Rob van Zanen, Lucent Technologies
RECOMMENDATION: Revise the definition of MSDS as follows:
Material Safety Data Sheet (MSDS). Written or printed material concerning a hazardous material that is prepared in accordance with the provisions of OSHA 29 CFR 1910.1200 or Directive 91/155/EEC, amended by Directive 93/112/EC defining and laying down detailed arrangements for the system of specific information relating to dangerous preparations and substances.
SUBSTANTIATION: Material Safety Data Sheets are used throughout the world. The revised definition has been broadened to include Europe.
The April 2000 Edition of Manual of Style of NFPA Technical Committee Documents, Section 2.5.1.1 states "Documents shall be written to enhance their international acceptance and adaptability."
COMMITTEE ACTION:Accept in Principle
See Committee Action on Proposal 55-6 (Log #5).
COMMITTEE STATEMENT: Committee Action on Proposal 55-6 (Log #5) addresses this proposal.
NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE:18
VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 14
NOT RETURNED: 4 Barlen, Bender, Trojak, Viscomi

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(Log #7)

55-8-(1-4 TC) : Accept
SUBMITTER: Stanley Kaufman, Rob van Zanen, Lucent Technologies
RECOMMENDATION: Add a definition of TC to read as follows:
TC Transport Canada
SUBSTANTIATION: TC is used without definition in Section 6-1. It should be defined. It is mentioned in the definition of cylinder, but that is not adequate for the user.
COMMITTEE ACTION:Accept
NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE:18
VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 14
NOT RETURNED: 4 Barlen, Bender, Trojak, Viscomi

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(Log #8)

55-9-(2-2.1.3) : Accept
SUBMITTER: Stanley Kaufman, Rob van Zanen, Lucent Technologies
RECOMMENDATION: Revise Section 2-2.1.3 to include an electrical classification according to Article 505 of the NEC.
SUBSTANTIATION: Article 505 is the International Electrotechnical Commission (IEC) classification scheme. It is suitable for international use.
The April 2000 Edition of Manual of Style of NFPA Technical Committee Documents, Section 2.5.1.1 states "Documents shall be written to enhance their international acceptance and adaptability."
COMMITTEE ACTION:Accept
NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE:18
VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 14
NOT RETURNED: 4 Barlen, Bender, Trojak, Viscomi

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(Log #2)

55-10-(2-2.2.2, Exceptions 1 & 2) : Accept
SUBMITTER: Technical Committee on Sprinkler System Discharge Criteria,
RECOMMENDATION: In Section 2-2.2.2 Exceptions 1 & 2, delete the phrase "or Light Hazard Occupancies".
SUBSTANTIATION: This proposal is a result of a Standards Council directive to NFPA's Sprinkler System Project to consolidate and centralize sprinkler system information located throughout NFPA's documents. This proposal originated at the October 1998 meeting of the Technical Committee on Sprinkler System Discharge Criteria.
NFPA 55 currently allows for the same space to be protected with either ordinary hazard Group 1 or light hazard sprinkler system discharge densities. This option is without proper justification and can result in inadequate sprinkler system protection.
COMMITTEE ACTION:Accept
NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE:18
VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 14
NOT RETURNED: 4 Barlen, Bender, Trojak, Viscomi

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(Log #10)

55-11-(4-1.2) : Accept
SUBMITTER: Stanley Kaufman, Rob van Zanen, Lucent Technologies
RECOMMENDATION: Delete text as follows:
~~Signs shall be in English as a primary language or in symbols.~~
SUBSTANTIATION: This requirement is in conflict with law and custom in many customs and will thereby prevent the use of NFPA 55 in those countries.
The April 2000 Edition of Manual of Style of NFPA Technical Committee Documents, Section 2.5.1.1 states "Documents shall be written to enhance their international acceptance and adaptability."
Acceptance of this proposal will improve the international acceptability of the Standard.
COMMITTEE ACTION:Accept
NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE:18
VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 14
NOT RETURNED: 4 Barlen, Bender, Trojak, Viscomi

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(Log #9)

55-12-(4-2) : Accept in Principle
SUBMITTER: Stanley Kaufman, Rob van Zanen, Lucent Technologies
RECOMMENDATION: Revise section text to read as follows:
In the United States, individual compressed gas cylinders shall be marked or labeled in accordance with DOT and OSHA requirements. In other countries, individual compressed gas cylinders shall be marked or labeled in accordance with applicable laws and regulations.
SUBSTANTIATION: The current requirement (conformance to DOT and OSHA) may conflict with laws and regulations in many countries and will thereby prevent the use of NFPA 55 in those countries. The proposed text addresses this issue.
The April 2000 Edition of Manual of Style of NFPA Technical Committee Documents, Section 2.5.2.2 states "Documents shall be written to enhance their international acceptance and adaptability."
COMMITTEE ACTION:Accept in Principle
See Proposal 55-16 (Log #CP4).
COMMITTEE STATEMENT: The text in Proposal 55-16 (Log #CP4) addresses this proposed requirement.
NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE:18
VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 14
NOT RETURNED: 4 Barlen, Bender, Trojak, Viscomi

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(Log #11)

55-13-(7-6 (New)) : Accept
SUBMITTER: Jim Everitt,
RECOMMENDATION: Add a new section to read:
7-6 Emergency shutoff for flammable, oxidizing and pyrophoric gases. Flammable, oxidizing and pyrophoric gas systems shall be provided with approved emergency shutoff valves that can be activated at each point of use and at each source.
SUBSTANTIATION: Currently there are no provision to address emergency shutoff and this wording comes from the Uniform Fire Code.
COMMITTEE ACTION:Accept
COMMITTEE STATEMENT: See Committee Action on Proposal 55-16 (Log #CP4).
NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE:18
VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 14
NOT RETURNED: 4 Barlen, Bender, Trojak, Viscomi

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(Log #1)

55-14-(A-1-2.2(1)) : Accept
SUBMITTER: Steve Leeds, Lawrence Livermore National Laboratory
RECOMMENDATION: Revise as follows:
~~A-1-2.2(1)~~ to A-1.1.2(1)
SUBSTANTIATION: This appendix note appears to have been misnumbered.
COMMITTEE ACTION:Accept
NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE:18
VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 14
NOT RETURNED: 4 Barlen, Bender, Trojak, Viscomi

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(Log #CP3)

55-15-(Entire Document) : Accept
SUBMITTER: Technical Committee on Industrial and Medical Gases,
RECOMMENDATION: Incorporate NFPA 50 as Chapter 9, 50A as Chapter 10, 50B as Chapter 11. (NFPA 50, 50A, 50B will be processed for withdrawal A03)
SUBSTANTIATION: This action would increase ease of use.
COMMITTEE ACTION:Accept
NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE:18
VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 14
NOT RETURNED: 4 Barlen, Bender, Trojak, Viscomi

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(Log #CP4)

55-16-(Entire Document) : Accept

SUBMITTER: Technical Committee on Industrial and Medical Gases,

RECOMMENDATION: The Committee on Industrial and Medical Gases proposes a complete revision to NFPA 55, Standard for the Storage, Use, and Handling of Compressed and Liquefied Gases in Portable Cylinders. The Committee also proposes to retitle the docum,ent to NFPA 55, Standard for the Storage, Use, and Handling of CompressedGases and Cryogenic Fluids in Portable and Stationary Containers, Cylinderss, and Tanks.

SUBSTANTIATION: The Compressed Gas Association submitted a major rewrite of NFPA 55 for consideration by the Industrial Medical Gases Committee. This rewrite has been prepared by the committee to update requirements for compressed gases and to provide additional requirements for cryogenic fluids whether found in portable containers or tanks and stationary tanks. This expansion of the standard into cryogenic fluids accomplishes a standing goal of the committee as expressed in Section A-1.1.2(e) of the current document.

There are over 50,000 stationary cryogenic fluid tanks installed throughout the country. In addition, there are tens of thousands of portable containers that are used for small quantities of materials ranging from several liters to 150 liters in size. At present, the guidance for the installation of cryogenic fluids is limited to NFPA 50, Standard for Bulk Oxygen Systems at Consumer Sites and NFPA 50B, Standard for Liquefied Hydrogen Systems at Consumer Sites as well as the standards of care developed by the producing members of the Compressed Gas Association CGA P-18, Standard for Bulk Inert Gas Systems at Consumer Sites.

The proposed standard has been divided into eight Chapters including Administration, Referenced Materials, Definitions and related sections in accordance with the April 2000 Edition of NFPA's Manual of Style for NFPA Technical Committee Documents. There are three chapters containing technical provisions including Hazard Classification, Emergency Response, and Building Related Controls that relate to all storage and use of compressed gases and/or cryogenic fluids. There are two technical chapters Compressed Gases and Cryogenic Fluids that provide the minimum safeguards deemed to be reasonable for the control of these materials based on their nature and physical state. The Uniform Fire Code (UFC), Articles 74, 75 and 80 has been used as the primary basis for the technical provisions found in these two chapters; however, there are several changes to formerly established concepts including separation of incompatible materials and the use of treatment systems.

In recognition of NFPA's efforts to develop a building code, requirements have been established for the use of limit areas (control areas) and levels of protection that are expected to correlate with NFPA 5000. Protection levels are comparable with Occupancy Groups historically developed by the model codes as a means to isolate the hazards of varying uses. The protection levels chosen have been correlated with those expected in NFPA 5000.

The UFC formulated generic provisions for compressed gases and cryogens into Articles 74 and 75 respectively. As these were generic articles for compressed gases and cryogenic fluids they lacked material specific provisions, i.e., flammables, oxidizers, etc. Material specific provisions were either found in Article 80 by class of hazard or in Article 75 through the use of reference standards including UFC Standards or NFPA Standards which were either based on standards promulgated by NFPA such as NFPA 50 or 50B for oxidizing or flammable cryogens or CGA P-18 for inert cryogenic fluids.

Approval of the proposed standard will accomplish two primary goals. First, it will serve to provide minimum controls across the entire spectrum of cryogenic fluids whether flammable or oxidizing and whether in stationary or portable containers. This improvement will serve to round out the control provisions inherent in NFPA's regulatory scheme. Second, it will serve to collect material specific provisions that can be applied generically for all compressed and cryogenic gases into a single reference document. The general provisions for control will apply to all compressed gases and cryogenic fluids regardless of quantity while special provisions will be applied when threshold quantities are exceeded. NFPA 1 will reference the use of the standard under proposals offered by the Compressed Gas Association to the NFPA 1 Technical Committee. In addition, the building related controls correlate with the concepts being proposed for control of hazardous materials in NFPA 5000. Approval of the revised standard represents an important progress step for NFPA in the control of one of the three primary states of matter (the gaseous state).

COMMITTEE ACTION:Accept

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE:18

VOTE ON COMMITTEE ACTION:

AFFIRMATIVE: 14

NOT RETURNED: 4 Barlen, Bender, Trojak, Viscomi

COMMENT ON AFFIRMATIVE:

ANICELLO: Comment 1-Re: Paragraph 6.10 Fire Protection.

Although 6.10 addresses fire protection systems through the use of NFPA 13, specific guidance is needed as NFPA 55 is referenced by NFPA 13 for requirements. CGA will propose requirements in the comments phase.

Comment 2-Re: Paragraph 7.10.3 Storage Configuration.

The CGA submittal contained a fundamental error that was listing the units of measure in standard cubic feet (implies volume of gas). The intent is to correlate with NFPA 1 concepts and the limitation is a physical pile size of 500 cu ft. of spatial volume. Regardless of the actions taken by the committee to except portable and stationary tanks and tube trailers, the units of measure should be corrected to reflect the spatial volume concerns.

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NFPA 55

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

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

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

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

Chapter 1 Administration

1.1 Scope.

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

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

(1)* Off-site transportation of materials covered by this standard

(2) Storage, use, and handling of radioactive gases in accordance with NFPA 801, *Standard for Fire Protection for Facilities Handling Radioactive Materials*

(3)* Storage, use, and handling of medical compressed gases at healthcare facilities in accordance with NFPA 99, *Standard for Health Care Facilities*

(4) Systems consisting of cylinders of oxygen and cylinders of fuel gas used for welding and cutting in accordance with NFPA 51, *Standard for the Design and Installation of Oxygen-Fuel Gas Systems for Welding, Cutting, and Allied Processes*

(5) Acetylene cylinders in acetylene cylinder charging plants in accordance with NFPA 51A, *Standard for Acetylene Cylinder Charging Plants*

(6) Ethylene oxide containers stored, handled, or used for sterilization and fumigation in accordance with NFPA 560, *Standard for the Storage, Handling and Use of Ethylene Oxide for Sterilization and Fumigation*

(7)* Flammable gases used as a vehicle fuel when stored on a vehicle.

(8)* Storage, use, and handling of liquefied and nonliquefied compressed gases, in laboratory work areas that are in accordance with NFPA 45, S*tandard on Fire Protection for Laboratories Using Chemicals*

(9)* Storage, use, and handling of liquefied petroleum gases in accordance with NFPA 58, *Liquefied Petroleum Gas Code*

(10) Gases within approved refrigeration systems complying with the mechanical code

(11) LNG storage at utility plants under NFPA 59A, *Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG*)

(12) LNG handled as a vehicle fuel under NFPA 57, *Liquefied Natural Gas (LNG) Vehicular Fuel Systems Code*

(13) CNG handled as a vehicle fuel under NFPA 52, *Compressed Natural Gas (CNG) Vehicular Fuel Systems Code*

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

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

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

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

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

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

1.5 Equivalency. Nothing in this standard is intended to prevent the use of systems, methods, or devices or equivalent or superior quality, strength, fire resistance, effectiveness, durability, and safety over those prescribed by this standard. Technical documentation shall be submitted to the authority having jurisdiction to demonstrate equivalency. The system, method, or device shall be approved for the intended purpose by the authority having jurisdiction.

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

Chapter 2 Referenced Publications

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

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

NFPA 13, *Standard for the Installation of Sprinkler Systems,* 1999 edition.

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

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

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

NFPA 52, *Compressed Natural Gas (CNG) Vehicular Fuel Systems,* 1998 edition.

NFPA 57 *Liquefied Natural Gas (LNG) Vehicular Fuel Systems Code*, 1999 edition.

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

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

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

NFPA 69, *Standard on Explosion Prevention Systems,* 1997 edition.

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

NFPA 72, National Fire Alarm Code®, 1999 edition.

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

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

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

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

NFPA 801, *Standard for Fire Protection for Facilities Handling Radioactive Materials*, 1998 edition.

2.3 Other Publications.

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

ASME A13.1, *Scheme For The Identification Of Piping Systems,* 1996 edition.

ASME-31.3, *Process Piping*, 2000 edition.

ASME, *Boiler and Pressure Vessel Code,* "Rules for the Construction of Unfired Pressure Vessels," Section VIII, ASME Boiler and Pressure Vessel Code, 1998 edition.

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

ASTM E 681, *Test for Limits of Flammability of Chemicals*, 1985 edition.

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

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

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

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

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

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

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

CGA S-1.2, *Pressure Relief Device Standards – Part 2 – Cargo and*

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

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

Transportation of Dangerous Goods Regulations, Canadian Communications Group Publication Centre, Ordering Department, Ottawa, Canada, K1A 0S9.
Applicable equivalent regulations in the country of use.

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

Title 16, *Code of Federal Regulations,* Parts 1500.41 and 1500.42.
Title 29, *Code of Federal Regulations,* Part 1910.
Title 49, *Code of Federal Regulations,* Parts 100-180 (Transportation).

Chapter 3 Definitions

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

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

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

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

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

3.2.5 Shall. Indicates a mandatory requirement.

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

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

3.3 General Definitions.

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

3.3.2 Area.

3.3.2.1 Control Area. A space within a building that is enclosed and bounded by exterior walls, fire walls, fire barriers, and roofs, or a combination thereof, where quantities of hazardous materials that do not exceed the quantity thresholds for gases requiring special provisions are stored, dispensed, used, or handled.

3.3.2.2 Indoor Area. An area that is not an outdoor area. (*See outdoor area.*)

3.3.2.3 Outdoor Area. An area that is either outside the confines of a building, or an area sheltered from the elements by overhead cover, that is protected from weather expsure by an exterior wall that obstructs not more than 25 percent of the building boundary.

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

3.3.4 ASTM. American Society for Testing and Materials.

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

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

3.3.7 CFR. Code of Federal Regulations.

3.3.8 CGA. Compressed Gas Association.

3.3.9 Container. A vessel, such as a cylinder, portable tank, or stationary tank, that varies in shape, size, and material of construction, and of a design meeting the specifications of the ASME, Transport Canada (TC), or DOTn regulations.

3.3.9.1 Compressed Gas Container. A pressure vessel designed to hold compressed gases at pressures greater than 1 atmosphere at 20ºC (68ºF) that includes cylinders, containers, and tanks.

3.3.10* Corrosive Liquid. A liquid chemical that causes full thickness destruction of human skin at the site of contact within a specified period of time.

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

3.3.12 Cylinder. A portable compressed gas container, fabricated to or authorized for use by the U.S. Department of Transportation (DOTn), or fabricated to Transport Canada (TC) *Transportation of Dangerous goods Regulations,* or the ASME *Boiler and Pressure Vessel Code* "Rules for the Construction of Unfired Pressure Vessels," Section VIII.

3.3.13 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.

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

3.3.15 DOTn. United States Department of Transportation.

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

3.3.17* 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.

3.3.18 Gas.

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

3.3.18.2 Corrosive Gas. A gas whose saturated water solution at normal temperature and pressure (NTP) results in a liquid that is classified as a corrosive liquid.

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

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

3.3.18.5 Highly Toxic Gas. A chemical that has a median lethal concentration (LC_{50}) in air of 200 parts per million by volume or less of gas or vapor, or 2 milligrams per liter or less of mist, fume, or dust, when administered by continuous inhalation for 1 hour (or less if death occurs within 1 hour) to albino rats weighing between 200 g and 300 g (0.44 lb and 0.66 lb) each.

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

3.3.18.7 Irritant Gas. A gas that is not corrosive, but that causes a reversible inflammatory effect on living tissue by chemical action at the site of contact. A gas is a skin irritant if, when tested on the intact skin of albino rabbits by the methods of 16 CFR, Part 1500.41, for an exposure of 4 or more hours or by other appropriate techniques, it results in an empirical score of 5 or more. A gas is classified as an eye irritant if so determined under the procedure specified in 16 CFR, Part 1500.42, or other approved techniques.

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

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

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

3.3.18.11 Pyrophoric Gas. A gas that spontaneously ignites in air at or below a temperature of 54.4°C (130°F) .

3.3.18.12 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 200 g and 300 g (0.44 lb and 0.66 lb) each.

3.3.18.13* Unstable Reactive Gas. A material, other than an explosive, that, in the pure state or as commercially produced, vigorously polymerizes, decomposes, condenses, or becomes self-reactive and undergoes other violent chemical changes, including explosion, when exposed to heat, friction, or shock, where an inhibitor is absent, where contaminants are present, or when such material comes into contact with incompatible materials.

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

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

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

3.3.22 Handling. Transporting, connecting, or disconnecting a non-liquefied or liquefied compressed gas or cryogenic fluid container, cylinder, or tank.

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

3.3.24* 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 form that a person could escape within 30 minutes without any escape-impairing symptoms or irreversible health effects.

3.3.25 Limit.

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

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

3.3.25.3* 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).

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

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

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

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

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

3.3.31 Separation of Hazards. Storage or use of incompatible materials in the same room or area, but physically separated by a specified distance, construction, or appliance.

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

3.3.33 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.

3.3.34 System.

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

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

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

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

3.3.35 Tank.

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

3.3.35.2* 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.

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

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

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

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

Chapter 4 General Requirements

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

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

4.3 Hazardous Materials Management Plan (HMMP).

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

4.3.2 The HMMP shall include the following information:

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

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

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

4.4.2 Permanently Out-of-Service Facilities.

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

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

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

4.4.3 Facility Closure Plan.

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

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

4.5 Emergency Plan.

4.5.1 Emergency Plan Requirements.

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

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

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

Chapter 5 Classification of Hazards

5.1 Hazardous Materials Classification.

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

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

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

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

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

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

5.1.4.2 Flammability. Flammability shall be classified in accordance with CGA P-23, *Standard for Categorizing Gas Mixtures Containing Flammable and Nonflammable Components* or by physical testing in accordance with the requirements of ASTM E 681 *Standard Test Method for Concentration Limits of Flammability of Chemicals or ISO 10156.*

Chapter 6 Building Related Controls

6.1 General.

6.2 Control Areas.

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

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

6.3 Occupancy Protection Levels.

6.3.1 Quantity Thresholds for Compressed Gases and Cryogenic Fluids Requiring Special Provisions. Where the quantities of compressed gases or cryogenic fluids stored or used within an indoor control area exceeds that shown in Table 6.3.1, the area shall meet the requirements for high hazard occupancies in accordance with the building code. (See Table 6.3.1 on the following page.)

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

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

6.3.1.3 Containers, cylinders or tanks not exceeding 7.1 m^3 (250 ft^3) content at normal temperature and pressure (NTP) and used for maintenance purposes, patient care, or operation of equipment shall be permitted.

6.3.1.4 Toxic and Highly Toxic Compressed Gases. Except for containers or cylinders not exceeding 20 ft^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.

6.3.1.5 Smaller Containers. Containers, cylinders, or tanks not exceeding 7.1 m^3 (250 ft^3) content at NTP and used for maintenance purposes, patient care, or operation of equipment shall be permitted.

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 6.3.2.4.

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 are 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 in quantities that exceed the quantity thresholds for gases requiring special provisions are classified as Protection Level 2.

Table 6.3.1 Quantity Thresholds for Gases Requiring Special Provisions*

	Unsprinklered Area			Sprinklered Area		
Material	No gas cabinet, gas room, or exhausted enclosure ft³ (lb) [gal]	Exhausted enclosure ft³ (lb) [gal]	Gas cabinet or gas room ft³ (lb) [gal]	No gas cabinet, gas room, or exhausted enclosure ft³ (lb) [gal]	Exhausted enclosure ft³ (lb) [gal]	Gas cabinet or gas room ft³ (lb) [gal]
Corrosive Gas						
Liquefied	(150 lb) 68 kg	(300 lb) 136 kg	(300 lb) 136 kg	(300 lb) 136 kg	(600 lb) 272 kg	(600 lb) 272 kg
Nonliquefied	810 ft³ 23 m³	1620 ft³ 46 m³	1620 ft³ 46 m³	1620 ft³ 46 m³	3240 ft³ 92 m³	3240 ft³ 92 m³
Cryogenic Liquid (Flammable or Oxidizing)	[45 gal]	[90 gal]	[90 gal]	[90 gal]	[90 gal]	[180 gal]
Flammable Gas						
Liquefied	(30 lb) 14 kg	(60 lb) 27 kg	(60 lb) 27 kg	(60 lb) 27 kg	(120 lb) 55 kg	(120 lb) 55 kg
Nonliquefied	1000 ft³ 28 m³	2000 ft³ 28 m³	2000 ft³ 28 m³	2000 ft³ 28 m³	4000 ft³ 56 m³	4000 ft³ 56 m³
Highly Toxic Gas						
Liquefied	(0 lb)	(5 lb) 2.3 kg	(5 lb) 2.3 kg	(0 lb)	(10 lb) 4.5 kg	(10 lb) 4.5 kg
Nonliquefied	0 ft³	20 ft³ 0.6 m³	20 ft³ 0.6 m³	0 ft³	40 ft³ 1.1 m³	40 ft³ 1.1 m³
Nonflammable Gas						
Liquefied	No limit					
Nonliquefied	No limit					
Oxidizing Gas						
Liquefied	(30 lb) 14 kg	(60 lb) 27 kg	(60 lb) 27 kg	(60 lb) 27 kg	(120 lb) 55 kg	(120 lb) 55 kg
Nonliquefied	1500 ft³ 43 m³	3000 ft³ 85 m³	3000 ft³ 85 m³	3000 ft³ 85 m³	6000 ft³ 170 m³	6000 ft³ 170 m³
Pyrophoric Gas						
Liquefied	(0 lb)	(0 lb)	(0 lb)	(4 lb)	(8 lb)	(8 lb)
Nonliquefied	0 ft³	0 ft³	0 ft³	50 ft³	100 ft³	100 ft³
Toxic Gas						
Liquefied	(150 lb) 68 kg	(300 lb) 136 kg	(300 lb) 136 kg	(300 lb) 136 kg	(600 lb) 273 kg	(600 lb) 273 kg
Nonliquefied	810 ft³ 23 m³	1620 ft³ 46 m³	1620 ft³ 46 m³	1620 ft³ 46 m³	3240 ft³ 92 m³	3240 ft³ 92 m³
Unstable Reactive (Detonable) Gas, Class 3 or Class 4						
Liquefied	(0 lb)	(0 lb)	(0 lb)	(1 lb) 0.5 kg	(2 lb) 1 kg	(2 lb) 1 kg
Nonliquefied	0 ft³	0 ft³	0 ft³	10 ft³ 0.3 m³	20 ft³ 0.6 m³	20 ft³ 0.6 m³
Unstable Reactive (Nondetonable) Gas, Class 3						
Liquefied	(2 lb) 1 kg	(4 lb) 2 kg	(4 lb) 2 kg	(4 lb) 2 kg	(8 lb) 4 kg	(8 lb) 4 kg
Nonliquefied	50 ft³ 1.4 m³	100 ft³ 3 m³	100 ft³ 3 m³	100 ft³ 3 m³	200 ft³ 6 m³	200 ft³ 6 m³
Unstable Reactive Gas, Class 2						
Liquefied	(30 lb) 14 kg	(60 lb) 27 kg	(60 lb) 27 kg	(60 lb) 27 kg	(120 lb) 55 kg	(120 lb) 55 kg
Nonliquefied	750 ft³ 21 m³	1500 ft³ 43 m³	1500 ft³ 43 m³	1500 ft³ 43 m³	3000 ft³ 85 m³	3000 ft³ 85 m³

* The aggregate quantity in use and storage shall not exceed the quantity listed for storage.

6.3.2.3 Protection Level 3. Occupancies used for the storage or use of oxidizing compressed gases and unstable, reactive, Class 2 compressed gases in quantities that exceed the quantity thresholds for gases requiring special provisions are 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 are classified as Protection Level 4.

6.4 Gas Rooms. Gas rooms shall meet the requirements of 6.4.1 through 6.4.4.

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.

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

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

Gas Hazard	Class	Quantity of Material (ft^3)
Unstable reactive (detonable)	4 or 3	Quantity thresholds for gases requiring special provisions*
Unstable reactive (nondetonable)	3 2	2000 ft^3 57 m^3 10000 ft^3 283 m^3
Pyrophoric gas	NA	2000 ft^3 57 m^3

NA = Not applicable
* *Quantity thresholds for gases requiring special* provisions refers to quantities listed in Table 6.3.1.

6.6 Temperature Protection.

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

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

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

(A) Emergency alarm initiating devices shall be installed outside of each interior exit or exit access doors.
(B) Activation of an emergency alarm-initiating device shall sound a local alarm to alert occupants of an emergency situation involving a compressed gas.

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

6.8.1 Standby Power.

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

(1) Mechanical ventilation
(2) Treatment systems
(3) Temperature controls
(4) Alarms
(5) Detection systems
(6) Other electrically operated systems

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

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

6.9 Explosion Control. Explosion control shall be provided as required by Table 6.9 in accordance with NFPA 68, *Guide for Venting of Deflagrations,* or NFPA 69, *Standard on Explosion Prevention Systems,* where amounts of compressed gases in storage or use exceed the quantity thresholds requiring special provisions.

Table 6.9 Explosion Control Requirements

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

6.10 Fire Protection. Sprinklers shall be provided for occupancies classified as Protection Levels 1, 2, 3, and 4 in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems,* for the highest hazard class for the anticipated storage.

6.10.1 Alternate Fire-Extinguishing Systems. Alternate fire-extinguishing systems shall not be used for separate buildings, storage areas, gas cabinets, exhausted enclosures, or gas rooms.

6.10.2 Oxidizing Gases. Occupancies containing oxidizing gases shall not be required to be provided with fire-extinguishing systems where the following criteria are met:

(1) They shall be comprised of noncombustible construction.
(2) They shall not be exposed by other areas or hazards.
(3) All areas shall contain wholly noncombustible contents.

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

6.12 Hazard Identification Signs.

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

(A) Ratings shall be assigned in accordance with NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response.*
(B) The authority having jurisdiction shall be permitted to waive this requirement where consistent with safety.

6.12.2 Application. Signage shall be provided as specified in 6.12.2.1 and 6.12.2.2.

6.12.2.1 Signs. Signs shall not be obscured or removed.

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

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

6.14 Shelving.

6.14.1 Shelves used for the storage of cylinders shall be of noncombustible construction and designed to support the weight of the cylinders.

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

6.15 Venting From Piping Systems and Controls. Venting of gas shall be to an approved location.

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

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

6.16.2 Compressed Air. The requirements of Sections 6.16 and 6.16.1 shall not apply to cylinders, containers, and tanks containing compressed air.

6.16.3 Mechanical Ventilation Rate. Mechanical ventilation shall be at a rate of not less than 1 $ft^3/min/ft^2$ of floor area covered by the cylinders, containers, or tanks.

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

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

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

VENTILATION SYSTEM EMERGENCY SHUTOFF.

6.16.7 Inlets to the Exhaust System.

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

6.16.7.2 For gases that are heavier than air, exhaust shall be taken from a point within 6 in. (152 mm) of the floor.

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

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

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

6.17 Gas Cabinets.

6.17.1 Construction. Where a gas cabinet is required, is used to provide separation of gas hazards, or is used to increase the threshold quantity for a gas requiring special provisions, the gas cabinet shall be in accordance with the requirements of 6.17.1.1 through 6.17.1.6.

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

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

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

6.17.1.4 Ventilation. The gas cabinet shall be provided with an exhaust ventilation system designed to operate at a negative pressure.

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

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

6.17.2 Quantity Limits. Gas cabinets shall contain not more than three containers or cylinders.

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

6.18 Exhausted Enclosures.

6.18.1 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.

6.18.1.1 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 of access ports or windows shall not be less than 61 m/min (200 ft/min) average, with not less than 46 m/min (150 ft/min) at any one point.

6.18.1.2 Separation of Incompatible Gases within Enclosures. Cylinders shall be separated in accordance with Table 7.1.5.2.

6.18.1.3 Fire Protection. Exhausted enclosures shall be internally sprinklered.

6.18.2 Quantity Limits. Exhausted enclosures shall contain not more than three containers, cylinders, or tanks.

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

Chapter 7 Compressed Gases

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

7.1.1 Containers, Cylinders, and Tanks.

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

7.1.1.2 Defective Containers, Cylinders, and Tanks.

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

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

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

7.1.2 Labeling Requirements.

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

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

7.1.2.3 Stationary Compressed Gas Containers, Cylinders, and Tanks.

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

7.1.2.3.2 Markings shall be visible from any direction of approach.

7.1.2.4 Piping Systems. Piping systems shall be marked in accordance with ASME A13.1, *Scheme for the Identification of Piping Systems or Other Applicable Standards*.

(A) Marking shall include the name of the gas and a direction of flow arrow.
(B) 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.
(C) Markings for piping systems shall be provided at the following locations:
(1) At each valve
(2) At wall, floor, or ceiling penetrations
(3) At each change of direction
(4) At a minimum of every 20 ft or fraction thereof throughout the piping run

7.1.3 Security.

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

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

7.1.3.3 Physical Protection.

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

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

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

(1) Compressed gas containers, cylinders, and tanks in the process of examination, servicing, and refilling shall not be required to be secured.
(2) At cylinder-filling plants and distributors' warehouses, the nesting of cylinders shall be permitted as a means to secure cylinders.

7.1.4 Valve Protection.

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

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

7.1.4.3 Valve Outlet Caps or Plugs.

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

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

7.1.5 Separation from Hazardous Conditions.

7.1.5.1 General.

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

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

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

7.1.5.3 Clearance from Combustibles and Vegetation. Combustible waste, vegetation, and similar materials shall be kept a minimum of 0.3048m (10ft) from compressed gas containers, cylinders, tanks, and systems.

(A) A noncombustible partition without openings or penetrations and extending sides not less than 457 mm (18 in.) above and to the sides of the storage area shall be permitted in lieu of the minimum distance.
(B) The noncombustible partition shall either be an independent structure, or the exterior wall of the building adjacent to the storage area.

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

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

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

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

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

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

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

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

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

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

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

20 ft = 6.1 m
NR = No separation required.
Notes:
1. The 20 ft (6.1 m) distance shall be permitted to be reduced without limit when separated by a barrier of noncombustible materials at least 5 ft (1.5 m) high that has a fire resistance rating of at least — hour.
2. The 20 ft (6.1 m) distance shall be permitted to be reduced to 5ft (1.m) where one of the gases is enclosed in a gas cabinet or without limit where both gases are enclosed in gas cabinets.
3. Cylinders without pressure relief devices shall not be stored without separation from flammable and pyrophoric gases with pressure relief devices.
4. Spatial separation is not required between cylinders deemed to be incompatible that are connected to manifolds for the purposes of filling and manufacturing procedures prescribing the required controls for the manufacture of gas mixtures are in place.

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

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

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

7.1.9 Leaks, Damage, or Corrosion.

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

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

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

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

7.1.10 Surfaces.

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

7.1.10.2 Surfaces shall be graded to prevent accumulation of water.

7.2 Storage.

7.2.1 General.

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

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

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

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

7.2.1.2.3 Palletized Containers, Cylinders and Tanks. 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.

7.2.2 Material-Specific Regulations.

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

7.2.2.2 Exterior Storage.

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

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

7.3 Use and Handling.

7.3.1 General.

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

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

7.3.1.3 Controls.

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

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

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

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

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

7.3.1.5 Valves.

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

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

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

7.3.1.7 Upright Use.

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

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

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

(A) Flammable liquefied gases at processing plants shall be permitted to use this inverted position method while transfilling.
(B) The container, cylinder, or tank shall be secured, and the dispensing apparatus shall be designed for use with liquefied gas.

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

7.3.1.10 Transfer.

7.3.1.10.1 Transfer of gases between containers, cylinders, and tanks shall be performed by qualified personnel using equipment and operating procedures in accordance with CGA P-1, *Safe Handling of Compressed Gases in Containers*. The requirements of 7.3.1.10.1 shall not apply to fueling of vehicles with compressed natural gas (CNG).

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

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

(A) Emergency shutoffs shall be located at the point of use and at the tank, cylinder, or bulk source.
(B) These requirements shall not apply to systems containing only a single cylinder not exceeding the quantity threshold for gases requiring special provisions.

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

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

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

7.3.1.13.2 Location. The location of excess flow control shall be as specified in 7.3.1.11.2(A) and 7.3.1.11.2(B).

(A) Where piping originates from a source located in a room or area, the excess flow control shall be located within the room or area.
(B) Where piping originates from a bulk source, the excess flow control shall be as close to the bulk source as possible.

7.3.1.13.3 Location Requirement Exemptions. The requirements of 7.3.1.13.2 shall not apply to the following:

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

7.3.2 Material-Specific Regulations.

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

7.3.2.2 Exterior Use.

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

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

7.3.3 Handling.

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

7.3.3.2 Carts and Trucks.

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

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

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

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

7.5 Corrosive Gases.

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

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

(A) A 2-hour fire barrier wall without openings or penetrations, and extending 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 (6096-mm) distance.
(B) The fire barrier wall shall be either an independent structure or the exterior wall of the building adjacent to the storage or use area.
(C) The 2-hour fire barrier shall be located at least 5 ft from any exposure.
(D) The 2-hour fire barrier 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).

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

7.5.4 Limit Controls.

7.5.4.1 Stationary Tanks. Stationary tanks that can generate pressures exceeding the tank or equipment design limits due to exposure fires or internal reaction shall be equipped with pressure-limiting or pressure-relief devices.

7.5.4.2 Pressure-Relief Devices. Pressure-relief devices for stationary tanks or equipment shall vent to an exhaust scrubber or treatment system for processing of vapors or gases.

7.5.4.3 Treatment System Design and Performance. Where treatment systems are provided, they shall be capable of diluting, adsorbing, absorbing, containing, neutralizing, burning, or otherwise processing corrosive gas by reducing the allowable discharge concentrations to one-half the immediately dangerous to life and health (IDLH) threshold at the point of discharge.

7.5.4.4 Alternatives to Treatment System. A treatment system shall not be required where the controls required by 7.5.4.4.1 through 7.5.4.4.5 are provided.

7.5.4.4.1 Containment Vessels or Systems. Approved cylinder containment vessels or cylinder containment systems shall be provided on site for gases in storage or use.

7.5.4.4.2 Trained Personnel. Personnel trained in the use of cylinder containment vessels or cylinder containment systems shall be readily available.

7.5.4.4.3 Gas Detection. A gas detection system with a sensing interval not exceeding 5 minutes shall be provided when corrosive gases are in use.

7.5.4.4.4 Monitoring. The gas detection system shall monitor the exhaust system at the point of discharge from the gas cabinet or exhausted enclosure when gases are contained within, or within the gas room or other area in which either the gas source or use is located.

7.5.4.4.5 Automatic-Closing Valve.

(A) An approved automatic-closing fail-safe valve shall be located immediately adjacent to the gas delivery valve.
(B) The fail-safe valve shall automatically close when gas is detected at the permissible exposure limit or ceiling limit by the gas detection system required by 7.5.4.4.3.

7.6 Flammable Gases.

7.6.1 Storage, Use, and Handling.

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

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

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

Table 7.6.2 Distance to Exposures for Flammable Gases*

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

*1. The minimum required distances shall be reduced to 1.5 m (5 ft) where protective structures having a minimum fire resistance rating of 2 hours interrupt the line of sight between the container and the exposure. The protective structure shall be at least 1.5 m (5 ft) from the storage or use area perimeter. The configuration of the protective structure shall be designed to allow natural ventilation to prevent the accumulation of hazardous gas concentrations.

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

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

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

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

7.7 Oxidizing Gases.

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

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

Table 7.7.2 Oxidizing Gases Distance from Use to Exposures*

Quantity of Gas Stored (ft^3 at NTP)	Distance to a Building or Public Way or Property Line (ft)	Distance Between Storage Areas (ft)
× 3.785 for L	× 0.3048 for m	
0 – 50,000	5	5
50,001 – 100,000	10	10
100,001 or greater	15	10

* The distances do not apply where protective structures having a minimum fire resistance of 2 hours interrupt the line of sight between the container and the exposure. The protective structure shall be at least 5 ft from the storage or use area perimeter. The configuration of the protective structure shall allow natural ventilation to prevent the accumulation of hazardous gas concentrations.

7.8 Pyrophoric Gases.

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

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

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

7.9 Toxic and Highly Toxic Gases.

7.9.1 General. The storage or use of toxic and highly toxic gases exceeding the quantity thresholds for gases requiring special provisions as specified in Table 6.3.1 shall be in accordance with Chapter 1, Chapter 4 through Chapter 6, Section 7.1 through Section 7.3, and Section 7.9.

7.9.2 Ventilation and Arrangement.

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

(A) Gas cabinets shall be in accordance with Section 6.17.
(B) Exhausted enclosures shall be in accordance with Section 6.18.
(C) Gas rooms shall be in accordance with Section 6.4.

7.9.2.2 Outdoors. When containers, cylinders, or tanks are used outdoors, in excess of the quantities specified in the column for unsprinklered (unprotected by gas cabinets or exhausted enclosures) in Table 6.3.1 gas cabinets, exhausted enclosures or equivalent means of local exhaust for controlling the release of gas or vapor in the event of a leak shall be provided.

7.9.2.2.1 Distance to Exposures. The outdoor storage or use of toxic and highly toxic compressed gases shall not be within 75 ft (6096 mm) of lot lines, streets, alleys, public ways of means of egress, or buildings not associated with such storage or use.

(A) A 2-hour fire barrier wall without openings or penetrations, and extending not less than 30 in. (762 mm) above and to the sides of the storage or use area, that interrupts the line of site between the storage or use and the exposure, shall be permitted in lieu of the 75-ft (6096-mm) distance.
(B) The fire barrier wall shall be either an independent structure or the exterior wall of the building adjacent to the storage or use area.
(C) The 2-hour fire barrier shall be located at least 5 ft from any storage or use area perimeter.
(D) The 2-hour fire barrier 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).

7.9.2.2.2 Openings in Exposed Buildings. Where the storage or use area is located closer than 22 m (75 ft) to a building not associated with the manufacture or distribution of toxic or highly toxic compressed gases, openings in the building other than for piping shall not be permitted above the height of the top of the 2-hour fire barrier wall or within 15 m (50 ft) horizontally from the storage area, regardless of whether they are shielded by a fire barrier.

7.9.2.3 Air Intakes. Storage and use of toxic and highly toxic compressed gases shall not be located within 22 m (75 ft) of air intakes.

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

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

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

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

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

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

7.9.3.2.1 Gas Detection.

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

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

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

(A) The fail-safe valve shall close when gas is detected at the permissible exposure limit, short term exposure limit (STEL), or ceiling limit by the gas detection system.
(B) For attended operations a manual closing valve shall be permitted when in accordance 7.9.3.4.3.

7.9.3.2.2 Unattended Operations.

7.9.3.2.2.1 For gases used at unattended operations for the protection of

Table 7.8.3 Pyrophoric Gases Distance from Storage to Exposures*

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

* The distances can be reduced to 5 ft when protective structures having a minimum fire resistance of 2 hours interrupt the line of sight between the container and the exposure. The protective structure shall be at least 5 ft from the storage or use area perimeter. The configuration of the protective structure shall allow natural ventilation to prevent the accumulation of hazardous gas concentrations.

public health, such as chlorine at water or wastewater treatment sites, a detector shall be provided to alert anyone on site and also to alert a responsible person off-site when the gas concentration in the storage/use area reaches the OSHA (PEL), OSHA ceiling limit, or STEL.

7.9.3.2.2.2 An automatic valve shall be set to close and stop the flow if the concentration reaches ____ of the IDLH.

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

(A) Where a total containment system is used, the system shall be designed to handle the maximum anticipated pressure of release to the system when it reaches equilibrium.
(B) Treatment systems shall be capable of reducing the allowable discharge concentrations to one-half the immediately dangerous to life and health threshold at the point of discharge.

7.9.3.4 Treatment System Sizing.

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

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

7.9.3.4.3 Attended Operations — Alternative Method of System Sizing.

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

7.9.3.4.3.2 Such process piping systems shall comply with the requirements of 7.9.3.4.1(A) through 7.9.3.4.1(E).

(A) **Local Exhaust.** All gas transfer operations shall be conducted within a zone of local exhaust that is connected to a treatment system.
(B) **Gas Detection.** Gas detection shall be used to provide a warning to alert the operators to emission of gas into the zone of local exhaust, and the following requirements also shall apply:
(1) The system shall be capable of detecting gas at the permissible exposure limit or ceiling limit for the gas being processed.
(2) Activation of the gas detection system shall provide a local alarm.
(C) **Process Shutdown.** Operations involving the gas detected shall be shut down and leaks repaired.
(D) **Piping System Construction.** Piping systems used to convey gases shall be of all-welded construction throughout, with the exception of fittings used to connect containers, cylinders, or tanks, or any combination thereof, to the process system.
(E) Piping systems shall be designed to provide for readily accessible manual shutdown controls.

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

Table 7.9.3.5 Rates of Release

Container Type	Nonliquefied (min)	Liquefied (min)
Cylinders	5	30
Portable tanks	40	240
All others	Based on peak flow from maximum valve orifice	Based on peak flow from maximum valve orifice

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

7.9.4 Leaking Containers, Cylinders, and Tanks. A gas cabinet, exhausted enclosure, or containment vessel or system shall be provided to handle leaks from leaking containers, cylinders, and tanks in accordance with 7.9.4.1 through 7.9.4.2.3.

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

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

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

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

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

7.9.5 Emergency Power.

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

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

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

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

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

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

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

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

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

7.9.6.4 Automatic Shutdown. Where gas is in use in a gas distribution manifold, the gas detection system shall automatically shut off the flow of gas for operating pressures that exceed 29.7 psia.

7.9.6.5 Detection Points. Detection shall be provided at the locations specified in 7.9.6.5.1 through 7.9.6.5.3.

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

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

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

7.9.6.6 Level of Detection. The gas detection system shall detect the

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

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

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

7.10.1 Distances to Exposures for Class 2. The outdoor storage or use of unstable reactive Class 2 compressed gas shall not be within 20 ft (6096 mm) of buildings, lot lines, streets, alleys, or public ways of means of egress.

(A) A 2-hour fire barrier wall without openings or penetrations, and extending 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 (6096-mm) distance.
(B) The fire barrier wall either shall be an independent structure or the exterior wall of the building.
(C) The 2-hour fire barrier shall be located at least 5 ft (1.5 m) from any storage area or use area perimeter.
(D) The 2-hour fire barrier 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).

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

(A) A 2-hour fire barrier wall without openings or penetrations, and extending not less than 30 in. (762 mm) above and to the sides of the storage or use area, that interrupts the line of site between the storage or use and the exposure, shall be permitted in lieu of the 75-ft (23-m) distance.
(B) The fire barrier wall either shall be an independent structure or the exterior wall of the building adjacent to the storage or use area.
(C) The 2-hour fire barrier shall be located at least 5 ft (1.5 m) from any storage or use area perimeter.
(D) The 2-hour fire barrier 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.)
(E) The fire barrier either shall be an independent structure or the exterior wall of the building adjacent to the storage or use area.

7.10.3 Storage Configuration.

7.10.3.1 Unstable reactive Class 3 compressed gases in cylinders, excluding tube trailers, stored in quantities greater than 500 scf, shall be separated into groups, each not larger than 500 scf. Aisle widths shall not be less than the height of the cylinders or 4 ft (1219 mm), whichever is greater.

7.10.3.2 Unstable reactive gases in portable or stationary tanks or tube trailers shall be separated from each other by 4 ft.

7.10.4 Smoke and Heat Venting. Smoke and heat venting shall be provided in accordance with the building code.

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

7.10.6 Unstable Reactive Gases (Detonable).

7.10.6.1 Storage or Use. The storage or use of unstable reactive (detonable) gases exceeding the quantity thresholds for gases requiring special provisions as specified in Table 6.3.1 shall be in accordance with Chapter 1 through Chapter 6, Section 7.1 through Section 7.3, and 7.10.6.

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

Chapter 8 Cryogenic Fluids

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

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

8.1.2 Closed-Cycle Refrigeration Systems. Fluids within an approved closed-cycle refrigeration system complying with the mechanical code shall not be required to comply with the requirements of Chapter 8.

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

8.2.1 Nonstandard Containers.

8.2.1.1 Containers, equipment, and devices that are not in compliance with recognized standards for design and construction shall be permitted if approved by the authority having jurisdiction upon presentation of evidence that they are designed and constructed for safe operation.
8.2.1.2 The following data shall be submitted to the authority having jurisdiction with reference to the deviation from the standard with the application for approval:

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

8.2.2 Concrete Containers.

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

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

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

(1) Stationary tanks shall be supported to prevent the concentration of excessive loads on the supporting portion of the shell.
(2) Foundations for horizontal containers shall be constructed to accommodate expansion and contraction of the container.
(3) Foundations shall be provided to support the weight of vaporizers and/or heat exchangers.

8.2.3.1 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.

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

8.2.6 Pressure-Relief Devices.

8.2.6.1 General.

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

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

8.2.6.2 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.

8.2.6.3 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.

8.2.6.4 Sizing.

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

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

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

8.2.6.6 Arrangement.

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

8.2.6.6.2 Portable Containers with Volume Less than 2 ft³.

8.2.6.6.2.1 The arrangement of the discharge from pressure-relief devices from DOTn specified containers with an internal water volume of 2.0 ft^3 (0.057 m^3) or less shall be incorporated in the design of the container.

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

8.2.6.7 Shutoffs between Pressure-Relief Devices and Containers.

8.2.6.7.1 General. Shutoff valves installed between pressure-relief devices and containers shall be in accordance with 8.2.6.7.

8.2.6.7.2 Location. Shutoff valves shall not be installed between pressure-relief devices and containers unless the valves or their use meets the requirements of 8.2.6.7.2.1 or 8.2.6.7.2.

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

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

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

8.3 Pressure-Relief Vent Piping.

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

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

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

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

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

8.4 Marking.

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

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

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

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

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

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

(A) The nameplate shall be installed on the container in an accessible location.
(B) The nameplate shall be marked in accordance with nationally recognized standards.

8.4.4 Identification of Container Connections.

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

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

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

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

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

8.5 Security.

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

8.5.2 Security of Areas. Containers and systems shall be secured against unauthorized entry.

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

(A) Portable containers subject to shifting or upset shall be secured.
(B) Nesting shall be permitted as a means of securing portable containers.

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

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

8.6 Separation from Hazardous Conditions.

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

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

Table 8.6.2 Minimum Separation Distance Between Stationary Cryogenic Containers and Exposures

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

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

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

8.6.3 Portable Cryogenic Containers.

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

Table 8.6.3 Minimum Separation Distance Between Portable Cryogenic Containers and Exposures

Exposure	Minimum distance	
	ft	m
Building exits	10	3.1
Wall openings	10	0.3
Air intakes	10	3.1
Property lines	5	1.5
Room or area exits	3	0.9
Combustible materials, such as paper, leaves, weeds, dry grass, or debris	15	4.5
Incompatible hazardous materials	20	6.1

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

8.7 Electrical Wiring and Equipment.

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

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

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

(A) When electrical grounding and bonding is required, the system shall be in accordance with NFPA 70, *National Electrical Code®*.
(B) The grounding system shall be protected against corrosion, including corrosion caused by stray electric currents.

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

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

8.8.2 Systems. Service and repair of systems shall be performed by trained personnel in accordance with nationally recognized standards.

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

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

8.12 Storage.

8.12.1 Indoor Storage.

8.12.1.1 Installation. Stationary containers indoors shall be installed in accordance with Chapter 9 and Chapter 11, or CGA P18, *Standard for Bulk Inert Gas Systems at Consumer Sites.*

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

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

8.12.1.4 Ventilation. Ventilation shall be in accordance with Section 6.16.

8.12.2 Outdoor Storage.

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

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

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

8.12.2.4 Drainage.

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

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

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

8.13 Use and Handling.

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

8.13.1.1 Design.

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

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

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

8.13.1.2.1 Design and Construction.

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

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

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

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

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

(A) Shutoff valves for containers with multiple pressure -relief devices shall be permitted in accordance with 8.2.6.7.
(B) Shutoff valves shall be accessible and located as close as practical to the container.

8.13.1.2.5 Shutoff Valves on Piping.

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

8.13.1.2.5.2 Pressure-relief valves shall be installed where liquid can be trapped between shutoff valves in the piping system. (*See 8.2.6.*)

8.13.1.2.6 Physical Protection and Support.

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

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

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

8.13.1.2.8 Testing.

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

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

8.13.2 Material-Specific Requirements.

8.13.2.1 Indoor Use. Indoor use of cryogenic fluids shall be in accordance with the material-specific provisions of Chapter 9 and Chapter 11, or CGA P18, *Standard for Bulk Inert Gas Systems at Consumer Sites,* and 8.13.2.

8.13.2.2 Outdoor Use.

8.13.2.2.1 General. Outdoor use of cryogenic fluids shall be in accordance with the material-specific provisions Chapter 9 and Chapter 11 or CGA P18, *Standard for Bulk Inert Gas Systems at Consumer Sites,* and 8.13.2.2.

8.13.2.2.2 Separation. Distances from property lines, buildings, and exposure hazards shall be in accordance with Table 8.6.2 and Table 8.6.3 and the material-specific provisions of Chapter 9 and Chapter 11 or CGA P18, *Standard for Bulk Inert Gas Systems at Consumer Sites*.

8.13.2.2.3 Shutoff Valves.

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

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

8.13.2.3 Filling and Dispensing.

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

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

(A) Indoor Dispensing Areas. Dispensing indoors shall be conducted in areas constructed in accordance with the building code.
(B) Ventilation. Indoor areas in which cryogenic fluids are dispensed shall be ventilated in accordance with the requirements of Section 6.16 and the mechanical code.
(C) Piping Systems. Piping systems utilized for filling or dispensing of cryogenic fluids shall be designed and constructed in accordance with 8.13.1.2.

8.13.2.3.3 Vehicle Loading and Unloading Areas. Loading or unloading areas shall be constructed in accordance with the requirements of Chapter 9 and Chapter 11 or CGA P18, *Standard for Bulk Inert Gas Systems at Consumer Sites*.

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

8.13.2.4 Handling.

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

8.13.2.4.2 Carts and Trucks.

8.13.2.4.2.1 Cryogenic containers shall be moved using an approved method.

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

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

8.13.2.4.4 Closed Containers.

8.13.2.4.4.1 Pressurized containers shall be closed while transported.

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

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

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

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

Annex A Explanatory Material

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

A.1.1.2.1 For regulations on the transportation of gases, see the Code of Federal Regulations, Title 49, Parts 100 to 179 (Transportation) and Transportation of Dangerous Goods Regulations of Transport Canada.

A.1.1.2.3 For information on storage of medical gases at health care facilities, see NFPA 99, *Standard for Health Care Facilities*.

A.1.1.2.7 For information, see NFPA 52, *Standard for Compressed Natural Gas (CNG) Vehicular Fuel Systems,* or NFPA 58, *Liquefied Petroleum Gas Code.*

A.1.1.2.8 The storage of gases outside of laboratory work areas is covered by this standard.

A.1.1.2.9 For information on storage and use of more than 735 lb (333 kg) water capacity [nominal 300 lb (136 kg) propane] of liquefied flammable gas, see NFPA 58, *Liquefied Petroleum Gas Code.*

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

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

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

A.3.3.10 A chemical is considered corrosive if so determined when tested by the method described in DOTn 49 CFR, Part 173, Section 173.137. A liquid that has a severe corrosion rate on steel or aluminum based on the criteria in Section 173.137(c)(2) is also a corrosive material.

A.3.3.17 Such enclosures include laboratory hoods, exhaust fume hoods, and similar appliances and equipment used to retain and exhaust locally the gases, fumes, vapors, and mists that could be released. Rooms or areas provided with general ventilation, in and of themselves, are not exhausted enclosures.

A.3.3.18.1 The states of a compressed gas are categorized as follows:

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

A.3.3.18.3 The limits specified are determined at an absolute pressure of 101.325 kPa (14.7 psia) and a temperature of 20°C (68°F) in accordance with ASTM E 681.

A.3.3.18.13 Unstable reactive materials are subdivided into five classifications. Class 4 materials are materials that in themselves are readily capable of detonation or explosive decomposition or explosive reaction at normal temperatures and pressures, which include the following:
(1) Materials that are sensitive to localized thermal or mechanical shock at normal temperatures and pressures
(2) Materials that have an instantaneous power density (product of heat of reaction and reaction rate) at 482°F (250°C) of 1000 W/mL or greater.

Class 3 materials are materials that in themselves are capable of detonation or explosive decomposition or explosive reaction but require a strong initiating source or heat under confinement before initiation. Class 3 materials include the following:
(1) Materials that have an instantaneous power density (product of heat of reaction and reaction rate) at 482°F (250°C) at or above 100 W/mL and below 1000 W/mL
(2) Materials that are sensitive to thermal or mechanical shock at elevated temperatures and pressures
(3) Materials that react explosively with water without requiring heat or confinement

Class 2 materials are materials that readily undergo violent chemical change at elevated temperatures and pressures, including the following:
(1) Materials that have an instantaneous power density (product of heat of reaction and reaction rate) at 482°F (250°C) at or above 10 W/mL and below 100 W/mL
(2) Materials that react violently with water or form potentially explosive mixtures with water

Class 1 materials are materials that in themselves are normally stable but that can become unstable at elevated temperatures and pressures, including the following:
(1)Materials that have an instantaneous power density (product of heat of reaction and reaction rate) at 482°F (250°C) at or above 0.01 W/mL and below 10 W/mL
(2) Materials that react vigorously with water, but not violently
(3) Materials that change or decompose on exposure to air, light, or moisture

Class 0 materials are materials that in themselves are normally stable, even under fire conditions, including the following:
(1) Materials that have an instantaneous power density (product of heat of reaction and reaction rate) at 482°F (250°C) below 0.01 W/mL
(2) Materials that do not react with water
(3) Materials that do not exhibit an exotherm at temperatures less than or equal to 932°F (500°C) when tested by differential scanning calorimetry

A.3.3.19 Doors and access ports for exchanging cylinders and accessing pressure-regulating controls are permitted to be included as part of a gas cabinet.

A.3.3.23 The criteria for hazard rating are as defined in NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response*.

A.3.3.24 IDLH. This level is established by the national Institute of Occupational Safety and Health (NIOSH). If adequate data do not exist for precise establishment of IDLH data, an independent certified industrial hygienist, industrial toxicologist or appropriate regulatory agency should make such determination.

A.3.3.25.2 The maximum permitted time-weighted average exposures to be utilized are those published in 29 CFR 1910.1000.

A.3.3.25.3 STEL limits are published in 29 CFR 1910.1000.

A.3.3.35.1 A compressed gas system can consist of a compressed gas container or containers, reactors, and appurtenances, including pumps, compressors, and connecting piping and tubing.

A.3.3.36.1 A portable tank does not include any cylinder having less than 453.5 kg (1000 lb) water capacity, cargo tank, tank car tank, or trailers carrying cylinders of over 453.5 kg (1000 lb) water capacity.

A.3.3.36.2 A stationary tank does not include a cylinder having less than 453.5 kg (1000 lb) water capacity.

A.7.1.9.1 The gas supplier should be consulted for advice under these circumstances.

A.7.9.3.6 Where portable containers, cylinders, or tanks are equipped with reduced flow orifices, the worst-case rate of release shall be determined by the maximum achievable flow from the valve determined based on the following formula:

$$CFM = (767 \times A \times P)(28.96/MW)/60$$

where:

CFM = Standard cubic feet per minute of gas of concern under flow conditions
A = Area of orifice in square inches
P = Supply pressure of gas at NTP in pounds per square inch absolute
MW = Molecular weight (For mixtures, the average of molecular weights shall be used)

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

Table A.7.9.3.6 Typical Orifice Areas

Orifice Diameter (in.)	Area (in.^{2})
0.006	2.83 × 10 E-5
0.010	7.85 × 10 E-5
0.014	1.54 × 10 E-4

The formula has been taken from industry publications including the Airco (BOC) Special Gases and Equipment Data Book.1 It is published by other suppliers of specialty and mixed gases, including Scott Semiconductor Gases. It is based on estimated flow rates for air at 70°F discharging to normal atmospheric pressure through an average shape and quality orifice. It can be assumed to be 15 percent accurate. Correction factors have been built into the formula as presented in 7.9.3.5.1 to accommodate the use of gases other than air, for example, use of specific gravity data.

Annex B Attended Operations

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

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

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

(1) The five scenarios as listed in Section 68.28
(2) The 5-year accident history of all accidental releases from covered processes that resulted in deaths, injuries, or significant property damage on-site, or all known off-site deaths, injuries, evacuations, sheltering-in-place, or property or environmental damage.
(3) The hazard review or process hazards analysis completed as part of the required prevention program

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

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

B.1.3 Based on comparable analysis, it was determined that the most likely alternative release scenario having an off-site impact from compressed gas systems would be a process piping failure that is either outdoors, or indoors and entrained into an unspecified exhaust system where either discharge results in a continuous emission resulting in a plume on-site or off-site. An accidental release of this type might occur due to mechanical failure, corrosion, failure of a piping component such as a joint or valve, or another cause.

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

B.2 Parameters. Each parameter, whether selected by the user or preselected, as is typical, is explained in B.3.1 through B.3.5.

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

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

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

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

B.2.5 Pipe Break Flow Area. Most piping breaks result in less than full pipe diameter being open to flow. For example, a full-guillotine break is not nearly as likely as a reduced flow area break or a small leak. It is unlikely that small leaks will have an off-site impact. Therefore, it is appropriate to select as an alternative release case, a piping failure characterized by a fraction of the full-open area that is typical of the majority of piping failures while significantly greater than that of a small leak.
For the purposes of calculation, a 20-percent flow rate versus a full bore line break shall be used. Statistics indicate that piping failures of this magnitude would be expected to occur between two and ten times as often as a full-guillotine break.

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