

NFPA® 2

Hydrogen Technologies Code

2011 Edition



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NFPA® 2

Hydrogen Technologies Code

2011 Edition

This edition of NFPA 2, *Hydrogen Technologies Code*, was prepared by the Technical Committee on Hydrogen Technology. It was issued by the Standards Council on December 14, 2010, with an effective date of January 3, 2011.

This edition of NFPA 2 was approved as an American National Standard on January 3, 2011.

Origin and Development of NFPA 2

With the increased interest in hydrogen being used as a fuel source, the National Fire Protection Association was petitioned to develop an all-encompassing document that establishes the necessary requirements for hydrogen technologies. In 2006, the Technical Committee on Hydrogen Technology was formed and tasked to develop a document that addresses all aspects of hydrogen storage, use, and handling, that draws from existing NFPA codes and standards, and that identifies and fills technical gaps for a complete functional set of requirements for code users and enforcers. This document is also structured so that it works seamlessly with building and fire codes.

This code is largely extracted from other NFPA codes and standards (e.g., NFPA 52, NFPA 55, and NFPA 853) and is organized in a fashion that is specific for hydrogen. Paragraphs that have been extracted from other documents are shown with the extract reference brackets [] at the end of the paragraph. In some cases, modifications have been made to the extracted text to use terminology appropriate for this code, such as the terms GH_2 instead of compressed gas and LH_2 instead of cryogenic fluid. In those instances, brackets [] encase the modifying words. Similarly, where language was deleted to adhere to requirements based exclusively on hydrogen and no other changes were made to the paragraph, brackets that encompass a dash [-] are inserted into the paragraph to denote a change to the original material while retaining the extract to the source document. In short, added or modified text is shown with [] around the differing language and pure deletions of text are shown as [-].



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

Committee Scope: This committee shall have primary responsibility for documents on the storage, transfer, production, and use of hydrogen. The use of hydrogen would include stationary, portable, and vehicular applications.

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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, the complete title and edition of the source documents for extracts in mandatory sections of the document are given in Chapter 2 and those for extracts in informational sections are given in Annex L. Extracted text may be edited for consistency and style and may include the revision of internal paragraph references and other references as appropriate. Requests for interpretations or revisions of extracted text shall be sent to the technical committee responsible for the source document.

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

Chapter 1 Administration

1.1 Scope. (Reserved)

1.2 Purpose. The purpose of this code shall be to provide fundamental safeguards for the generation, installation, storage, piping, use, and handling of hydrogen in compressed gas (GH₂) form or cryogenic liquid (LH₂) form.

1.3* Application.

1.3.1 This code shall apply to the production, storage, transfer, and use of hydrogen in all occupancies and on all premises.

1.3.2 The use of hydrogen shall include stationary, portable, and vehicular infrastructure applications.

1.3.3 The fundamental requirements of Chapters 1 through 8 shall apply in addition to the use-specific requirements provided in Chapters 9 through 20, as applicable.

1.3.4 Exemptions. This code shall not apply to the following:

- (1) Onboard vehicle or mobile equipment components or systems, including the onboard GH₂ or LH₂ fuel supply
- (2) Mixtures of GH₂ and other gases with a hydrogen concentration of less than 95 percent by volume when in accordance with NFPA 55, *Compressed Gases and Cryogenic Fluids Code*
- (3) The storage, handling, use, or processing of metal hydride materials outside of metal hydride storage systems defined in Chapter 3

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

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

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

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

1.5 Equivalency.

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

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

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

1.6 Units and Formulas.

1.6.1 The units of measure in this code are presented first in U.S. customary units (inch-pound units). International System (SI) of Units follow the inch-pound units in parentheses.

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

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

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

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

1.6.6 If a value for measurement given in this standard is followed by an equivalent value in other units, the first stated shall be regarded as the requirement. The given equivalent value shall be considered to be approximate.

1.6.7 All pressures in this document are gauge pressures, unless otherwise indicated.

1.7 Enforcement.

1.7.1* This code shall be administered and enforced by the authority having jurisdiction designated by the governing authority under the administrative provisions of the adopted building or fire prevention code. (See Annex C for sample wording for enabling legislation.)

1.7.2 The administrative provisions of Annex B shall be allowed to be used when specifically adopted.

Chapter 2 Referenced Publications

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

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

NFPA 1, *Fire Code*, 2009 edition.

NFPA 10, *Standard for Portable Fire Extinguishers*, 2010 edition.

NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam*, 2010 edition.

NFPA 11A, *Standard for Medium- and High-Expansion Foam Systems*, 1999 edition.

NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*, 2011 edition.

NFPA 12A, *Standard on Halon 1301 Fire Extinguishing Systems*, 2009 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2010 edition.

NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*, 2010 edition.

NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*, 2007 edition.

NFPA 17, *Standard for Dry Chemical Extinguishing Systems*, 2009 edition.

NFPA 17A, *Standard for Wet Chemical Extinguishing Systems*, 2009 edition.

NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*, 2010 edition.

NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, 2011 edition.

NFPA 30, *Flammable and Combustible Liquids Code*, 2008 edition.

NFPA 30A, *Code for Motor Fuel Dispensing Facilities and Repair Garages*, 2008 edition.

NFPA 31, *Standard for the Installation of Oil-Burning Equipment*, 2011 edition.

NFPA 37, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines*, 2010 edition.

NFPA 45, *Standard on Fire Protection for Laboratories Using Chemicals*, 2011 edition.

NFPA 51, *Standard for the Design and Installation of Oxygen-Fuel Gas Systems for Welding, Cutting, and Allied Processes*, 2007 edition.

NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work*, 2009 edition.

NFPA 52, *Vehicular Gaseous Fuel Systems Code*, 2010 edition.

NFPA 54, *National Fuel Gas Code*, 2009 edition.

NFPA 55, *Compressed Gases and Cryogenic Fluids Code*, 2010 edition.

NFPA 58, *Liquefied Petroleum Gas Code*, 2011 edition.

NFPA 59, *Utility LP-Gas Plant Code*, 2008 edition.

NFPA 68, *Standard on Explosion Protection by Deflagration Venting*, 2007 edition.

NFPA 69, *Standard on Explosion Prevention Systems*, 2008 edition.

NFPA 70®, *National Electrical Code®*, 2011 edition.

NFPA 72®, *National Fire Alarm and Signaling Code*, 2010 edition.

NFPA 79, *Electrical Standard for Industrial Machinery*, 2007 edition.

NFPA 80, *Standard for Fire Doors and Other Opening Protectives*, 2010 edition.

NFPA 82, *Standard on Incinerators and Waste and Linen Handling Systems and Equipment*, 2009 edition.

NFPA 86, *Standard for Ovens and Furnaces*, 2011 edition.

NFPA 88A, *Standard for Parking Structures*, 2011 edition.

NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems*, 2009 edition.

NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids*, 2010 edition. 2004 edition.

NFPA 101®, *Life Safety Code®*, 2009 edition.

NFPA 110, *Standard for Emergency and Standby Power Systems*, 2010 edition.

NFPA 211, *Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances*, 2010 edition.

NFPA 241, *Standard for Safeguarding Construction, Alteration, and Demolition Operations*, 2009 edition.

NFPA 251, *Standard Methods of Tests of Fire Resistance of Building Construction and Materials*, 2006 edition.

NFPA 259, *Standard Test Method for Potential Heat of Building Materials*, 2008 edition.

NFPA 484, *Standard for Combustible Metals*, 2009 edition.

NFPA 496, *Standard for Purged and Pressurized Enclosures for Electrical Equipment*, 2008 edition.

NFPA 497, *Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*, 2008 edition.

NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response*, 2007 edition.

NFPA 750, *Standard on Water Mist Fire Protection Systems*, 2010 edition.

NFPA 853, *Standard for the Installation of Stationary Fuel Cell Power Systems*, 2010 edition.

NFPA 1962, *Standard for the Inspection, Care, and Use of Fire Hose, Couplings, and Nozzles and the Service Testing of Fire Hose*, 2008 edition.

NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems*, 2008 edition.

NFPA 5000®, *Building Construction and Safety Code®*, 2009 edition.

2.3 Other Publications.

2.3.1 AIHA Publications. American Industrial Hygiene Association, 2700 Prosperity Avenue, Suite 250, Fairfax, VA 22031-4319.

AIHA Z9.5, *Laboratory Ventilation*, 2003.

2.3.2 ANSI Publications. American National Standards Institute, Inc., 25 West 43rd Street, 4th Floor, New York, NY 10036.

ANSI A13.1, *Scheme for Identification of Piping Systems*, 1996.

ANSI/IAS NGV 4.4 *Breakaway Devices for Dispensing Systems*, 1999 Edition.

ANSI C2, *National Electrical Safety Code*, 2007.

ANSI/CSA FC 1, *American National Standard for Fuel Cell Power Systems*, 2004.

ANSI/CSA FC 3, *American National Standard/CSA American Standard for Portable Fuel Cell Power Systems*.

ANSI Z535.1, *Safety Color Code*, 2006.

ANSI Z535.2, *Environmental and Facility Safety Signs*, 2007.

ANSI Z535.3, *Criteria for Safety Symbols*, 2007.

ANSI Z535.4, *Product Safety Signs and Labels*, 2007.

ANSI Z9.5, *Laboratory Ventilation*, 2003.

2.3.3 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*, 2007.

ASME B31.3, *Process Piping*, 2006.

ASME Boiler and Pressure Vessel Code, Section VIII, 2004.

ASME International, *Boiler and Pressure Vessel Code*, "Rules for the Construction of Unfired Pressure Vessels," Section VIII, 2007.

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

ASTM E 84, *Standard Test Method for Surface Burning Characteristics of Building Materials*, 2009.

ASTM E 681-01, *Code Test Method for Concentration Limits of Flammability of Chemicals (Vapors and Gases)*, 2004.

ASTM E 1529, *Determining Effects of Large Hydrocarbon Pool Fire on Structural Members and Assemblies*, 2006.

ASTM E 1591, *Standard Guide for Data for Fire Models*.

2.3.5 CGA Publications. Compressed Gas Association, 4221 Walney Road, 5th Floor Chantilly, VA 20151-2923.

CGA C-7, *Guide to the Preparation of Precautionary Labeling and Marking of Compressed Gas Containers*, 2004.

CGA G-4.1, *Cleaning Equipment for Oxygen Service*, 2009.

CGA G-5.5, *Hydrogen Vent Systems*, 2004.

CGA P-1, *Safe Handling of Compressed Gases in Containers*, 2008.

CGA P-23, *Standard for Categorizing Gas Mixtures Containing Flammable and Nonflammable Components*, 2008.

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

CGA S-1.2, *Pressure Relief Device Standards — Part 2 — Cargo and Portable Tanks for Compressed Gases*, 2009.

CGA S-1.3, *Pressure Relief Device Standards — Part 3 — Stationary Storage Containers for Compressed Gases*, 2008.

CGA H-1, *Service Conditions for Portable, Reversible Hydride Systems*, 2004.

CGA H-2, *Guidelines for The Classification and Labeling of Hydrogen Storage Systems with Hydrogen Absorbed in Reversible Metal Hydrides*, 2004.

2.3.6* CTC Publications. Canadian Transport Commission, Queen's Printer, Ottawa, Ontario, Canada. (Available from the Canadian Communications Group Publication Centre, Ordering Department, Ottawa, Canada K1A 0S9.)

Transportation of Dangerous Goods Regulations.

2.3.7 ICC Publications. International Code Council, 5203 Leesburg Pike, Suite 600, Falls Church, VA 22041.

IFGC, *International Fuel Gas Code*, 2006.

2.3.8 IAPMO Publications. International Association of Plumbing and Mechanical Officials, 5001 E. Philadelphia Street, Ontario, CA 91761.

Uniform Mechanical Code, 2003 edition.

2.3.9 ISO Publications. International Organization for Standardization Publications, 1 rue de Varembé, Case Postale 56, CH-1211 Geneve 20, Switzerland.

ISO 10156, *Gases and gas mixtures — Determination of Fire Potential and Oxidizing Ability for the Selection of Cylinder Valve Outlets*, 1996.

ISO 10298, *Determination of Toxicity of a Gas or Gas Mixture*, 1995.

ISO/DIS 22734-1, *Hydrogen generators using water electrolysis process — Part 1: Industrial and commercial applications*.

2.3.10 NSF Publication. National Sanitation Foundation International, 789 North Dixboro Road, P.O. Box 130140, Ann Arbor, MI 48113-1040.

NSF/ANSI 49, *Class II (Laminar Flow) Biosafety Cabinetry*, 2007.

2.3.11 SAE Publications. Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096, www.SAE.org.

SAE J2600, *Compressed Hydrogen Surface Refueling Connection Devices*, 2002.

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

ANSI/UL 723, *Tests for Surface Burning Characteristics of Building Materials*, 2008.

UL 429, *Electrically Operated Valves*, 2009.

ANSI/UL 2085, *Protected Aboveground Tanks for Flammable and Combustible Liquids*, 1997, Revised 1999.

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

Title 29, *Code of Federal Regulations*, Part 1910.1000.

Title 49, *Code of Federal Regulations*, Part 173.

2.3.14 Other Publications.

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

2.4 References for Extracts in Mandatory Sections.

NFPA 1, *Fire Code*, 2009 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2010 edition.

NFPA 30, *Flammable and Combustible Liquids Code*, 2008 edition.

NFPA 30A, *Code for Motor Fuel Dispensing Facilities and Repair Garages*, 2008 edition.

NFPA 45, *Standard on Fire Protection for Laboratories Using Chemicals*, 2011 edition.

NFPA 52, *Vehicular Gaseous Fuel Systems Code*, 2010 edition.

NFPA 54, *National Fuel Gas Code*, 2009 edition.

NFPA 55, *Compressed Gases and Cryogenic Fluids Code*, 2010 edition.

NFPA 58, *Liquefied Petroleum Gas Code*, 2011 edition.

NFPA 70®, *National Electrical Code®*, 2011 edition.

NFPA 80, *Standard for Fire Doors and Other Opening Protectives*, 2010 edition.

NFPA 86, *Standard for Ovens and Furnaces*, 2011 edition.

NFPA 88A, *Standard for Parking Structures*, 2011 edition.

NFPA 88B, *Standard for Repair Garages*, 1997 edition.

NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids*, 2010 edition.

NFPA 99, *Standard for Health Care Facilities*, 2005 edition.

NFPA 101®, *Life Safety Code*®, 2009 edition.

NFPA 220, *Standard on Types of Building Construction*, 2009 edition.

NFPA 318, *Standard for the Protection of Semiconductor Fabrication Facilities*, 2009 edition.

NFPA 400, *Hazardous Materials Code*, 2010 edition.

NFPA 801, *Standard for Fire Protection for Facilities Handling Radioactive Materials*, 2008 edition.

NFPA 820, *Standard for Fire Protection in Wastewater Treatment and Collection Facilities*, 2008 edition.

NFPA 853, *Standard for the Installation of Stationary Fuel Cell Power Systems*, 2010 edition.

NFPA 914, *Code for Fire Protection of Historic Structures*, 2010 edition.

NFPA 921, *Guide for Fire and Explosion Investigations*, 2011 edition.

NFPA 1925, *Standard on Marine Fire-Fighting Vessels*, 2008 edition.

NFPA 5000®, *Building Construction and Safety Code*®, 2009 edition.

Chapter 3 Definitions

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

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

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

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

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

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

3.2.6 Shall. Indicates a mandatory requirement.

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

3.3 General Definitions.

3.3.1 Aboveground Storage Tank. See 3.3.220.5.1.

3.3.2 Aboveground Tank. See 3.3.220.1.

3.3.3 Absolute Pressure. See A.3.3.183.1.

3.3.4 Air.

3.3.4.1 Auxiliary Air. Supply or supplemental air delivered near the outside face of a chemical fume hood to reduce room air consumption. [45, 2004]

3.3.4.2 Exhaust Air [Fuel Cell Power System]. Air removed from a space [-] and not reused. [853, 2010]

3.3.4.3 Ventilation Air [Fuel Cell Power System]. The portion of supply air whose source is the outside/outdoors plus any recirculated. [853, 2010]

3.3.5 Apparatus. Furniture, chemical fume hoods, centrifuges, refrigerators, and commercial or made-on-site equipment used in a laboratory. [45, 2011]

3.3.6 Area.

3.3.6.1 Control Area. A designated area, either indoors or outdoors, within which hazardous materials are allowed to be stored, used, handled, or dispensed in quantities not exceeding the maximum allowable quantity (MAQ). [1, 2009]

3.3.6.2 Indoor Area. An area that is within a building or structure having overhead cover, other than a structure qualifying as "weather protection" in accordance with Section 6.6. (See also 3.3.6.5, *Outdoor Area*.) [55, 2010]

3.3.6.3 Laboratory Work Area. A room or space [regulated by Chapter 16 used] for testing, analysis, research, instruction, or similar activities that involve the use of chemicals. [45, 2011]

3.3.6.4 Non-Laboratory Area. Any space within a [laboratory] building not included in a laboratory unit. (See also 3.3.13.2 and 3.3.227.1.) [45, 2011]

3.3.6.5 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 exposure by an exterior wall that obstructs not more than 25 percent of the building boundary. [1, 2009]

3.3.7 ASME. American Society of Mechanical Engineers. [58, 2011]

3.3.8 ASTM. American Society for Testing and Materials. [58, 2011]

3.3.9 Automatic Emergency Shutoff Valve. See 3.3.232.1.1.

3.3.10 Automatic Fire Detection System. See 3.3.219.2.1.

3.3.11 Auxiliary Air. See 3.3.4.1.

3.3.12 Baffle. An object placed in an appliance to change the direction of or to retard the flow of air, air-gas mixtures, or flue gases. [54, 2009]

3.3.13 Building. Any structure used or intended for supporting or sheltering any use or occupancy. [101, 2009]

3.3.13.1 Detached Building. A separate building that is separated from other structures or uses as required by this code for a freestanding structure. [5000, 2009]

3.3.13.2 Laboratory Building. A structure consisting wholly or principally of one or more laboratory units. (See also 3.3.227.1 and 3.3.227.2) [45, 2011]

3.3.14 Building Code. See 3.3.37.1.

3.3.15 Bulk Hydrogen Compressed Gas System. See 3.3.219.6.1.1.

3.3.16 Bulk Liquefied Hydrogen Gas System. See 3.3.219.7.1.

3.3.17 Bulk Oxygen System. See 3.3.219.1.

3.3.18 Burner. A device or group of devices used for the introduction of fuel, air, oxygen, or oxygen-enriched air into a furnace at the required velocities, turbulence, and concentration to maintain ignition and combustion of fuel. [86, 2011]

3.3.19 Burn-In. The procedure used in starting up a special atmosphere furnace to replace air within the heating chamber(s) and vestibule(s) with flammable special atmosphere. [86, 2011]

3.3.20 Burn-Out. The procedure used in shutting down or idling a special atmosphere to replace flammable atmosphere within the heating chamber(s) and vestibule(s) with nonflammable atmosphere. [86, 2011]

3.3.21 Bypass [Laboratory Hoods]. An airflow-compensating opening that maintains a relatively constant volume exhaust through a chemical fume hood regardless of sash position, serving to limit the maximum face velocity as the sash is lowered. [45, 2011]

3.3.22 Cabinet.

3.3.22.1* Gas Cabinet. A fully enclosed, noncombustible enclosure used to provide an isolated environment for compressed gas cylinders in storage or use. [5000, 2009]

3.3.22.2 Laminar Flow Cabinet. A ventilated, partially enclosed cabinet primarily intended to provide filtered airflow over the work surface by use of laminar airflow methods. [45, 2010]

3.3.23 Canopy Hood. See 3.3.113.1.

3.3.24 Capacity [Vehicular Fuel Container]. The water volume of a container in gallons (liters). [52, 2010]

3.3.25 Cargo Transport [Vehicle]. A mobile unit designed to transport GH_2 , or LH_2 . [52, 2010]

3.3.26 Cathodic Protection. See 3.3.188.1.

3.3.27 Cathodic Protection Tester. A person who demonstrates an understanding of the principles and measurements of all common types of cathodic protection systems applicable to metal piping and container systems and who has education and experience in soil resistivity, stray current, structure-to-soil potential, and component electrical isolation measurements of metal piping and container systems. [55, 2010]

3.3.28 Ceiling Limit. See 3.3.134.1.

3.3.29 CFR. The Code of Federal Regulations of the United States Government. [1, 2009]

3.3.30 CGA. Compressed Gas Association. [55, 2010]

3.3.31* Chemical. A substance with one or more of the following hazard ratings as defined in NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response*: Health — 2, 3, or 4; Flammability — 2, 3, or 4; Instability — 2, 3, or 4. (See also Section B.2.) [45, 2011]

3.3.32 Chemical Fume Hood. See 3.3.113.2.

3.3.33 Class 2 Unstable Reactive Gas. See 3.3.100.12.1.

3.3.34 Class 3 Unstable Reactive Gas. See 3.3.100.12.2.

3.3.35 Class 4 Unstable Reactive Gas. See 3.3.100.12.3.

3.3.36* Class C Furnace. An oven or furnace that has a potential hazard due to a flammable or other special atmosphere being used for treatment of material in process. [86, 2011]

3.3.37 Code.

3.3.37.1 Building Code. The building or construction code adopted by the jurisdiction. [55, 2010]

3.3.37.2 Mechanical Code. The mechanical or mechanical construction code adopted by the jurisdiction. [55, 2010]

3.3.38 Combustible. Capable of undergoing combustion. [853, 2011]

3.3.38.1 Limited Combustible. [-]. Refers to a building construction material not complying with the definition of noncombustible that, in the form in which it is used, has a potential heat value not exceeding 3500 Btu/lb (8141 kJ/kg), where tested in accordance with NFPA 259 and includes either (1) materials having a structural base of noncombustible material, with a surfacing not exceeding a thickness of $\frac{1}{8}$ (3.2 mm) that has a flame spread index not greater than 50, or (2) materials, in the form and thickness used having neither a flame spread index greater than 25 nor evidence of continued progressive combustion, and of such composition that surfaces that would be exposed by cutting through the material on any plane would have neither a flame spread index greater than 25 nor evidence of continued progressive combustion, when tested in accordance with ANSI/UL 723 or ASTM E 84. [220, 2009]

3.3.39 Combustible Liquid. See 3.3.137.1.

3.3.40 Combustion Safeguard. A safety device directly responsive to flame properties that senses the presence or absence of flame using flame sensors. [86, 2011]

3.3.41 Compressed Gas. See 3.3.100.1.

3.3.42 Compressed Gas Container. See 3.3.46.1.

3.3.43 Compressed Gas System. See 3.3.219.6.1.

3.3.44 Compression Discharge Pressure. See 3.3.183.2.

3.3.45 Compressor. A device used for increasing the pressure and density of a gas. [853, 2011]

3.3.46 Container. A vessel, such as a cylinder, portable tank, or stationary tank, that varies in shape, size, and material of construction. [55, 2010]

3.3.46.1 Compressed Gas Container. A pressure vessel designed to hold compressed gas at an absolute pressure greater than 1 atmosphere at 68°F (20°C) that includes cylinders, containers, and tanks. [55, 2010]

3.3.46.2 Fuel Supply Container. A container mounted on a vehicle to store [-] LH_2 , or GH_2 as the fuel supply to the vehicle. [52, 2010]

3.3.47 Control.

3.3.47.1 Excess Flow Control. A fail-safe system or approved means designed to shut off flow due to a rupture in pressurized piping systems. [55, 2010]

3.3.47.2* Explosion Control. A means of [either] preventing an explosion through the use of explosion suppression, fuel reduction, or oxidant reduction systems or a means to prevent the structural collapse of a building in the event of an explosion through the use of deflagration venting, barricades, or related construction methods. [55, 2010]

3.3.47.3 Remotely Located, Manually Activated Shutdown Control. A control system that is designed to initiate shutdown of the flow of gas or liquid that is manually activated from a point located some distance from the delivery system. [55, 2010]

3.3.48 Control Area. See 3.3.6.1.

3.3.49 Controller.

3.3.49.1 Excess Temperature Limit Controller. A device designed to cut off the source of heat if the operating temperature exceeds a predetermined temperature set point.

3.3.49.2 Temperature Controller. A device that measures the temperature and automatically controls the input of heat into the furnace. [86, 2011]

3.3.50 Corrosion Expert. A person who, by reason of knowledge of the physical sciences and the principles of engineering acquired through professional education and related practical experience, is qualified to engage in the practice of corrosion control of container systems. [55, 2010]

3.3.51 Corrosion Protection. See 3.3.188.2.

3.3.52 Corrosive Gas. See 3.3.100.2.

3.3.53 Court. An open, uncovered, unoccupied space, unobstructed to the sky, bounded on three or more sides by exterior building walls. [101, 2009]

3.3.53.1 Enclosed Court. A court bounded on all sides by the exterior walls of a building or by the exterior walls and lot lines on which walls are permitted. [5000, 2010]

3.3.54 Cryogenic Fluid. A fluid with a boiling point lower than -130°F (-90°C) at an absolute pressure of 14.7 psi (101.3 kPa). [55, 2010]

3.3.54.1 Flammable Cryogenic Fluid. A cryogenic fluid that is flammable in its vapor state.

3.3.55 Cylinder. A pressure vessel designed for absolute pressures higher than 40 psi (276 kPa) and having a circular cross-section. It does not include a portable tank, multiunit tank car tank, cargo tank, or tank car. [55, 2010]

3.3.56* Cylinder Pack. An arrangement of cylinders into a cluster where the cylinders are confined into a grouping or arrangement with a strapping or frame system and connections are made to a common manifold. The frame system is allowed to be on skids or wheels to permit movement. [55, 2010]

3.3.57 Detached Building. See 3.3.13.1.

3.3.58 Device.

3.3.58.1 Emergency Shutdown Device (ESD) [Vehicle Fueling]. A device that closes all operations within the fueling facility from either local or remote locations. [52, 2010]

3.3.58.2 Pressure Relief Device. A device designed to open to prevent a rise of internal pressure in excess of a specified value. [55, 2010]

3.3.58.3 Safety Device [Furnaces]. An instrument, a control, or other equipment that acts, or initiates action, to cause the furnace to revert to a safe condition in the event of equipment failure or other hazardous event. [86, 2011]

3.3.59* Distributed Integrated Controls (DIC). Systems or integrated controls used to monitor and control the functions of equipment, systems, or plants. [853, 2010]

3.3.60 Distributor. A business engaged in the sale or resale, or both, of compressed gases or cryogenic fluids, or both. [55, 2010]

3.3.61 DOT. U.S. Department of Transportation. [52, 2010]

3.3.62 Duct System. See 3.3.219.3.

3.3.63 Emergency Shutdown Device (ESD). See 3.3.58.1.

3.3.64 Emergency Shutoff Valve. See 3.3.232.1.

3.3.65 Enclosed Court. See 3.3.53.1.

3.3.66 Enclosed Parking Structure. See 3.3.172.1.

3.3.67 Engineered and Field-Constructed Fuel Cell Power System. See 3.3.219.5.1.

3.3.68 Evaluation.

3.3.68.1* Fire Risk Evaluation. A detailed engineering review of a plant's construction features and operating process conducted to ensure that applicable fire prevention and fire protection requirements for safeguarding life and physical property are met. [853, 2010]

3.3.69 Excess Flow Control. See 3.3.47.1.

3.3.70 Excess Temperature Limit Controller. See 3.3.49.1.

3.3.71 Exhaust Air. See 3.3.4.2.

3.3.72 Exhaust System. See 3.3.219.4.

3.3.73* 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. [55, 2010]

3.3.74 Exit Access. That portion of a means of egress that leads to an exit. [101, 2009]

3.3.75 Explosion Control. See 3.3.47.2.

3.3.76 Face Velocity. The rate of flow or velocity of air moving into the chemical fume hood entrance or face, as measured at the plane of the chemical fume hood face. [45, 2011]

3.3.77 Facility.

3.3.77.1 Incidental Testing Facility. An area within a production facility set aside for the purpose of conducting in-process control tests that are related to the production process. [45, 2011]

3.3.77.2 Motor Fuel Dispensing Facility. That portion of a property where motor fuels are stored and dispensed from fixed equipment into the fuel tanks of motor vehicles or marine craft or into approved containers, including all equipment used in connection therewith. [30A, 2008]

3.3.77.2.1 Attended Self-Service Motor Fuel Dispensing Facility. A motor fuel dispensing facility that has an attendant or employee on duty whenever the facility is open for business. The attendant or employee on duty does not typically dispense motor fuels into fuel tanks or containers. The customer or vehicle operator usually conducts the dispensing. [30A, 2008]

3.3.77.2.2 Fleet Vehicle Motor Fuel Dispensing Facility. A motor fuel dispensing facility at a commercial, industrial, governmental, or manufacturing property where motor fuels are dispensed into the fuel tanks of motor vehicles that are used in connection with the business or operation of that property by persons within the employ of such business or operation. [30A, 2008]

3.3.77.2.3 Full-Service Motor Fuel Dispensing Facility. A motor fuel dispensing facility that has one or more attendants or supervisors on duty to dispense motor fuels into fuel tanks or containers whenever the facility is open for business. [30A, 2008]

3.3.77.2.4* Motor Fuel Dispensing Facility Located Inside a Building. That portion of a motor fuel dispensing facility located within the perimeter of a building or building structure that also contains other occupancies. [30A, 2008]

3.3.77.2.5 Unattended Self-Service Motor Fuel Dispensing Facility. A motor fuel dispensing facility that has no attendant or employee on duty. The customer or vehicle operator conducts the dispensing operation. This includes coin, currency, membership card, and credit card dispensing operations. [30A, 2008]

3.3.77.3 Residential GH₂ Fueling Facility (RFF-GH₂). An assembly with a capacity not exceeding 18 scf/min (0.5 scm/min) of GH₂, that generates and compresses hydrogen and that can be used for fueling a vehicle at a home or residence. [52, 2010]

3.3.78* Fail-Safe. A design arrangement incorporating one or more features that automatically counteracts the effect of an anticipated source of failure or which includes a design arrangement that eliminates or mitigates a hazardous condition by compensating automatically for a failure or malfunction.

3.3.79 Fire Damper. A device, installed in an air-distribution system, that is designed to close automatically upon detection of heat to interrupt migratory airflow and to restrict the passage of flame. [5000, 2010]

3.3.80 Fire Prevention. Measures directed toward avoiding the inception of fire. [801, 2008]

3.3.81 Fire Protection. See 3.3.188.3.

3.3.82 Fire Risk Evaluation. See 3.3.68.1.

3.3.83 Flammable Cryogenic Fluid. See 3.3.54.1.

3.3.84 Flammable Gas. See 3.3.100.3.

3.3.85 Flammable Liquefied Gas. See 3.3.100.4.

3.3.86 Flammable Liquid. See 3.3.137.2.

3.3.87 Flammable Special Atmosphere. See 3.3.210.1.

3.3.88 Flash Point. The minimum temperature at which a liquid or a solid emits vapor sufficient to form an ignitable mixture with air near the surface of the liquid or the solid. [853, 2010]

3.3.89 Fleet Vehicle Motor Fuel Dispensing Facility. See 3.3.77.2.2.

3.3.90 Flow Switch. A switch that is activated by the flow of a fluid in a duct or piping system. [86, 2011]

3.3.91 Fuel Cell Cartridge. A removable article that contains and supplies fuel to the micro fuel cell power unit or internal reservoir.

3.3.92 Fuel Cell Power System. See 3.3.219.5.

3.3.93 Fuel Gas. See 3.3.100.5.

3.3.94 Fuel Line. The pipe, tubing, or hose on a vehicle, including all related fittings, through which [-] hydrogen passes. [52, 2010]

3.3.95 Fueling Nozzle. A mating device at the refueling station, including shutoff valves, that connects the fueling dispenser hose to the vehicle fuel filling system receptacle for the transfer of liquid or vapor. [52, 2010]

3.3.96 Fuel Supply Container. See 3.3.46.2.

3.3.97* Full Trycock. A valve connected to a line inserted into the inner tank of a cryogenic fluid tank and positioned such that liquid just begins to flow from the valve when opened.

3.3.98 Gallon, U.S. Standard. 1 U.S. gal = 0.833 Imperial gal = 231 in.³ = 3.785 L. [58, 2011]

3.3.99 Garages.

3.3.99.1 Major Repair Garage. A building or portions of a building where major repairs, such as engine overhauls, painting, body and fender work, and repairs that require venting of the motor vehicle fuel tank are performed on motor vehicles, including associated floor space used for offices, parking, or showrooms. [30A, 2008].

3.3.99.2 Repair Garages. Buildings and structures used for service and repair operations in connection with self-propelled GH₂ and LH₂ fueled vehicles (including, but not limited to, passenger automobiles, buses, trucks and tractors).

3.3.100 Gas.

3.3.100.1* Compressed Gas. A material, or mixture of materials, that (1) is a gas at 68°F (20°C) or less at 14.7 psia (101.3 kPa) of pressure, and (2) has a boiling point of 68°F (20°C) or less at 14.7 psia (101.3 kPa) that is either liquefied, nonliquefied, or in solution, except those gases that have no other health or physical hazard properties are not considered to be compressed until the pressure in the packaging exceeds 41 psia (282.5 kPa) at 68°F (20°C). [5000, 2009]

3.3.100.2 Corrosive Gas. A gas that causes visible destruction of or irreversible alterations in living tissue by chemical action at the site of contact. [55, 2010]

3.3.100.3* Flammable Gas. A material that is a gas at 68°F (20°C) or less at an absolute pressure of 14.7 psi (101.3 kPa), that is ignitable at an absolute pressure of 14.7 psi (101.3 kPa) when in a mixture of 13 percent or less by volume with air, or that has a flammable range at an absolute pressure of 14.7 psi (101.3 kPa) with air of at least 12 percent, regardless of the lower limit. [55, 2010]

3.3.100.4 Flammable Liquefied Gas. A liquefied compressed gas that, when under a charged pressure, is partially liquid at a temperature of 68°F (20°C) and is flammable. [55, 2010]

3.3.100.5 Fuel Gas. A gas used as a fuel source, including natural gas, manufactured gas, sludge gas, liquefied petroleum gas-air mixtures, liquefied petroleum gas in the vapor phase, and mixtures of these gases. [820, 2008]

3.3.100.6* Inert Gas. A nonreactive, nonflammable, non-corrosive gas such as argon, helium, krypton, neon, nitrogen, and xenon. [55, 2010]

3.3.100.7 Nonflammable Gas. A gas that does not meet the definition of a flammable gas. [55, 2010]

3.3.100.8* Other Gas. A gas that is not a corrosive gas, flammable gas, highly toxic gas, oxidizing gas, pyrophoric gas, toxic gas, or unstable reactive gas with a hazard rating of Class 2, Class 3, or Class 4 gas. [55, 2010]

3.3.100.9 Oxidizing Gas. A gas that can support and accelerate combustion of other materials more than air does. [55, 2010]

3.3.100.10 Pyrophoric Gas. A gas with an autoignition temperature in air at or below 130°F (54.4°C). [55, 2010]

3.3.100.11 Toxic Gas. A gas with a median lethal concentration (LC₅₀) in air of more than 200 ppm but not more than 2000 ppm by volume of gas or vapor, or more than 2 mg/L but not more than 20 mg/L of mist, fume, or dust, when administered by continuous inhalation for 1 hour (or less if death occurs within 1 hour) to albino rats weighing between 0.44 lb and 0.66 lb (200 g and 300 g) each. [55, 2010]

3.3.100.11.1 Highly Toxic Gas. A chemical that has a median lethal concentration (LC₅₀) in air of 200 ppm by volume or less of gas or vapor, or 2 mg/L or less of mist, fume, or dust, when administered by continuous inhalation for 1 hour (or less if death occurs within 1 hour) to albino rats weighing between 0.44 lb and 0.66 lb (200 g and 300 g) each. [55, 2010]

3.3.100.12* Unstable Reactive Gas. A gas that, in the pure state or as commercially produced, will vigorously polymerize, decompose, or condense; become self-reactive; or otherwise undergo a violent chemical change under conditions of shock, pressure, or temperature. [55, 2010]

3.3.100.12.1 Class 2 Unstable Reactive Gas. Materials that readily undergo violent chemical change at elevated temperatures and pressures. [55, 2010]

3.3.100.12.2 Class 3 Unstable Reactive Gas. Materials that in themselves are capable of detonation or explosive decomposition or explosive reaction, but that require a strong initiating source or that must be heated under confinement before initiation. [55, 2010]

3.3.100.12.3 Class 4 Unstable Reactive Gas. Materials that in themselves are readily capable of detonation or explosive decomposition or explosive reaction at normal temperatures and pressures. [55, 2010]

3.3.101 Gas Analyzer. A device that measures concentrations, directly or indirectly, of some or all components in a gas or mixture. [86, 2011]

3.3.102 Gas Cabinet. See 3.3.22.1.

3.3.103 Gas Detection System. See 3.3.219.2.2.

3.3.104 Gas Manufacturer/Producer. A business that produces compressed gases or cryogenic fluids, or both, or fills portable or stationary gas containers, cylinders, or tanks. [55, 2010]

3.3.105* Gas Room. A separately ventilated, fully enclosed room in which only compressed gases, cryogenic fluids, associated equipment, and supplies are stored or used. [55, 2010]

3.3.106 Gaseous Hydrogen System. See 3.3.219.9.1.

3.3.107 Gasifier. An assembly of equipment that converts carbonaceous materials, such as coal or petroleum, into carbon monoxide and hydrogen by reacting the raw material at high temperatures with a controlled amount of oxygen. [55, 2010]

3.3.108 GH₂. Hydrogen in the gas phase.

3.3.109* Handling. The deliberate movement of material in containers by any means to a point of storage or use. [55, 2010]

3.3.110* Hazard Rating. The numerical rating of the health, flammability, self-reactivity, and other hazards of the material, including its reaction with water. [55, 2010]

3.3.111 Hazardous Material (Chemical). See A.3.3.139.1.

3.3.112 Health Hazard Material. A chemical or substance classified as a toxic, highly toxic, or corrosive material in accordance with definitions set forth in this code. [400, 2010]

3.3.113 Hood.

3.3.113.1 Canopy Hood. A suspended ventilating device used only to exhaust heat, water vapor, odors, and other non-hazardous materials. This is not a chemical fume hood and generally is not effective for exhausting toxic or flammable materials. [45, 2011]

3.3.113.2* Chemical Fume Hood. A ventilated enclosure designed to contain and exhaust fumes, gases, vapors, mists, and particulate matter generated within the hood interior. [45, 2011]

3.3.114 Hood Interior. The volume enclosed by the side, back, and top enclosure panels, the work surface, the access opening (called the face), the sash or sashes, and the exhaust plenum, including the baffle system for airflow distribution. [45, 2011]

3.3.115 Hydrogen Generation System. See 3.3.219.8.

3.3.116 Hydrogen Generator. A packaged or factory matched hydrogen gas generation device that (a) uses electrochemical reactions to electrolyze water to produce hydrogen and oxygen gas (electrolyzer) and (b) converts hydrocarbon fuel to a hydrogen-rich stream of composition and conditions suitable for the type of device (e.g., fuel cells) using the hydrogen (reformer). [52, 2010]

3.3.117 Incidental Testing Facility. See 3.3.77.1.

3.3.118 Indoor Area. See 3.3.6.2.

3.3.119* Indoor Installation. See 3.3.121.1.

3.3.120 Inert Gas. See 3.3.100.6.

3.3.121 Installation [Fuel Cell Power System]. The location where a fuel cell power system [other than a portable micro fuel cell power system] is sited as a unit or built as an assembly. [853, 2010]

3.3.121.1 Indoor Installation [Fuel Cell Power System]. A fuel cell power system [other than a portable or micro fuel cell power system] completely surrounded and enclosed by walls, a roof, and a floor. [853, 2007]

3.3.121.2 Outside or Outdoor Installation [Fuel Cell Power System]. A power system installation (other than a portable or micro fuel cell power system) that is not located inside a building or that has only partial weather protection (maximum coverage of a roof and up to 25 percent enclosing walls).

3.3.121.3 Portable Fuel Cell [Power System] Installation. A fuel cell [power system] generator [other than a micro fuel cell power system] of electricity that is not fixed in place. A portable appliance utilizes a cord and plug connection to a grid-isolated load and has an integral fuel supply. [853, 2010]

3.3.121.4 Rooftop Installation. A power system installation located on the roof of a building. [853, 2010]

3.3.122 Instructional Laboratory Unit. See 3.3.227.1.1.

3.3.123 Interactive System. See 3.3.219.11.

3.3.124* ISO Module. An assembly of tanks or tubular cylinders permanently mounted in a frame conforming to International Organization for Standardization (ISO) requirements. [55, 2010]

3.3.125 Laboratory. A laboratory is a facility regulated by Chapter 16 that provides controlled conditions in which scientific research, experiments, or measurements are performed.

3.3.126 Laboratory Building. See 3.3.13.2.

3.3.127 Laboratory Equipment. See 3.3.5, Apparatus.

3.3.128 Laboratory Unit. See 3.3.227.1.

3.3.129* Laboratory Work Area. See 3.3.6.3.

3.3.130 Laminar Flow Cabinet. See 3.3.22.2.

3.3.131 Lecture Bottle. A small compressed gas cylinder up to a size of approximately 5 cm × 33 cm (2 in. × 13 in.). [45, 2011]

3.3.132* LH₂. Hydrogen in the liquid phase.

3.3.133 LH₂ System. An assembly of equipment designed to contain, distribute, or transport LH₂.

3.3.134 Limit.

3.3.134.1* Ceiling Limit. The maximum concentration of an airborne contaminant to which one can be exposed. [5000, 2009]

3.3.134.2 Exposure Limit.

3.3.134.2.1* Permissible Exposure Limit (PEL). The maximum permitted 8-hour, time-weighted average concentration of an airborne contaminant. [55, 2010]

3.3.134.2.2* 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). [55, 2010]

3.3.134.3 Lower Flammability Limit (LFL). That concentration of a combustible material in air below which ignition will not occur. [52, 2010]

3.3.135 Limited Combustible. See 3.3.38.1.

3.3.136 Liquefied Hydrogen System. See 3.3.219.9.2.

3.3.137 Liquid.

3.3.137.1* Combustible Liquid. Any liquid that has a closed-cup flash point at or above 100°F (37.8°C), as determined by the test procedures and apparatus set forth in [NFPA 30, *Flammable and Combustible Liquids Code*.] Combustible liquids are classified according to Section 4.3 [of NFPA 30]. [30, 2008]

3.3.137.2* Flammable Liquid (Class I). Any liquid having a closed-cup flash point not exceeding 100°F (37.8°C). [55, 2010]

3.3.138 Lower Flammability Limit (LFL). See 3.3.134.3.

3.3.139 Material.

3.3.139.1* Hazardous Material. A chemical or substance that is classified as a physical hazard material or a health hazard material, whether the chemical or substance is in

usable or waste condition. (See also 3.3.112, *Health Hazard Material*, and 3.3.174, *Physical Hazard Material*). [400, 2010]

3.3.139.2 Noncombustible Material. A material that, in the form in which it is used and under the conditions anticipated, will not ignite, burn, support combustion, or release flammable vapors, when subjected to fire or heat. Materials that are reported as passing ASTM E 136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750 Degrees C*, shall be considered noncombustible materials. [5000, 2009]

3.3.140 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. [1, 2009]

3.3.141 Maximum Allowable Quantity per Control Area (MAQ). A threshold quantity of hazardous material in a specific hazard class that once exceeded requires the application of additional administrative procedures, construction features, or engineering controls. [55, 2010]

3.3.142 Maximum Allowable Working Pressure (MAWP). See 3.3.183.3.

3.3.143* Maximum Operating Pressure. See 3.3.183.5.1.

3.3.144 Mechanical Code. See 3.3.37.2.

3.3.145 Mechanical Ventilation. See 3.3.236.1.

3.3.146 Metal Hydride. A generic name for compounds composed of metallic element(s) and hydrogen. [55, 2010]

3.3.147 Metal Hydride Storage System. See 3.3.219.15.2.

3.3.148 Metallic Hose. A hose whose strength depends primarily on the strength of its metallic parts; it can have metallic liners or covers, or both. [52, 2010]

3.3.149 Micro Fuel Cell. A fuel cell that is wearable or easily carried by hand providing a direct current output that does not exceed 60 VDC and power output that does not exceed 240 VA.

3.3.150* Mobile [Refueler]. A DOT-approved vehicle with tank(s) and pump(s) that dispenses engine fuel directly to vehicles. [52, 2010]

3.3.151 Mobile Supply Unit. See 3.3.227.2.

3.3.152 Motor Fuel Dispensing Facility. See 3.3.77.2.

3.3.153 Motor Fuel Dispensing Facility Located Inside a Building. See 3.3.77.2.4.

3.3.154 Natural Ventilation. See 3.3.236.2.

3.3.155 Nesting. A method of securing cylinders upright in a tight mass using a contiguous three-point contact system whereby all cylinders in a group have a minimum of three contact points with other cylinders or a solid support structure (e.g., a wall or railing). [55, 2010]

3.3.156* Nonbulk Hydrogen Compressed Gas. Gaseous hydrogen (GH₂) packaged in cylinders, containers, or tanks with a contained volume not exceeding 400 scf (6600 cm³) each at NTP that are either not interconnected by manifolds or piping systems or that when interconnected have an aggregate contained volume of less than 400 scf (6600 cm³).

3.3.157 Noncombustible. Not capable of igniting and burning when subjected to a fire. [80, 2010]

3.3.158 Noncombustible Material. See 3.3.139.2.

3.3.159 Nonflammable Gas. See 3.3.100.7.

3.3.160 Non-Laboratory Area. See 3.3.6.4.

3.3.161 Normal Temperature and Pressure (NTP). See 3.3.183.4.

3.3.162 Open Parking Structure. See 3.3.172.2.

3.3.163 Operating Pressure. See 3.3.183.5.

3.3.164 Operator [Furnace]. An individual trained and responsible for the start-up, operation, shutdown, and emergency handling of the furnace and associated equipment. [86, 2011]

3.3.165 OSHA. The Occupational Safety and Health Administration of the U.S. Department of Labor. [55, 2010]

3.3.166 Other Gas. See 3.3.100.8.

3.3.167 Outdoor Area. See 3.3.6.5.

3.3.168 Outside or Outdoor Installation. See 3.3.121.2.

3.3.169 Oven. See 3.3.36, Class C Furnace.

3.3.170 Overpressure. See 3.3.183.6.

3.3.171 Oxidizing Gas. See 3.3.100.9.

3.3.172* Parking Structure. A building, structure, or portion thereof used for the parking, storage, or both, of motor vehicles. [88A, 2011]

3.3.172.1 Enclosed Parking Structure. Any parking structure that is not an open parking structure. [88A, 2011]

3.3.172.2 Open Parking Structure. A parking structure that meets the requirements of 17.3.3.1. [88A, 2011]

3.3.173 Permissible Exposure Limit (PEL). See 3.3.134.2.1.

3.3.174 Physical Hazard Material. A chemical or substance classified as a combustible liquid, explosive, flammable cryogen, flammable gas, flammable liquid, flammable solid, organic peroxide, oxidizer, oxidizing cryogen, pyrophoric, unstable (reactive), or water-reactive material. [400, 2010]

3.3.175 Pilot. A flame that is used to light the main burner. [86, 2011]

3.3.176 Pilot Plant. An experimental assembly of equipment for exploring process variables or for producing semicommercial quantities of materials. [45, 2011]

3.3.177 Piping System. See 3.3.219.13.

3.3.178 Point of Transfer. The location where connections and disconnections are made. [52, 2010]

3.3.179 Portable Fuel Cell [Power System] Installation. See 3.3.121.3.

3.3.180 Portable Tank. See 3.3.220.3.

3.3.181 Pre-Engineered and Matched Modular Components Fuel Cell Power System. See 3.3.219.5.3.

3.3.182 Prepackaged, Self-Contained Fuel Cell Power System. See 3.3.219.5.4.

3.3.183 Pressure.

3.3.183.1* Absolute Pressure. Pressure based on a zero reference point, the perfect vacuum. [55, 2010]

3.3.183.2 Compression Discharge Pressure. The varying pressure at the point of discharge from the compressor. [52, 2010]

3.3.183.3 Maximum Allowable Working Pressure (MAWP) [GH₂ Fueling Facilities]. The maximum pressure to which any component or portion of the pressure system can be subjected over the entire range of design temperatures. This value is $1.1 \times 1.25 \times$ the service pressure. [52, 2010]

3.3.183.4* Normal Temperature and Pressure (NTP). A temperature of 70°F (21°C) at an absolute pressure of 14.7 psi (101.3 kPa). [55, 2010]

3.3.183.5 Operating Pressure. The varying pressure in a fuel supply container during normal container use. [52, 2010]

3.3.183.5.1 Maximum Operating Pressure [GH₂ Vehicular Fueling]. The steady-state gauge pressure at which a part or system normally operates. This value is $1.25 \times$ the pressure. [52, 2010]

3.3.183.6 Overpressure. The pressure in a blast wave above atmospheric pressure, or a pressure within a containment structure that exceeds the maximum allowable working pressure of the containment structure. [52, 2010]

3.3.183.7 Service Pressure. The settled gas pressure at a uniform gas temperature [-] 59°F (15°C) for GH₂ systems when the equipment is fully charged with gas. [52, 2010]

3.3.183.8 Set Pressure. The start-to-discharge pressure for which a relief valve is set and marked. [52, 2010]

3.3.183.9 Settled Pressure. The pressure in a container after the temperature of the gas reaches equilibrium. [52, 2010]

3.3.183.10 Storage Pressure. The varying pressure in the storage containers. [52, 2010]

3.3.184 Pressure Regulator. See 3.3.196.1.

3.3.185 Pressure Relief Device. See 3.3.58.2.

3.3.186 Pressure Relief Device Channels. The passage or passages beyond the operating parts of the pressure relief device through which fluid passes to reach the atmosphere. [52, 2010]

3.3.187 Pressure Vessel. A container or other component designed in accordance with the ASME *Boiler and Pressure Vessel Code* or the CSA B51, *Boiler, Pressure Vessel and Pressure Piping Code*. [52, 2010]

3.3.188 Protection.

3.3.188.1* Cathodic Protection. A technique to resist the corrosion of a metal surface by making the surface the cathode of an electrochemical cell. [55, 2010]

3.3.188.2 Corrosion Protection. Protecting a container, piping, or system to resist degradation of the metal through oxidation or reactivity with the environment in which it is installed. [55, 2010]

3.3.188.3 Fire Protection. Methods of providing for fire control or fire extinguishment. [801, 2008]

3.3.189* Protection Level. A tier of building safety that exceeds the construction requirements for control areas to accommodate quantities of hazardous materials in excess of those permitted using the control area concept. [55, 2010]

3.3.190* Purge [Special Atmosphere Applications]. The replacement of a flammable, indeterminate, or high-oxygen-bearing atmosphere with another gas that, when complete, results in a nonflammable final state. [86, 2011]

3.3.191 Pyrophoric Gas. See 3.3.100.10.

3.3.192 Qualified Individual. An individual knowledgeable in the hazards of compressed gases and cryogenic fluids through training and work experience. [55, 2010]

3.3.193 Qualified Person. A person who, by possession of a recognized degree, certificate, professional standing, or skill, and who, by knowledge, training, and experience, has demonstrated the ability to deal with problems relating to a particular subject matter, work, or project. [45, 2011]

3.3.194 Ramp-Type Parking Structure. See 3.3.172.

3.3.195 Reformer. An assembly of equipment that can be used to produce hydrogen gas from hydrocarbons or other hydrogen-containing fuel, usually at high temperature and usually in the presence of a catalyst. The gaseous stream consists principally of a mixture of hydrogen and carbon monoxide. [55, 2010]

3.3.196 Regulator.

3.3.196.1 Pressure Regulator. A device, either adjustable or nonadjustable, for controlling and maintaining, within acceptable limits, a uniform outlet pressure. [52, 2010]

3.3.197 Remotely Located, Manually Activated Shutdown Control. See 3.3.47.3.

3.3.198 Residential GH_2 Fueling Facility (RFF- GH_2). See 3.3.77.3.

3.3.199 Rooftop Installation. See 3.3.121.4.

3.3.200* Safety Device. See 3.3.58.3.

3.3.201 Safety Interlock. A device required to ensure safe startup and safe operation and to cause safe equipment shutdown. [86, 2011]

3.3.202 Safety Shutoff Valve. See 3.3.232.2.1.

3.3.203 Sash. A movable panel or panels set in the hood entrance. [45, 2011]

3.3.204* Self-Service Motor Fuel Dispensing Facility. A property where liquids or gases used as motor fuels are stored and dispensed from fixed, approved dispensing equipment into the fuel tanks of motor vehicles by persons other than the facility attendant.

3.3.205 Service Pressure. See 3.3.183.7.

3.3.206 Set Pressure. See 3.3.183.8.

3.3.207 Settled Pressure. See 3.3.183.9.

3.3.208 Short-Term Exposure Limit (STEL). See 3.3.134.2.2.

3.3.209 Source Valve. See 3.3.232.3.

3.3.210 Special Atmosphere. A prepared gas or a gas mixture that is introduced into the work chamber of a furnace to replace air, generally to protect or intentionally change the surface of the material undergoing heat processing (heat treatment). [86, 2011]

3.3.210.1 Flammable Special Atmosphere. A special atmosphere in which gases are known to be flammable and predictably ignitable where mixed with air. [86, 2011]

3.3.210.2 Synthetic Special Atmosphere. A special atmosphere such as those of anhydrous ammonia, hydrogen, nitrogen, or inert gases obtained from compressed gas cylinders or bulk storage tanks and those derived by chemical dissociation or mixing of hydrocarbon fluids, including mixtures of synthetic and generated atmospheres. [86, 2011]

3.3.211 Sprinkler System. See 3.3.219.14.

3.3.212 Standard Cubic Foot (scf) of Gas. Cubic foot of gas at an absolute pressure of 14.7 psi (101 kPa) and a temperature of 70°F (21°C). [55, 2010]

3.3.213 Stationary. Permanently connected and fixed in place. [853, 2010]

3.3.214 Stationary Tank. See 3.3.220.4.

3.3.215 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. [55, 2010]

3.3.216 Storage Pressure. See 3.3.183.10.

3.3.217 Storage Tank. See 3.3.220.5.

3.3.218 Synthetic Special Atmosphere. See 3.3.210.2.

3.3.219 System.

3.3.219.1* Bulk Oxygen System. An assembly of equipment, such as oxygen storage containers, pressure regulators, pressure relief devices, vaporizers, manifolds, and interconnecting piping, that has a storage capacity of more than 320,000 ft³ (scf) (566 m³) of oxygen, including unconnected reserves on hand at the site, and that terminates at the source valve. [55, 2010]

3.3.219.2 Detection System.

3.3.219.2.1 Automatic Fire Detection System. A fire detection system that senses the presence of fire, smoke, or heat and activates a [fire suppression] system [and/] or an automatic alarm system. [853, 2010]

3.3.219.2.2 Gas Detection System. One or more sensors capable of detecting hydrogen at specified concentrations and activating alarms and safety systems. [52, 2010]

3.3.219.3 Duct System. A continuous passageway for the transmission of air that, in addition to ducts, includes duct fittings, dampers, fans, and accessory air-managing equipment and appliances. [853, 2010]

3.3.219.4 Exhaust System. An air-conveying system for moving materials from a source to a point of discharge. [91, 2010]

3.3.219.5* Fuel Cell Power System. A generator system that converts the chemical energy of reactants (a fuel and oxidant) by an electrochemical process to electric energy (direct current or alternating current electricity) and thermal energy. [853, 2010]

3.3.219.5.1* Engineered and Field-Constructed Fuel Cell Power System. A fuel cell power system that is not preassembled or does not have factory-matched components. [853, 2010]

3.3.219.5.2 Micro Fuel Cell Power System. A micro fuel cell power unit and associated fuel cartridges that is wearable or that is easily carried by hand.

3.3.219.5.3* Pre-Engineered and Matched Modular Components Fuel Cell Power System. A fuel cell power system that has components that are assembled in a factory in separate modules, such as the fuel cell [power system] stack, reformer, and inverter. [853, 2010]

3.3.219.5.4 Prepackaged, Self-Contained Fuel Cell Power System. A fuel cell power system that is designed as one unit, assembled in a factory, and shipped to site. [853, 2010]

3.3.219.6 Gas System.

3.3.219.6.1 Compressed Gas System. An assembly of equipment designed to contain, distribute, or transport compressed gases. [318, 2009]

3.3.219.6.1.1* Bulk Hydrogen Compressed Gas System. An assembly of equipment that consists of, but is not limited to, storage containers, pressure regulators, pressure relief devices, compressors, manifolds, and piping, with a storage capacity of more than 400 ft³ (scf) (11 m³) of compressed hydrogen gas, including unconnected reserves on hand at the site, and that terminates at the source valve. [55, 2010]

3.3.219.7 Hydrogen Gas System.

3.3.219.7.1* Bulk Liquefied Hydrogen Gas System. An assembly of equipment that consists of, but is not limited to, storage containers, pressure regulators, pressure relief devices, vaporizers, liquid pumps, compressors, manifolds, and piping, with a storage capacity of more than 39.7 gal (150 L) of liquefied hydrogen, including unconnected reserves on hand at the site, and that terminates at the source valve. [55, 2010]

3.3.219.8 Hydrogen Generation System. A packaged, factory matched, or site constructed hydrogen gas generation appliance or system such as (a) an electrolyzer that uses electrochemical reactions to electrolyze water to produce hydrogen and oxygen gas; (b) a reformer that converts hydrocarbon fuel to a hydrogen-rich stream of composition and conditions suitable for the type of device using the hydrogen; or (c) a gasifier that converts coal to a hydrogen-rich stream of composition and conditions suitable for a type of device using the hydrogen. It does not include hydrogen generated as a by-product of a waste treatment process. [55, 2010]

3.3.219.9 Hydrogen System.

3.3.219.9.1* Gaseous Hydrogen System. A system in which hydrogen is delivered, stored, and discharged in the gaseous form to a piping system. The gaseous hydrogen system terminates at the point where hydrogen at service pressure first enters the distribution piping. [55, 2010]

3.3.219.9.2* Liquefied Hydrogen System. A system into which liquefied hydrogen is delivered and stored and from which it is discharged in the liquid or gaseous form to a piping system. The system originates at the storage container fill connection and terminates at the point where hydrogen at service pressure first enters the supply line. [55, 2010]

3.3.219.10 Hydrogen Use System. Placing hydrogen into action through the use of piping, pressure or control systems downstream of the source valve.

3.3.219.11 Interactive System. A fuel cell [power] system that operates in parallel with and may deliver power to an electrical production and distribution network. For the purpose of this definition, an energy storage subsystem of a fuel cell [power] system, such as a battery, is not another electrical production source. [70:692.2]

3.3.219.12 LH₂ System. An assembly of equipment designed to contain, distribute, or transport LH₂.

3.3.219.13* Piping System. Interconnected piping consisting of mechanical components suitable for joining or assembly into pressure-tight fluid-containing system. Components include pipe, tubing, fittings, flanges, bolting, valves, and devices such as expansion joints, flexible

joints, pressure hoses, in-line portions of instruments, and wetted components other than individual pieces or stages of equipment. [55, 2010]

3.3.219.14 Sprinkler System. For fire protection purposes, an integrated system of underground and overhead piping designed in accordance with fire protection engineering standards. The installation includes at least one automatic water supply that supplies one or more systems. The portion of the sprinkler system above ground is a network of specially sized or hydraulically designed piping installed in a building, structure, or area, generally overhead, and to which sprinklers are attached in a systematic pattern. Each system has a control valve located in the system riser or its supply piping. Each sprinkler system includes a device for actuating an alarm when the system is in operation. The system is usually activated by heat from a fire and discharges water over the fire area. [13, 2010]

3.3.219.15 Storage System.

3.3.219.15.1 Hydrogen Storage System. That portion of a closed system used for retention of hydrogen gas or liquid upstream of the source valve.

3.3.219.15.2 Metal Hydride Storage System. A closed system consisting of a group of components assembled as a package to contain metal-hydrogen compounds for which there exists an equilibrium condition where the hydrogen-absorbing metal alloy(s), hydrogen gas, and the metal-hydrogen compound(s) coexist and where only hydrogen gas is released from the system in normal use. [55, 2010]

3.3.219.16 Treatment System. An assembly of equipment capable of processing a hazardous gas and reducing the gas concentration to a predetermined level at the point of discharge from the system to the atmosphere. [55, 2010]

3.3.220 Tank (flammable or combustible liquid).

3.3.220.1 Aboveground Tank. A storage tank that is installed above grade, at grade, or below grade without backfill. [30, 2008]

3.3.220.2* Portable Tank [Flammable or Combustible Liquids]. Any vessel having a liquid capacity over 60 gal (230 L) intended for storing liquids and not intended for fixed installation. [30, 2008]

3.3.220.3 Portable Tank. Any packaging over 60 U.S. gal (227.1 L) capacity designed primarily to be loaded into or on, or temporarily attached to, a transport vehicle or ship and equipped with skids, mountings, or accessories to facilitate handling of the tank by mechanical means. [55, 2010]

3.3.220.4* 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. [55, 2010]

3.3.220.5 Storage Tank. Any vessel having a liquid capacity that exceeds 60 gal (230 L), is intended for fixed installation, and is not used for processing. [30, 2008]

3.3.220.5.1 Aboveground Storage Tank [Flammable or Combustible Liquids]. A horizontal or vertical tank that is listed and intended for fixed installation, without backfill, above or below grade and is used within the scope of its approval or listing. [30A, 2008]

3.3.221 Temperature Controller. See 3.3.49.2.

3.3.222* Thermal Spraying. A coating process in which melted (or heated) materials are sprayed onto a surface. The “feedstock” (coating precursor) is heated by electrical (plasma or arc) or chemical means (combustion flame).

3.3.223 Toxic Gas. See 3.3.100.11.

3.3.224 Transport Canada (TC). [55, 2010]

3.3.225 Treatment System. See 3.3.219.16.

3.3.226* Tube Trailer. A truck or semitrailer on which a number of very long compressed gas tubular cylinders have been mounted and manifolded into a common piping system. [55, 2010]

3.3.227 Unit.

3.3.227.1* Laboratory Unit. An enclosed space [within a laboratory building] used for experiments or tests. A laboratory unit can include offices, lavatories, and other incidental contiguous rooms maintained for or used by laboratory personnel, and corridors within the unit. It can contain one or more separate laboratory work areas. It can be an entire building. [45, 2011]

3.3.227.1.1 Instructional Laboratory Unit. A laboratory unit used for education past the 12th grade and before post-college graduate-level instruction for the purposes of instruction of six or more persons for four or more hours per day or more than 12 hours per week. Experiments and tests conducted in instructional laboratory units are under the direct supervision of an instructor. Laboratory units used for graduate or post-graduate research are not to be considered instructional laboratory units. [45, 2011]

3.3.227.2* Mobile Supply Unit. Any supply source that is equipped with wheels so it is able to be moved around. [55, 2010]

3.3.228 Unstable Reactive Gas. See 3.3.100.12.

3.3.229 Use. To place a material into action, including solids, liquids, and gases. [55, 2010]

3.3.230* Vacuum Jacket. A term used to describe the construction of double walled pressure vessel consisting of an inner and outer vessel which has been constructed in a manner similar to a thermos bottle where the atmosphere between the inner and outer vessels has been removed by mechanical means.

3.3.231 Vacuum Pump. A compressor for exhausting air and noncondensable gases from a space that is to be maintained at subatmospheric pressure. [86, 2011]

3.3.232 Valve.

3.3.232.1 Emergency Shutoff Valve. A designated valve designed to shut off the flow of gases or liquids. [55, 2010]

3.3.232.1.1 Automatic Emergency Shutoff Valve. A designated fail-safe automatic closing valve designed to shut off the flow of gases or liquids that is initiated by a control system where the control system is activated by either manual or automatic means. [55, 2010]

3.3.232.2 Shutoff Valve.

3.3.232.2.1* Safety Shutoff Valve. A normally closed valve installed in the piping that closes automatically to shut off the fuel, atmosphere gas, or oxygen in the event of abnormal conditions or during shutdown. [86, 2011]

3.3.232.3* Source Valve. A shutoff valve on the piping system serving a bulk gas supply system where the gas supply, at service pressure, first enters the supply line. [55, 2010]

3.3.233* Vaporizer. A heat exchanger that transfers heat from an outside source to a liquid, typically a cryogenic fluid contained within a closed piping system, in order to transform the fluid from its liquid phase to the gaseous phase.

3.3.234 Vehicle. A device or structure for transporting persons or things; a conveyance (e.g., automobiles, trucks, marine vessels, railroad trains). [52, 2010]

3.3.235 Vehicle Fueling Appliance (VEA). A listed, self-contained system that compresses natural gas or that generates and compresses hydrogen and dispenses [-] to a vehicle’s engine fueling system. [52, 2010]

3.3.236 Ventilation.

3.3.236.1 Mechanical Ventilation. The flow of air or gas created by a fan, blower, or other mechanical means that will push or induce the gas stream through a ventilation system. [853, 2010]

3.3.236.2 Natural Ventilation. The flow of air or gases created by the difference in the pressures or gas densities between the outside and inside of a vent, room, or space. [853, 2010]

3.3.237 Ventilation Air. See 3.3.4.3.

3.4 Definitions for Performance-Based Designs.

3.4.1 Alternative Calculation Procedure. A calculation procedure that differs from the procedure originally employed by the design team but that provides predictions for the same variables of interest. [101, 2009]

3.4.2 Analysis.

3.4.2.1 Sensitivity Analysis. An analysis performed to determine the degree to which a predicted output will vary given a specified change in an input parameter, usually in relation to models. [5000, 2009]

3.4.2.2 Uncertainty Analysis. An analysis performed to determine the degree to which a predicted value will vary. [5000, 2009]

3.4.3 Data Conversion. The process of developing the input data set for the assessment method of choice. [101, 2009]

3.4.4 Design Fire Scenario. See 3.4.9.1.

3.4.5 Design Specification. See 3.4.20.1.

3.4.6 Design Team. A group of stakeholders including, but not limited to, representatives of the architect, client, and any pertinent engineers and other designers. [101, 2009]

3.4.7* Exposure Fire. A fire that starts at a location that is remote from the area being protected and grows to expose that which is being protected. [101, 2009]

3.4.8* Fire Model. A structured approach to predicting one or more effects of a fire. [101, 2009]

3.4.9* Fire Scenario. A set of conditions that defines the development of fire, the spread of combustion products throughout a building or portion of a building, the reactions of people to fire, and the effects of combustion products. [101, 2010]

3.4.9.1 Design Fire Scenario. A fire scenario selected for evaluation of a proposed design. [914, 2010]

3.4.10 Fuel Load. The total quantity of combustible contents of a building, space, or fire area, including interior finish and trim, expressed in heat units or the equivalent weight in wood. [101, 2011]

3.4.11 Incapacitation. A condition under which humans do not function adequately and become unable to escape untenable conditions. [101, 2009]

3.4.12 Input Data Specification. See 3.4.20.2.

3.4.13 Occupant Characteristics. The abilities or behaviors of people before and during a fire. [101, 2009]

3.4.14* Performance Criteria. Threshold values on measurement scales that are based on quantified performance objectives. [101, 2009]

3.4.15* Proposed Design. A design developed by a design team and submitted to the authority having jurisdiction for approval. [101, 2009]

3.4.16 Safe Location. A location remote or separated from the effects of a fire so that such effects no longer pose a threat. [101, 2009]

3.4.17 Safety Factor. A factor applied to a predicted value to ensure that a sufficient safety margin is maintained. [101, 2009]

3.4.18 Safety Margin. The difference between a predicted value and the actual value where a fault condition is expected. [101, 2009]

3.4.19 Sensitivity Analysis. See 3.4.2.1.

3.4.20 Specification.

3.4.20.1* Design Specification. A building characteristic and other conditions that are under the control of the design team. [5000, 2009]

3.4.20.2 Input Data Specification. Information required by the verification method. [101, 2009]

3.4.21 Stakeholder. An individual, or representative of same, having an interest in the successful completion of a project. [101, 2009]

3.4.22 Uncertainty Analysis. See 3.4.2.2.

3.4.23 Verification Method. A procedure or process used to demonstrate or confirm that the proposed design meets the specified criteria. [101, 2009]

Chapter 4 General Fire Safety Requirements

4.1 Application. Sections 4.1 and 4.2 shall establish the minimum goals and objectives commensurate with public safety to be considered in the application of this code.

4.1.1 For applications where buildings or structures are to be provided, this code and the building code adopted by the jurisdiction shall be used to regulate matters of construction, including requirements for life safety in the building or structure in which hydrogen is stored, handled, or used.

4.1.2* For applications in facilities located outdoors, the proximity of hydrogen storage systems and systems that use or produce hydrogen shall be regulated by this code in addition to the requirements of building or local zoning regulations that address matters of location, quantity restrictions, or matters that are the subject of local, state, or federal regulations.

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

4.1.4 Subsection 4.4.1 shall be the default design option applicable to facilities when hydrogen is stored, handled, used, or produced.

4.1.4.1 The use of 4.4.2 shall be permitted at the option of the permittee with the approval of the authority having jurisdiction.

4.1.4.2 Performance-based designs shall be in accordance with the requirements of Chapter 5.

4.1.5 The requirements of Sections 4.5 through 4.1.5 shall be part of the prescriptive requirements of this code.

4.2* Goals and Objectives. (Also see Section 4.3.)

4.2.1* Goals. The goals of this code shall be to provide a reasonable level of safety, property protection, and public welfare from the hazards created by fire, explosion, and other hazardous conditions. [1:4.1.1]

4.2.2* Objectives. To achieve the goals stated in 4.2.1, the goals and objectives of 4.2.3 through 4.2.5 shall be used to determine the intent of this code. [1:4.1.2]

4.2.3* Safety. This code shall provide for life safety by reducing the probability of injury or death from fire, explosions, or events involving [GH₂ or LH₂]. [1:4.1.3]

4.2.3.1 Safety from Fire.

4.2.3.1.1* Safety-from-Fire Goals. The fire safety goals of this code shall be as follows: [1:4.1.3.1.1]

- (1) To provide an environment for the occupants in a building or facility and for the public near a building or facility that is reasonably safe from fire and similar emergencies [1:4.1.3.1.1(1)]
- (2) To protect fire fighters and emergency responders [1:4.1.3.1.1(2)]

4.2.3.1.2 Safety-from-Fire Objectives.

4.2.3.1.2.1 Buildings and facilities shall be designed, constructed, and maintained to protect occupants who are not intimate with the initial fire development for the amount of time needed to evacuate, relocate, or defend in place. [1:4.1.3.1.2.1]

4.2.3.1.2.2* Buildings shall be designed and constructed to provide reasonable safety for fire fighters and emergency responders during search and rescue operations. [1:4.1.3.1.2.2]

4.2.3.1.2.3 Buildings shall be designed, located, and constructed to reasonably protect adjacent persons from injury or death as a result of a fire. [1:4.1.3.1.2.3]

4.2.3.1.2.4 Buildings shall be designed, located, and constructed to provide reasonable access to the building for emergency responders. [1:4.1.3.1.2.4]

4.2.3.1.2.5* Operations shall be conducted at facilities in a safe manner that minimizes, reduces, controls, or mitigates the risk of fire injury or death for the operators, while protecting the occupants not intimate with initial fire development for the amount of time needed to evacuate, relocate, or defend in place. [1:4.1.3.1.2.5]

4.2.3.2 Safety During Building Use.

4.2.3.2.1* Safety-During-Building-Use Goal. The safety-during-building-use goal of this code shall be to provide an environment for the occupants of the building that is reasonably safe during the normal use of the building. [1:4.1.3.2.1]



4.2.3.2.2 Safety-During-Building-Use Objectives. Performance-based building design shall be in accordance with the requirements of the adopted building code.

4.2.3.3* Safety from Hydrogen Hazards.

4.2.3.3.1 Safety-from-Hydrogen Hazards Goal. The safety-from- [hydrogen hazards] goal of this code shall be to provide an environment for the occupants in a building or facility and to those adjacent to a building or facility that is reasonably safe from exposures to adverse affects from [hydrogen hazards] present therein. [1:4.1.3.3.1]

4.2.3.3.2 Safety-from-Hydrogen Hazards Objectives.

4.2.3.3.2.1 The storage, use, or handling of [hydrogen] in a building or facility shall be accomplished in a manner that provides a reasonable level of safety for occupants and for those adjacent to a building or facility from health hazards, illness, injury, or death during normal storage, use, or handling operations and conditions. [1:4.1.3.3.2.1]

4.2.3.3.2.2* The storage, use, or handling of [hydrogen] in a building or facility shall be accomplished in a manner that provides a reasonable level of safety for occupants and for those adjacent to a building or facility from illness, injury, or death due to the following conditions: [1:4.1.3.3.2.2]

- (1) An unplanned release of [hydrogen] [1:4.1.3.3.2.2(1)]
- (2) A fire impinging upon the [hydrogen piping or containment system] or the involvement of [hydrogen] in a fire [1:4.1.3.3.2.2(2)]
- (3) The application of an external force on the [hydrogen piping or containment system] that is likely to result in an unsafe condition [1:4.1.3.3.2.2(3)]

4.2.4 Property Protection.

4.2.4.1 Property Protection Goal. The property protection goal of this code shall be to limit damage created by a fire, explosion, or event associated with [GH₂ or LH₂] to a reasonable level to the building or facility and adjacent property. [1:4.1.4.1]

4.2.4.2 Property Protection Objectives.

4.2.4.2.1* Prevention of Ignition. The facility shall be designed, constructed, and maintained, and operations associated with the facility shall be conducted, to prevent unintentional explosions and fires that result in failure of or damage to adjacent compartments, emergency life safety systems, adjacent properties, adjacent outside storage, and the facility's structural elements. [1:4.1.4.2.1]

4.2.4.2.2* Fire Spread and Explosions. In the event that a fire or explosion occurs, the building or facility shall be sited, designed, constructed, or maintained, and operations associated with the facility shall be conducted and protected, to reasonably reduce the impact of unwanted fires and explosions on the adjacent compartments, emergency life safety systems, adjacent properties, adjacent outside storage, and the facility's structural elements. [1:4.1.4.2.2]

4.2.4.2.3 Structural Integrity. The facility shall be designed, constructed, protected, and maintained, and operations associated with the facility shall be conducted, to provide a reasonable level of protection for the facility, its contents, and adjacent properties from building collapse due to a loss of structural integrity resulting from a fire. [1:4.1.4.2.3]

4.2.4.2.4 Hydrogen Hazards. The facility shall be designed, constructed, and maintained, and operations associated with the facility shall be conducted, to provide reasonable property protection from damage resulting from fires, explosions, and other unsafe conditions associated with the storage, use, and handling of hydrogen therein. [1:4.1.4.2.4]

4.2.5 Public Welfare.

4.2.5.1* Public Welfare Goal. The public welfare goal of this code shall be to maintain a high probability that buildings and facilities that provide a public welfare role for a community continue to perform the function for their intended purpose following a fire, explosion, or hazardous materials event. [1:4.1.5.1]

4.2.5.2* Public Welfare Objective. Buildings and facilities that provide a public welfare role for a community shall be designed, constructed, maintained, and operated to provide reasonable assurance of continued function following fire, explosion or hazardous materials event. [1:4.1.5.2]

4.3 Assumptions.

4.3.1* Single Fire Source.

4.3.1.1 The fire protection methods of this code shall assume multiple simultaneous fire incidents will not occur. [1:4.2.1.1]

4.3.1.2 The single fire source assumption shall not preclude the evaluation of multiple design fire scenarios as required by Section 5.4. [1:4.2.1.2]

4.3.2* Single Hazardous Material Release.

4.3.2.1 The protection methods of this code shall assume that multiple simultaneous unauthorized releases of hazardous materials from different locations will not occur. [1:4.2.2.1]

4.3.2.2 The single hazardous material release assumption shall not preclude the evaluation of multiple design scenarios as required by Section 5.4. [1:4.2.2.2]

4.3.3* Incidents Impinging on Hazardous Materials. The protection methods of this code shall assume that a fire, explosion, hazardous materials release, or external force that creates a dangerous condition has the potential to impinge on hazardous materials being stored, handled, or used in the building or facility under normal conditions. (*See Section 5.4 for performance-based design scenarios.*) [1:4.2.3]

4.4 Compliance Options. Compliance with the goals and objectives of Section 4.2 shall be provided in accordance with either of the following: [1:4.3]

- (1) The prescriptive-based provisions per 4.4.1 [1:4.3]
- (2) The performance-based provisions per 4.4.2 [1:4.3]

4.4.1 Prescriptive-Based Option.

4.4.1.1 A prescriptive-based option shall be in accordance with Chapters 1 through 4 and Chapters 6 through 20 of this code [as applicable]. [1:4.3.1.1]

4.4.2 Performance-Based Option.

4.4.2.1 A performance-based option shall be in accordance with Chapter 1 through Chapter 5 of this code. [1:4.3.2.1]

4.4.2.2 Prescriptive requirements shall be permitted to be used as part of the performance approach, if they, in conjunction with the performance features, meet the overall goals and objectives of this code. [1:4.3.2.2]

4.5 Permits. Permits shall be obtained in accordance with the requirements of the jurisdiction in which the facility operates. [55:4.1]

4.6 Emergency Plan.

4.6.1 An emergency plan shall be prepared and updated wherever [GH₂ or LH₂] are produced, handled, stored, or used in amounts exceeding the maximum allowable quantity (MAQ) per control area or where required by the authority having jurisdiction (AHJ). [55:4.2.1.1]

4.6.2 The plan shall be available for inspection by the AHJ upon reasonable notice and shall include the following information:

[55:4.2.1.2]

- (1) The type of emergency equipment available and its location [55:4.2.1.2(1)]
- (2) A brief description of any testing or maintenance programs for the available emergency equipment [55:4.2.1.2(2)]
- (3) An indication that hazard identification labeling is provided for each storage area [55:4.2.1.2(3)]
- (4) The location of posted emergency procedures [55:4.2.1.2(4)]
- (5) A material safety data sheet (MSDS) or equivalent for [GH₂ or LH₂] stored or used on the site [55:4.2.1.2(5)]
- (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: [55:4.2.1.2(6)]
 - (a) Aiding the emergency responders in pre-emergency planning [55:4.2.1.2(6)(a)]
 - (b) Identifying the location of the [GH₂ and LH₂] stored or used [55:4.2.1.2(6)(b)]
 - (c) Accessing MSDSs [55:4.2.1.2(5)(c)]
 - (d) Knowing the site emergency procedures [55:4.2.1.2(6)(d)]
- (7) A list of the types and quantities of [GH₂ and LH₂] found within the facility [55:4.2.1.2(7)]

4.7 Facility Closure.

4.7.1 Temporarily Out-of-Service Facilities. Facilities that are temporarily out of service shall continue to maintain a permit and be monitored and inspected. [1:60.1.5.3.2]

4.7.2 Permanently Out-of-Service Facilities. Facilities for which a permit is not kept current or that are not monitored and inspected on a regular basis shall be deemed to be permanently out of service and shall be closed in accordance with 4.7.3. [1:60.1.5.3.3]

4.7.3 Closure Plan.

4.7.3.1 The permit holder or applicant shall submit a plan to the fire department to terminate storage, dispensing, handling, or use of [GH₂ or LH₂] at least 30 days prior to facility closure. [1:60.1.5.3.3.1]

4.7.3.2 The plan shall demonstrate that [GH₂ or LH₂] that was stored, dispensed, handled, or used in the facility has been transported, disposed of, or reused in a manner that eliminates the need for further maintenance and any threat to public health and safety. [1:60.1.5.3.3.2]

4.7.3.3 The plan shall be submitted with a permit application for facility closure in accordance with Section 4.5. [55:4.3.3.3]

4.8* Out-of-Service Stationary Bulk Gas Systems. Installed bulk gas systems no longer in use that remain in place shall be

removed from service by the supplier or shall be safeguarded in accordance with the following: [55:4.4]

- (1) Required permits shall be maintained. [55:4.4(1)]
- (2) The source and fill valves shall be closed to prevent the intrusion of air or moisture. [55:4.4(2)]
- (3) Cylinders, containers, and tanks shall be maintained in a serviceable condition. [55:4.4(3)]
- (4) Security shall be maintained in accordance with 7.1.7. [55:4.4(4)]

4.9 Management Plan and Hazardous Materials Documentation.

4.9.1 Hazardous Materials Management Plan. When required by the AHJ, permit applications shall include a hazardous materials management plan (HMMP) [including addressing the GH₂ or LH₂ present]. [1:60.1.6.1]

4.9.1.1 Contents. The HMMP shall include an emergency response training plan and facility site plan designating the following: [1:60.1.6.1.1]

- (1) Storage and use areas [1:60.1.6.1.1(1)]
- (2) Maximum amount of each [hazardous] material stored or used in each area [1:60.1.6.1.1(2)]
- (3) Range of container sizes [1:60.1.6.1.1(3)]
- (4) Product-conveying piping containing liquids or gases, other than utility-owned fuel gas lines and low-pressure fuel gas lines [1:60.1.6.1.1(4)]
- (5) Locations of emergency isolation and mitigation valves and devices [1:60.1.6.1.1(5)]
- (6) ON and OFF positions of valves for valves that are of the self-indicating type [1:60.1.6.1.1(6)]
- (7) Storage plan that is legible and drawn approximately to scale showing the intended storage arrangement, including the location and dimensions of aisles, with separate distribution systems permitted to be shown on separate pages [1:60.1.6.1.1(7)]

4.9.1.2 Location. The location of the HMMP shall be posted adjacent to permits when an HMMP is provided. [1:60.1.6.1.2]

4.9.2 Hazardous Materials Inventory Statement. When required by the AHJ, permit applications shall include a hazardous materials inventory statement (HMIS) [addressing the GH₂ or LH₂ present]. [1:60.1.6.2]

4.9.3 Material Safety Data Sheets. Material safety data sheets (MSDS) shall be readily available on the premises for [GH₂ or LH₂]. [1:60.1.7]

4.10 Release of GH₂ or LH₂.

4.10.1* Prohibited Releases. [GH₂ or LH₂] shall not be released into a sewer, storm drain, ditch, drainage canal, lake, river, or tidal waterway; upon the ground, sidewalk, street, or highway unless such release is permitted by the following: [1:60.1.8.1]

- (1) Federal, state, or local governing regulations [1:60.1.8.1(1)]
- (2) Permits of the jurisdictional air quality management board [1:60.1.8.1(2)]
- (3) National Pollutant Discharge Elimination System Permit [1:60.1.8.1(3)]
- (4) Waste discharge requirements established by the jurisdictional water quality control board [1:60.1.8.1(4)]
- (5) Local sewer pretreatment requirements for publicly owned treatment works [1:60.1.8.1(5)]
- (6) Pressure relief devices and vents designed as part of a system

4.10.2 Control and Mitigation of Unauthorized Discharges. Provisions shall be made for controlling and mitigating unauthorized discharges. [1:60.1.8.2]

4.10.3* Records of Unauthorized Discharges. Accurate records of the unauthorized discharge of [GH₂ or LH₂] shall be kept by the permittee. [1:60.1.8.3]

4.10.4 Notification of Unauthorized Discharges. The fire department shall be notified immediately or in accordance with approved emergency procedures when an unauthorized discharge becomes reportable under state, federal, or local regulations. [1:60.1.8.4]

4.10.5 Container Failure. When an unauthorized discharge due to primary container failure is discovered, the involved primary container shall be repaired or removed from service. [1:60.1.8.5]

4.10.6 Responsibility for Cleanup of Unauthorized Discharges.

4.10.6.1 The person, firm, or corporation responsible for an unauthorized discharge shall institute and complete all actions necessary to remedy the effects of such unauthorized discharge, whether sudden or gradual, at no cost to the AHJ. [1:60.1.8.6.1]

4.10.6.2 When deemed necessary by the AHJ, cleanup of an unauthorized discharge shall be permitted to be initiated by the fire department or by an authorized individual or firm, and costs associated with such cleanup shall be borne by the owner, operator, or other person responsible for the unauthorized discharge. [1:60.1.8.6.2]

4.11 Personnel Training.

4.11.1 Persons engaged in the handling and storage of GH₂, and LH₂ shall be trained in the hazards and properties of these materials.

4.11.2 Persons responsible for the operation of areas in which [GH₂ or LH₂] is stored, dispensed, handled, or used shall be familiar with the chemical nature of the materials and the appropriate mitigating actions necessary in the event of fire, leak, or spill. [1:60.1.9]

4.12 Ignition Source Controls.

4.12.1 Smoking. Smoking shall be prohibited in the following locations: [1:60.1.11.1]

- (1) Within 25 ft (7.6 m) of outdoor storage or dispensing areas [1:60.1.11.1(1)]
- (2) In rooms or areas where [GH₂ or LH₂] is stored or dispensed or used in amounts requiring a permit in accordance with Section 4.5 [1:60.1.11.1(2)]

4.12.2 Open Flames and High-Temperature Devices. Open flames and high-temperature devices shall not be used in a manner that creates a hazardous condition. [1:60.1.11.2]

4.12.3 Energy-Consuming Equipment. Energy-consuming equipment shall be listed or approved for use with GH₂ or LH₂.

4.12.4 Laboratories. Equipment in laboratories shall be in accordance with Chapter 16.

4.13 Signs.

4.13.1 General.

4.13.1.1 Design and Construction. Signs shall be durable, and the size, color, and lettering of signs shall be in accordance with nationally recognized standards. [1:60.1.13.1.1]

4.13.1.2 Language. Signs shall be in English as the primary language or in symbols allowed by this code. [1:60.1.13.1.2]

4.13.1.3 Maintenance. Signs shall not be obscured or removed. [1:60.1.13.1.3]

4.13.2 Hazard Identification Signs.

4.13.2.1 Visible hazard identification signs in accordance with NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response*, shall be placed on the following, except where the AHJ has received a hazardous materials management plan and a hazardous materials inventory statement in accordance with 4.9.1 through 4.9.2 and has determined that omission of such signs is consistent with safety: [1:60.1.13.2.1]

- (1) Stationary aboveground tanks [1:60.1.13.2.1(1)]
- (2) Stationary aboveground containers [1:60.1.13.2.1(2)]
- (3) At entrances to locations where hazardous materials are stored, dispensed, used, or handled in quantities requiring a permit [1:60.1.13.2.1(3)]
- (4)*At other entrances and locations designated by the AHJ [1:60.1.13.2.1(4)]

4.13.2.2 Identification of Containers, Cartons, and Packages. Individual containers, cartons, or packages shall be conspicuously marked or labeled in accordance with nationally recognized [codes and] standards. [1:60.1.13.2.2]

4.13.2.3 Identification of Gas Rooms and Cabinets. Rooms or cabinets containing compressed gases shall be conspicuously labeled as follows: COMPRESSED GAS [1:60.1.13.2.3]

4.13.3 No Smoking Signs. Signs prohibiting smoking shall be provided for an entire site, building, or in the following locations: [1:60.1.13.3]

- (1) In rooms or areas where [GH₂ or LH₂] is stored or dispensed in amounts requiring a permit in accordance with Section 4.5 [1:60.1.13.3(1)]
- (2) Within 25 ft (7.6 m) of outdoor storage [or] dispensing [1:60.1.13.3(2)]
- (3) In areas containing [GH₂ or LH₂] [1:60.1.13.3(3)]

4.14 Protection From Vehicular Damage.

4.14.1 When required, guard posts or other approved means shall be provided to protect against physical damage in accordance with Section 4.1.5.

4.14.1.1 Guard posts or other approved means shall be provided to protect the following areas where subject to vehicular damage: [1:60.1.15.1]

- (1)*Storage tanks and connected piping, valves, and fittings [1:60.1.15.1(1)]
- (2) Dispensing areas [1:60.1.15.1(2)]
- (3) Use areas [1:60.1.15.1(3)]

4.14.1.2 Where guard posts are installed, the posts shall meet the following criteria: [1:60.1.15.2]

- (1) They shall be constructed of steel not less than 4 in. (102 mm) in diameter and concrete filled. [1:60.1.15.2(1)]
- (2) They shall be spaced not more than 4 ft (1.2 m) between posts on center. [1:60.1.15.2(2)]
- (3) They shall be set not less than 3 ft (0.9 m) deep in a concrete footing of not less than a 15 in. (380 mm) diameter. [1:60.1.15.2(3)]
- (4) They shall be set with the top of the posts not less than 3 ft (0.9 m) above ground. [1:60.1.15.2(4)]
- (5) They shall be located not less than 5 ft (1.5 m) from the tank. [1:60.1.15.2(5)]

Chapter 5 Performance-Based Option

5.1* General.

5.1.1 Application. The requirements of this chapter shall apply to facilities designed to the performance-based option permitted by Section 4.4. [1:5.1.1]

5.1.2 Goals and Objectives. The performance-based design shall meet the goals and objectives of Section 4.2 in accordance with the assumptions of Section 4.3.

5.1.3* Approved Qualifications. The performance-based design shall be prepared by a person with qualifications acceptable to the AHJ. [1:5.1.3]

5.1.4* Plan Submittal Documentation. When a performance-based design is submitted to the AHJ for review and approval, the owner shall document, in an approved format, each performance objective and applicable scenario, including any calculation methods or models used in establishing the proposed design's fire and life safety performance. [1:5.1.4]

5.1.5* Independent Review. The AHJ shall be permitted to require an approved, independent third party to review the proposed design and provide an evaluation of the design to the AHJ at the expense of the owner. [1:5.1.5]

5.1.6 Sources of Data. Data sources shall be identified and documented for each input data requirement that is required to be met using a source other than a required design scenario, an assumption, or a facility design specification. [1:5.1.6]

5.1.6.1 The degree of conservatism reflected in such data shall be specified, and a justification for the source shall be provided. [1:5.1.6.1]

5.1.6.2 Copies of all references relied upon by the performance-based design to support assumptions, design features, or any other part of the design shall be made available to the AHJ if requested. [1:5.1.6.2]

5.1.7 Final Determination. The AHJ shall make the final determination as to whether the performance objectives have been met. [1:5.1.7]

5.1.8* Operations and Maintenance Manual. An approved Operations and Maintenance (O&M) Manual shall be provided by the owner to the AHJ and the fire department [for review] and shall be maintained at the facility in an approved location. [1:5.1.8]

5.1.9* Information Transfer to the Fire Service. Where a performance-based design is approved and used, the designer shall ensure that information regarding the operating procedures of the performance-based designed fire protection system is transferred to the owner and to the local fire service for inclusion in the pre-fire plan. [1:5.1.9]

5.1.10* Design Feature Maintenance.

5.1.10.1 The design features required for the facility to meet the performance goals and objectives shall be maintained by the owner and be readily accessible to the AHJ for the life of the facility. [1:5.1.10.1]

5.1.10.2 The facility shall be maintained in accordance with all documented assumptions and design specifications. [1:5.1.10.2]

5.1.10.2.1 Any proposed changes or variations from the approved design shall be approved by the AHJ prior to the actual change. [1:5.1.10.2.1]

5.1.10.2.2 Any approved changes to the original design shall be maintained in the same manner as the original design. [1:5.1.10.2.2]

5.1.11* Annual Certification. Where a performance-based design is approved and used, the property owner shall annually certify that the design features and systems have been maintained in accordance with the approved original performance-based design and assumptions and any subsequent approved changes or modifications to the original performance-based design. [1:5.1.11]

5.1.12 Hazardous Materials.

5.1.12.1 Performance-based designs for facilities containing high hazard contents shall identify the properties of hazardous materials to be stored, used, or handled and shall provide adequate and reliable safeguards to accomplish the following objectives, considering both normal operations and possible abnormal conditions: [1:5.1.12.1]

- (1) Minimize the potential occurrence of unwanted releases, fire, or other emergency incidents resulting from the storage, use, or handling of hazardous materials [1:5.1.12.1(1)]
- (2) Minimize the potential failure of buildings, equipment, or processes involving hazardous materials by ensuring that such buildings, equipment, or processes are reliably designed and are suitable for the hazards present [1:5.1.12.1(2)]
- (3) Minimize the potential exposure of people or property to unsafe conditions or events involving an unintended reaction or release of hazardous materials [1:5.1.12.1(3)]
- (4) Minimize the potential for an unintentional reaction that results in a fire, explosion, or other dangerous condition [1:5.1.12.1(4)]
- (5) Provide a means to contain, treat, neutralize, or otherwise handle plausible releases of hazardous materials to minimize the potential for adverse impacts to persons or property outside of the immediate area of a release [1:5.1.12.1(5)]
- (6) Provide appropriate safeguards to minimize the risk of and limit damage and injury that could result from an explosion involving hazardous materials that present explosion hazards [1:5.1.12.1(6)]
- (7) Detect hazardous levels of gases or vapors that are dangerous to health and alert appropriate persons or mitigate the hazard when the physiological warning properties for such gases or vapors are inadequate to warn of danger prior to personal injury [1:5.1.12.1(7)]
- (8) Maintain power to provide for continued operation of safeguards and important systems that are relied upon to prevent or control an emergency condition involving hazardous materials [1:5.1.12.1(8)]
- (9) Maintain ventilation where ventilation is relied upon to minimize the risk of emergency conditions involving hazardous materials [1:5.1.12.1(9)]
- (10) Minimize the potential for exposing combustible hazardous materials to unintended sources of ignition and for exposing any hazardous material to fire or physical damage that can lead to endangerment of people or property [1:5.1.12.1(10)]



5.1.12.2 A process hazard analysis and off-site consequence analysis shall be conducted when required by the AHJ to ensure that people and property are satisfactorily protected from potentially dangerous conditions involving hazardous materials. The results of such analyses shall be considered when determining active and passive mitigation measures used in accomplishing the objectives of 4.2.3.3.2 and 4.2.4.2. [1:5.1.12.2]

5.1.12.3 Written procedures for pre-start-up safety reviews, normal and emergency operations, management of change, emergency response, and accident investigation shall be developed prior to beginning operations at a facility [-]. Such procedures shall be developed with the participation of employees. [1:5.1.12.3]

5.1.13 Special Definitions. A list of special terms used in this chapter shall be as follows: [1:5.1.13]

- (1) Design Fire Scenario (*See 3.4.4.*) [1:5.1.13(1)]
- (2) Design Specification (*See 3.4.5.*) [1:5.1.13(2)]
- (3) Design Team (*See 3.4.6.*) [1:5.1.13(3)]
- (4) Exposure Fire (*See 3.4.7.*) [1:5.1.13(4)]
- (5) Fire Model (*See 3.4.8.*) [1:5.1.13(5)]
- (6) Fire Scenario (*See 3.4.9.*) [1:5.1.13(6)]
- (7) Fuel Load (*See 3.4.10.*) [1:5.1.13(7)]
- (8) Input Data Specification (*See 3.4.12.*) [1:5.1.13(8)]
- (9) Occupant Characteristics (*See 3.4.13.*) [1:5.1.13(9)]
- (10) Performance Criteria (*See 3.4.14.*) [1:5.1.13(10)]
- (11) Proposed Design (*See 3.4.15.*) [1:5.1.13(11)]
- (12) Safety Factor (*See 3.4.17.*) [1:5.1.13(12)]
- (13) Safety Margin (*See 3.4.18.*) [1:5.1.13(13)]
- (14) Sensitivity Analysis (*See 3.4.19.*) [1:5.1.13(14)]
- (15) Stakeholder (*See 3.4.21.*) [1:5.1.13(15)]
- (16) Uncertainty Analysis (*See 3.4.22.*) [1:5.1.13(16)]
- (17) Verification Method (*See 3.4.23.*) [1:5.1.13(17)]

5.2 Performance Criteria.

5.2.1 General. A design shall meet the objectives specified in Section 4.2 if, for each required design scenario, assumption, and design specification, the performance criteria of 5.2.2 are met. [1:5.2.1]

5.2.2* Specific Performance Criteria.

5.2.2.1* Fire Conditions. No occupant who is not intimate with ignition shall be exposed to instantaneous or cumulative untenable conditions. [1:5.2.2.1]

5.2.2.2* Explosion Conditions. The facility design shall provide an acceptable level of safety for occupants and for individuals immediately adjacent to the property from the effects of unintentional detonation or deflagration. [1:5.2.2.2]

5.2.2.3* Hazardous Materials Exposure. The facility design shall provide an acceptable level of safety for occupants and for individuals immediately adjacent to the property from the effects of an unauthorized release of hazardous materials or the unintentional reaction of hazardous materials. [1:5.2.2.3]

5.2.2.4* Property Protection. The facility design shall limit the effects of all required design scenarios from causing an unacceptable level of property damage. [1:5.2.2.4]

5.2.2.5* Public Welfare. For facilities that serve a public welfare role as defined in 4.2.5, the facility design shall limit the effects of all required design scenarios from causing an unacceptable interruption of the facility's mission. [1:5.2.2.5]

5.2.2.6 Occupant Protection from Untenable Conditions. Means shall be provided to evacuate, relocate, or defend in place occupants not intimate with ignition for sufficient time

so that they are not exposed to instantaneous or cumulative untenable conditions from smoke, heat, or flames. [1:5.2.2.6]

5.2.2.7 Emergency Responder Protection. Buildings shall be designed and constructed to reasonably prevent structural failure under fire conditions for sufficient time to enable fire fighters and emergency responders to conduct search and rescue operations. [1:5.2.2.7]

5.2.2.8 Occupant Protection from Structural Failure. Buildings shall be designed and constructed to reasonably prevent structural failure under fire conditions for sufficient time to protect the occupants. [1:5.2.2.8]

5.3 Retained Prescriptive Requirements.

5.3.1 Systems and Features. All fire protection systems and features of the building shall comply with applicable NFPA standards for those systems and features. [1:5.3.1]

5.3.2 Electrical Systems. Electrical systems shall comply with applicable NFPA standards for those systems. [1:5.3.2]

5.3.3 General. The design shall comply with the following requirements in addition to the performance criteria of Section 5.2 and the methods of Sections 5.4 through 5.7:

- (1) General requirements for precautions against fire from the adopted fire code
- (2) Emergency evacuation drill requirements from the adopted fire code
- (3) Smoking prohibitions of 4.12.1
- (4) Fire service feature requirements of the adopted fire code
- (5) Requirements for fire safety during construction and demolition from the adopted fire code

5.3.4 Means of Egress. The design shall comply with the adopted building code in addition to the performance criteria of Section 5.2 and the methods of Sections 5.4 through 5.7.

5.3.5 Equivalency. Equivalent designs for the features covered in the retained prescriptive requirements mandated by 5.3.1 through 5.3.4 shall be addressed in accordance with the equivalency provisions of Section 1.4. [1:5.3.5]

5.4* Design Scenarios.

5.4.1 General.

5.4.1.1 The proposed design shall be considered to meet the goals and objectives if it achieves the performance criteria for each required design scenario. The AHJ shall approve the parameters involved with required design scenarios. [1:5.4.1.1]

5.4.1.2* Design scenarios shall be evaluated for each required scenario using a method acceptable to the AHJ and appropriate for the conditions. Each scenario shall be as challenging and realistic as any that could realistically occur in the building. [1:5.4.1.2]

5.4.1.3* Scenarios selected as design scenarios shall include, but not be limited to, those specified in 5.4.2 through 5.4.5. [1:5.4.1.3]

5.4.1.3.1 Design fire scenarios demonstrated by the design team to the satisfaction of the AHJ as inappropriate for the building use and conditions shall not be required to be evaluated fully. [1:5.4.1.3.1]

5.4.1.4 Each design scenario used in the performance-based design proposal shall be translated into input data specifications, as appropriate for the calculation method or model. [1:5.4.1.4]

5.4.1.5 Any design scenario specifications that the design analyses do not explicitly address or incorporate and that are, therefore, omitted from input data specifications shall be identified, and a sensitivity analysis of the consequences of that omission shall be performed. [1:5.4.1.5]

5.4.1.6 Any design scenario specifications modified in input data specifications, because of limitations in test methods or other data generation procedures, shall be identified, and a sensitivity analysis of the consequences of the modification shall be performed. [1:5.4.1.6]

5.4.2* Required Design Scenarios — Fire. Performance-based building design for life safety affecting the egress system shall be in accordance with this code and the requirements of the adopted building code.

5.4.3 Required Design Scenarios — Explosion.

5.4.3.1 Explosion Design Scenario 1 — Hydrogen Pressure Vessel Burst Scenario. Explosion Design Scenario 1 shall be the prevention or mitigation of a ruptured hydrogen pressure vessel.

5.4.3.1.1 Explosion Design Scenario 1 shall identify the various pressure vessel failure prevention measures in relation to both expected and potential abnormal vessel fill and operating conditions.

5.4.3.1.2 Mitigation measures, if applicable, shall address the safety of individuals at various distances from the pressure vessel.

5.4.3.2 Explosion Design Scenario 2 — Hydrogen Deflagration. Explosion Design Scenario 2 shall be the deflagration of a hydrogen-air or hydrogen-oxidant mixture within an enclosure such as a room or within large process equipment containing hydrogen.

5.4.3.2.1 Explosion Design Scenario 2 shall identify the specific gas mixture formed in relation to both expected and potential abnormal operating conditions and ventilation in the enclosure.

5.4.3.2.2 Mitigation measures, such as deflagration venting, shall address the hazards to any individuals within the enclosure and in the vicinity of the enclosure.

5.4.3.3 Explosion Design Scenario 3 — Hydrogen Detonation. Explosion Design Scenario 3 shall be the detonation of a hydrogen-air or hydrogen-oxidant mixture within an enclosure such as a room or a process vessel or within piping containing hydrogen.

5.4.3.3.1 The specific enclosure selected shall be the enclosure that has the greatest potential for a detonation.

5.4.3.3.2 Explosion Design Scenario 3 shall identify the specific gas mixture formed in relation to both expected and potential abnormal operating conditions and ventilation in the enclosure.

5.4.3.3.3 Mitigation measures, such as detonation containment, shall address the hazards to any individuals in the vicinity of the enclosure.

5.4.4* Required Design Scenarios — Hazardous Materials.

5.4.4.1 Hazardous Materials Design Scenario 1. Hazardous Materials Design Scenario 1 involves an unauthorized release of hazardous materials from a single control area. This design scenario shall address the concern regarding the spread of hazardous conditions from the point of release. [1:5.4.4.1]

5.4.4.2 Hazardous Materials Design Scenario 2. Hazardous Materials Design Scenario 2 involves an exposure fire on a location where hazardous materials are stored, used, handled, or dispensed. This design scenario shall address the concern regarding how a fire in a facility affects the safe storage, handling, or use of hazardous materials. [1:5.4.4.2]

5.4.4.3 Hazardous Materials Design Scenario 3. Hazardous Materials Design Scenario 3 involves the application of an external factor to the hazardous material that is likely to result in a fire, explosion, toxic release, or other unsafe condition. This design scenario shall address the concern regarding the initiation of a hazardous materials event by the application of heat, shock, impact, or water onto a hazardous material being stored, used, handled, or dispensed in the facility. [1:5.4.4.3]

5.4.4.4 Hazardous Materials Design Scenario 4.

5.4.4.4.1 Hazardous Materials Design Scenario 4 involves an unauthorized discharge with each protection system independently rendered ineffective. This set of design hazardous materials scenarios shall address concern regarding each protection system or protection feature, considered individually, being unreliable or becoming unavailable. [1:5.4.4.4.1]

5.4.4.4.2* Hazardous Materials Design Scenario 4 shall not be required to be applied to protection systems or features for which both the level of reliability and the design performance in the absence of the system are acceptable to the AHJ. [1:5.4.4.4.2]

5.4.5 Required Design Scenarios — Safety During Building Use.

5.4.5.1* Building Use Design Scenario 1. Building Use Design Scenario 1 involves an event in which the maximum occupant load is in the assembly building and an emergency event occurs blocking the principal exit/entrance to the building. This design scenario shall address the concern of occupants having to take alternative exit routes under crowded conditions. [1:5.4.5.1]

5.4.5.2 Building Use Design Scenario 2. Building Use Design Scenario 2 involves a fire in an area of a building undergoing construction or demolition while the remainder of the building is occupied. The normal fire suppression system in the area undergoing construction or demolition has been taken out of service. This design scenario shall address the concern regarding the inoperability of certain building fire safety features during construction and demolition in a partially occupied building. [1:5.4.5.2]

5.5 Evaluation of Proposed Designs.

5.5.1 General.

5.5.1.1 A proposed design's performance shall be assessed relative to each performance objective in Section 4.2 and each applicable scenario in Section 5.4, with the assessment conducted through the use of appropriate calculation methods. [1:5.5.1.1]

5.5.1.2 The choice of assessment methods shall require the approval of the AHJ. [1:5.5.1.2]

5.5.2 Use. The design professional shall use the assessment methods to demonstrate that the proposed design achieves the goals and objectives, as measured by the performance criteria in light of the safety margins and uncertainty analysis, for each scenario, given the assumptions. [1:5.5.2]

5.5.3 Input Data.

5.5.3.1 Data.

5.5.3.1.1 Input data for computer fire models shall be obtained in accordance with ASTM E 1591, *Standard Guide for Data for Fire Models*. [1:5.5.3.1.1]

5.5.3.1.2 Data for use in analytical models that are not computer-based fire models shall be obtained using appropriate measurement, recording, and storage techniques to ensure the applicability of the data to the analytical method being used. [1:5.5.3.1.2]

5.5.3.2 Data Requirements. A complete listing of input data requirements for all models, engineering methods, and other calculation or verification methods required or proposed as part of the performance-based design shall be provided. [1:5.5.3.2]

5.5.3.3 Uncertainty and Conservatism of Data. Uncertainty in input data shall be analyzed and, as determined appropriate by the AHJ, addressed through the use of conservative values. [1:5.5.3.3]

5.5.4 Output Data. The assessment methods used shall accurately and appropriately produce the required output data from input data based on the design specifications, assumptions, and scenarios. [1:5.5.4]

5.5.5 Validity. Evidence shall be provided confirming that the assessment methods are valid and appropriate for the proposed facility, use, and conditions. [1:5.5.5]

5.6* Safety Factors. Approved safety factors shall be included in the design methods and calculations to reflect uncertainty in the assumptions, data, and other factors associated with the performance-based design. [1:5.6]

5.7 Documentation Requirements.

5.7.1* General.

5.7.1.1 All aspects of the design, including those described in 5.7.2 through 5.7.14, shall be documented. [1:5.7.1.1]

5.7.1.2 The format and content of the documentation shall be acceptable to the AHJ. [1:5.7.1.2]

5.7.2* Technical References and Resources.

5.7.2.1 The AHJ shall be provided with sufficient documentation to support the validity, accuracy, relevance, and precision of the proposed methods. [1:5.7.2.1]

5.7.2.2 The engineering standards, calculation methods, and other forms of scientific information provided shall be appropriate for the particular application and methodologies used. [1:5.7.2.2]

5.7.3 Facility Design Specifications. All details of the proposed facility design that affect the ability of the facility to meet the stated goals and objectives shall be documented. [1:5.7.3]

5.7.4 Performance Criteria. Performance criteria, with sources, shall be documented. [1:5.7.4]

5.7.5 Occupant Characteristics. Assumptions about occupant characteristics shall be documented. [1:5.7.5]

5.7.6 Design Scenarios. Descriptions of design hazards scenarios shall be documented. [1:5.7.6]

5.7.7 Input Data. Input data to models and assessment methods, including sensitivity analysis, shall be documented. [1:5.7.7]

5.7.8 Output Data. Output data from models and assessment methods, including sensitivity analysis, shall be documented. [1:5.7.8]

5.7.9 Safety Factors. Safety factors utilized shall be documented. [1:5.7.9]

5.7.10 Prescriptive Requirements. Retained prescriptive requirements shall be documented. [1:5.7.10]

5.7.11* Modeling Features.

5.7.11.1 Assumptions made by the model user, and descriptions of models and methods used, including known limitations, shall be documented. [1:5.7.11.1]

5.7.11.2 Documentation shall be provided that the assessment methods have been used validly and appropriately to address the design specifications, assumptions, and scenarios. [1:5.7.11.2]

5.7.12 Evidence of Modeler Capability. The design team's relevant experience with the models, test methods, databases, and other assessment methods used in the performance-based design proposal shall be documented. [1:5.7.12]

5.7.13 Performance Evaluation. The performance evaluation summary shall be documented. [1:5.7.13]

5.7.14 Use of Performance-Based Design Option. Design proposals shall include documentation that provides anyone involved in ownership or management of the facility with all of the following notification: [1:5.7.14]

- (1) The facility was approved as a performance-based design with certain specified design criteria and assumptions. [1:5.7.14(1)]
- (2) Any remodeling, modification, renovation, change in use, or change in the established assumptions requires a re-evaluation and re-approval. [1:5.7.14(2)]

Chapter 6 General Hydrogen Requirements

6.1 General.

6.1.1 Occupancies containing GH₂ or LH₂ shall comply with this chapter in addition to other applicable requirements of this code.

6.1.1.1 When specific requirements are provided in other chapters, those specific requirements shall apply.

6.1.1.2 Where there is a conflict between a general requirement and a specific requirement, the specific requirement shall be applicable.

6.1.1.3 The occupancy of a building or structure, or portion of a building or structure, [where hydrogen is stored or used,] shall be classified in accordance with the [adopted] building code. [55:6.1.1.2]

6.1.1.4 Quantities Less than or Equal to the MAQ. Building-related controls in areas with [GH₂ or LH₂] stored or used within an indoor control area in quantities less than or equal to those shown in Table 6.4.1.1 shall be in accordance with 6.4.1.5 and Sections 6.7, 6.8, 6.16, and 6.17. [55:6.2.3]

6.1.1.5 Quantities Greater than the MAQ. Building-related controls in areas with [GH₂ or LH₂] stored or used within an indoor area in quantities greater than those shown in Table 6.4.1.1 shall be in accordance with the requirements of Chapter 6. [55:6.3.1.2]

6.2 Design and Construction. Buildings, or portions thereof, shall be designed, located, and constructed in accordance with the adopted building code.

6.3 Control Areas.

6.3.1 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 [adopted] building code. [55:6.2.1]

6.3.2 Number. The number of control areas in buildings or portions of buildings shall not exceed that allowed by the [adopted] building code. [55:6.2.2]

6.4 Occupancy Classification.

6.4.1 Quantity Thresholds for GH₂ or LH₂ Requiring Special Provisions.

6.4.1.1 Threshold Exceedences. Where the quantities of [GH₂ or LH₂] stored or used within an indoor control area exceed those shown in Table 6.4.1.1, the area shall meet the requirements for [the occupancy classification] in accordance with the [adopted] building code, based on the requirements of 6.4.2. [55:6.3.1.1]

6.4.1.2 Aggregate Allowable Quantities. The aggregate quantity in use and storage shall not exceed the quantity listed for storage. [55:6.3.1.3]

6.4.1.3 Incompatible Materials. When the classification of materials in individual containers requires the area to be placed in more than one [occupancy classification], the separation of [occupancies] shall not be required providing the area is constructed to meet the requirements of the most restrictive [occupancy classification] and that the incompatible materials are separated as required by 7.2.1.1. [55:6.3.1.4]

6.4.1.4 Multiple Hazards. GH₂ blended with other gases having multiple hazards shall also comply with NFPA 55, *Compressed Gases and Cryogenic Fluids Code*.

6.4.1.5 GH₂.

6.4.1.5.1* [GH₂] shall not be stored or used in other than industrial and storage occupancies. [55:6.3.1.6.1]

6.4.1.5.2 Containers, cylinders, or tanks not exceeding 250 ft³ (7.1 m³) content at normal temperature and pressure (NTP) and used for maintenance purposes, patient care, or operation of equipment shall be permitted. [55:6.3.1.6.2]

6.4.1.5.3 Piping systems used to supply GH₂ in accordance with 7.3.1.2.1 shall be permitted.

6.4.2 Classification of Occupancy. The [occupancy classification] required shall be based on the hazard class of the material involved as indicated in 6.4.2.1. [55:6.3.2]

6.4.2.1 Occupancy Classification. Occupancies used for the storage or use of [GH₂ or LH₂] in quantities that exceed the quantity thresholds for gases requiring special provisions shall be classified [in accordance with the adopted building code]. [55:6.3.2.2]

6.5 Gas Rooms.

6.5.1 Pressure Control. Gas rooms shall operate at a negative pressure in relationship to the surrounding area. [55:6.4.1]

6.5.2 Exhaust Ventilation. Gas rooms shall be provided with an exhaust ventilation system. [55:6.4.2]

6.5.3 Construction. Gas rooms shall be constructed in accordance with the [adopted] building code. [55:6.4.3]

6.5.4 Separation. Gas rooms shall be separated from other occupancies by a minimum of 1-hour fire resistance. [55:6.4.4]

6.5.5 Limitation on Contents.

6.5.5.1 The function of compressed gas rooms shall be limited to storage and use of compressed gases and associated equipment and supplies. [55:6.4.5]

6.5.5.2 When GH₂ or LH₂ is stored and used in gas rooms it shall comply with 6.5.5.1.

6.6 Weather Protection.

6.6.1 Classification of Weather Protection as an Indoor Versus Outdoor Area.

6.6.1.1 A weather protection structure shall be permitted to be used for sheltering hydrogen in outdoor storage or use areas, without requiring these areas to be classified as indoor storage.

6.6.1.2 For such storage or use areas to be regulated as outdoor storage or use, compliance with conditions in 6.6.1.4 and 6.6.2 shall be required. [55:6.5.2.2]

Table 6.4.1.1 Maximum Allowable Quantity of Hydrogen per Control Area (Quantity Thresholds Requiring Special Provisions)

Material	Unsprinklered Areas		Sprinklered Areas	
	No Gas Cabinet, Gas Room, or Exhausted Enclosure	Gas Cabinet, Gas Room, or Exhausted Enclosure	No Gas Cabinet, Gas Room, or Exhausted Enclosure	Gas Cabinet, Gas Room, or Exhausted Enclosure
[LH ₂]*	0 gal (0 L)	45 gal (170 L)	45 gal (170 L)	45 gal (170 L) [†]
[GH ₂]*	1000 ft ³ (28 m ³)	2000 ft ³ (56 m ³)	2000 ft ³ (56 m ³)	4000 ft ³ (112 m ³)

Note: The maximum quantity indicated is the aggregate quantity of materials in storage and use combined.

[†]A gas cabinet or exhausted enclosure is required. Pressure relief devices or stationary or portable containers shall be vented directly outdoors or to an exhaust hood. (See 8.1.4.6.)

*This material is extracted from rows 2 and 3 of Table 6.3.1.1 of NFPA 55, *Compressed Gases and Cryogenic Fluids Code*.

6.6.1.3 Where storage or use areas are provided with weather protection that does not comply with these conditions, the storage or use area shall be regulated as an indoor storage or use area. [55:6.5.2.3]

6.6.1.4 Supports and walls shall not obstruct more than one side or more than 25 percent of the perimeter of the storage or use area. [55:6.5.3]

6.6.2 Structure Separation Distances.

6.6.2.1 The distance from the structure and the structural supports to buildings, lot lines, public ways or means of egress to a public way shall not be less than the distance required for an outside hazardous material storage or use area without weather protection. [55:6.5.4.1]

6.6.2.2 Where the weather protection structure is constructed of noncombustible materials, reductions in the separation distance shall be permitted based on the use of fire barrier walls where permitted for specific materials in accordance with the requirements of Chapters 7 and 8. [55:6.5.4.2]

6.7* Electrical Equipment. Electrical wiring and equipment shall be in accordance with Section 6.7 and *NFPA 70, National Electrical Code*. [55:6.6]

6.7.1 Standby Power.

6.7.1.1 Where the following systems are required by this code for the storage or use of [GH₂ or LH₂] 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*. [55:6.6.1.1]

- (1) Mechanical ventilation [55:6.6.1.1(1)]
- (2) Treatment systems [55:6.6.1.1(2)]
- (3) Temperature controls [55:6.6.1.1(3)]
- (4) Alarms [55:6.6.1.1(4)]
- (5) Detection systems [55:6.6.1.1(5)]
- (6) Other electrically operated systems [55:6.6.1.1(6)]

6.7.1.2 The requirements of 6.7.1.1 shall not apply where emergency power is provided in accordance with *NFPA 70, National Electrical Code*. [55:6.6.1.2]

6.7.2 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*. [55:6.6.2]

6.8* Employee Alarm System. Where required by government regulations, an employee alarm system shall be provided to allow warning for necessary emergency action as called for in the emergency action plan required by 4.6.1.1, or for reaction time for safe egress of employees from the workplace or the immediate work area, or both. [55:6.7]

6.9* Explosion Control.

6.9.1 Explosion control shall be provided where the quantity of GH₂ or LH₂ in storage or use exceed the quantity thresholds requiring special provisions as listed in Table 6.4.1.1 or where otherwise required.

6.9.2 When explosion control is required, it shall be provided by one or both of the following methods:

- (1) Explosion prevention in accordance with 6.9.3
- (2) Deflagration venting in accordance with 6.9.4

6.9.3* Explosion Prevention. When provided, explosion prevention shall be in accordance with one or more of the methods specified in *NFPA 69, Standard on Explosion Prevention Systems*.

6.9.4* Deflagration Venting. When provided, explosion protection by the use of deflagration venting shall be in accordance with *NFPA 68, Standard on Explosion Protection by Deflagration Venting*.

6.10 Fire Protection Systems. Buildings, or portions thereof, required to comply with the requirements for hazardous occupancies shall be protected by an approved automatic fire sprinkler system complying with *NFPA 13, Standard for the Installation of Sprinkler Systems*.

6.10.1 Sprinkler System Design. When sprinkler protection is provided, the area in which [GH₂ or LH₂] is stored or used shall be protected with a sprinkler system designed to be not less than that required by *NFPA 13, Standard for the Installation of Sprinkler Systems*, for Extra Hazard Group 1 with a minimum design area of 2500 ft² (232.25 m²). [55:6.9.2.2]

6.11 Fire Alarm Systems.

6.11.1 A manual fire alarm system shall be provided.

6.11.2 The system shall be designed, installed, and maintained in accordance with *NFPA 72, National Fire Alarm and Signaling Code*.

6.12 GH₂ Detection Systems.

6.12.1 Gas detection equipment shall be listed or approved.

6.12.2 Where GH₂ detection systems are installed, they shall be designed, installed, tested, inspected, calibrated, and maintained in accordance with the following:

- (1) Manufacturer's requirements
- (2) Equipment listing requirements

6.12.2.1 Maintenance, inspection, calibration, and testing shall be conducted by trained personnel.

6.12.2.1.1* Testing shall be conducted at least annually.

6.12.2.1.2 Maintenance, inspection, calibration, and testing records shall be retained for a minimum of 3 years.

6.13* Lighting. Approved lighting by natural or artificial means shall be provided [for the storage areas]. [55:6.10]

6.14 Spill Control, Drainage, and Secondary Containment.

6.14.1 GH₂. Spill control, drainage, and secondary containment shall not be required for [GH₂]. [55:6.12]

6.14.2 LH₂. Diking shall not be used to contain an [LH₂] spill. [55:11.3.1.2]

6.15 Shelving.

6.15.1 Shelves used for the storage of cylinders, containers, and tanks shall be of noncombustible construction and designed to support the weight of the materials stored. [55:6.13.1]

6.15.2 In seismically active areas, shelves and containers shall be secured from overturning. [55:6.13.2]

6.16* Vent Pipe Termination. Hydrogen venting systems discharging to the atmosphere shall be in accordance with *CGA G-5.5, Hydrogen Vent Systems*. [55:10.2.2]

6.17* Ventilation. Indoor storage and use areas and storage buildings for [GH₂ and LH₂] shall be provided with mechanical exhaust ventilation or natural ventilation, where natural

ventilation can be shown to be acceptable for [GH₂ or LH₂]. [55:6.15]

6.17.1 Mechanical Exhaust Ventilation.

6.17.1.1 Mechanical Ventilation Rate. Mechanical ventilation shall be at a rate of not less than 1 ft³/min/ft² (0.3048 m³/min/m²) of floor area over the area of storage or use. [55:6.15.3]

6.17.1.2 Continuous Operation. Systems shall operate continuously unless an alternate design is approved by the AHJ. [55:6.15.4]

6.17.1.3 Shutoff Controls. Where powered ventilation is provided, a manual shutoff switch shall be provided outside of the room in a position adjacent to the principal access door to the room or in an approved location. [55:6.15.5]

6.17.1.4 Manual Shutoff Switch. The switch shall be the break-glass or equivalent type and shall be labeled as follows:

WARNING:

VENTILATION SYSTEM EMERGENCY SHUTOFF

[55:6.15.6]

6.17.1.5 Inlets to the Exhaust System.

6.17.1.5.1 The exhaust ventilation system design shall take into account the density of the potential gases released. [55:6.15.7.1]

6.17.1.5.2 For gases that are lighter than air, exhaust shall be taken from a point within 12 in. (304.8 mm) of the ceiling. [55:6.15.7.3]

6.17.1.5.3* For gases that are heavier than air, exhaust shall be taken from a point within 12 in. (304.8 mm) of the floor. [55:6.15.7.2]

6.17.1.6 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. [55:6.15.8]

6.17.1.7 Recirculation of Exhaust. Exhaust ventilation shall not be recirculated within the room or building [-]. [55:6.15.9]

6.17.1.8 Ventilation Discharge. Ventilation systems shall discharge a minimum of 50 ft (15 m) from intakes of air-handling systems, air-conditioning equipment, and air compressors. [55:6.15.10]

6.17.1.9 Air Intakes. Storage and use of [GH₂ or LH₂] shall be located not less than 50 ft (15 m) from air intakes. [55:6.15.11]

6.17.2 Natural Ventilation. (Reserved)

6.18 Gas Cabinets. Where a gas cabinet is required, is used to provide separation of gas hazards, or is used to increase the threshold quantity for a gas requiring special provisions, the gas cabinet shall be in accordance with the requirements of 6.18.1 through 6.18.4. [55:6.16]

6.18.1 Construction.

6.18.1.1 Materials of Construction. The gas cabinet shall be constructed of not less than 0.097 in. (2.46 mm) (12 gauge) steel. [55:6.16.1.1]

6.18.1.2 Access to Controls. The gas cabinet shall be provided with self-closing limited access ports or noncombustible windows to give access to equipment controls. [55:6.16.1.2]

6.18.1.3 Self-Closing Doors. The gas cabinet shall be provided with self-closing doors. [55:6.16.1.3]

6.18.2 Ventilation Requirements. The gas cabinet shall be provided with an exhaust ventilation system designed to operate at a negative pressure relative to the surrounding area. [55:6.16.2.1]

6.18.3 Quantity Limits. Gas cabinets shall contain not more than three containers, cylinders, or tanks. [55:6.16.4]

6.18.4 Separation of Incompatibles. Incompatible gases, as defined by Table 7.2.1.1.1, shall be stored or used within separate gas cabinets. [55:6.16.5]

6.19 Exhausted Enclosures.

6.19.1 Ventilation Requirements. Where an exhausted enclosure is required or used to increase the threshold quantity for a gas requiring special provisions, the exhausted enclosure shall be provided with an exhaust ventilation system designed to operate at a negative pressure in relationship to the surrounding area. [55:6.17.1]

6.19.2 Separation of Incompatible Gases within Enclosures.

6.19.2.1 Cylinders, containers, and tanks within enclosures shall be separated in accordance with Table 7.2.1.1.1. [55:6.17.1.2]

6.19.2.2 Incompatible gases, as defined by Table 7.2.1.1.1, shall be stored or used within separate exhausted enclosures. [55:6.17.2]

6.19.3 Fire Protection. Exhausted enclosures shall be internally sprinklered. [55:6.17.1.3]

6.20* Source Valve. Bulk gas systems shall be provided with a source valve. [55:6.18]

6.20.1 The source valve shall be marked. [55:6.18.1]

6.20.2 The source valve shall be designated on the design drawings for the installation. [55:6.18.2]

Chapter 7 Gaseous Hydrogen

7.1 General.

7.1.1 The storage, use, and handling of GH₂ shall comply with this chapter in addition to other applicable requirements of this code.

7.1.1.1 Where specific requirements are provided in other chapters, those specific requirements shall apply.

7.1.1.2 Where there is a conflict between a general requirement and a specific requirement, the specific requirement shall be applicable.

7.1.1.3 The occupancy of a building or structure, or portion thereof, where hydrogen is stored or used shall be classified in accordance with the adopted building code.

7.1.2* GH₂ Systems.

7.1.2.1 [System] Design. [GH₂] systems shall be designed for the intended use and shall be designed by persons competent in such design. [55:7.1.1.1]

7.1.2.2 Installation. Installation of bulk [GH₂] systems shall be supervised by personnel knowledgeable in the application of the standards for their construction and use. [55:7.1.1.2]



7.1.2.3 Controls.

7.1.2.3.1 [GH₂] system controls shall be designed to prevent materials from entering or leaving the process at an unintended time, rate, or path. [55:7.3.1.2.1]

7.1.2.3.2 Automatic controls shall be designed to be fail-safe. [55:7.3.1.2.2]

7.1.3 Listed and Approved Hydrogen Equipment. Listed and approved hydrogen generating and consuming equipment shall be in accordance with the listing requirements and manufacturers' instructions. [55:7.1.3.1]

7.1.4* Metal Hydride Storage Systems.

7.1.4.1 General.

7.1.4.1.1 The storage and use of metal hydride storage systems shall be in accordance with 7.1.4. [55:7.1.4.1.1]

7.1.4.1.2 Metal Hydride Systems Storing or Supplying GH₂. Those portions of the system that are used as a means to store or supply GH₂ shall also comply with Sections 7.2 or 7.3 as applicable. [55:7.1.4.1.2]

7.1.4.1.3 Classification. The hazard classification of the metal hydride storage system shall be based on the GH₂ stored with-out regard to the metal hydride content.

7.1.4.1.4* Listed or Approved Systems. Metal hydride storage systems shall be listed or approved for the application and designed in a manner that prevents the addition or removal of the metal hydride by other than the original equipment manufacturer. [55:7.1.4.1.4]

7.1.4.1.5 Design and Construction of Containers. [GH₂] containers, cylinders, and tanks shall be designed and constructed in accordance with 7.1.5.1. [55:7.1.4.1.5]

7.1.4.1.6 Service Life and Inspection of Containers. Metal hydride storage system cylinders, containers, or tanks shall be inspected, tested, and requalified for service at not less than 5-year intervals. [55:7.1.4.1.6]

7.1.4.1.7 Marking and Labeling. Marking and labeling of cylinders, containers, tanks, and systems shall be in accordance with 7.1.5 and the requirements in 7.1.4.1.7.1 through 7.1.4.1.7.4. [55:7.1.4.1.7]

7.1.4.1.7.1 System Marking. Metal hydride storage systems shall be marked with the following: [55:7.1.4.1.7.1]

- (1) Manufacturer's name [55:7.1.4.1.7.1(1)]
- (2) Service life indicating the last date the system can be used [55:7.1.4.1.7.1(2)]
- (3) Unique code or serial number specific to the unit [55:7.1.4.1.7.1(3)]
- (4) System name or product code that identifies the system by the type of chemistry used in the system [55:7.1.4.1.7.1(4)]
- (5) Emergency contact name, telephone number, or other contact information [55:7.1.4.1.7.1(5)]
- (6) Limitations on refilling of containers to include rated charging pressure and capacity [55:7.1.4.1.7.1(6)]

7.1.4.1.7.2 Valve Marking. Metal hydride storage system valves shall be marked with the following: [55:7.1.4.1.7.2]

- (1) Manufacturer's name [55:7.1.4.1.7.2(1)]
- (2) Service life indicating the last date the valve can be used [55:7.1.4.1.7.2(2)]

- (3) Metal hydride service in which the valve can be used or a product code that is traceable to this information [55:7.1.4.1.7.2(3)]

7.1.4.1.7.3 Pressure Relief Device Marking.

(A) Metal hydride storage system pressure relief devices shall be marked with the following: [55:7.1.4.1.7.3]

- (1) Manufacturer's name [55:7.1.4.1.7.3(1)]
- (2) Metal hydride service in which the device can be used or a product code that is traceable to this information [55:7.1.4.1.7.3(2)]
- (3) Activation parameters to include temperature, pressure, or both [55:7.1.4.1.7.3(3)]

(B) The required markings for pressure relief devices that are integral components of valves used on cylinders, containers, and tanks shall be allowed to be placed on the valve. [55:7.1.4.1.7.3(A)]

7.1.4.1.7.4 Pressure Vessel Markings. Cylinders, containers, and tanks used in metal hydride storage systems shall be marked with the following: [55:7.1.4.1.7.4]

- (1) Manufacturer's name [55:7.1.4.1.7.4(1)]
- (2) Design specification to which the vessel was manufactured [55:7.1.4.1.7.4(2)]
- (3) Authorized body approving the design and initial inspection and test of the vessel [55:7.1.4.1.7.4(3)]
- (4) Manufacturer's original test date [55:7.1.4.1.7.4(4)]
- (5) Unique serial number for the vessel [55:7.1.4.1.7.4(5)]
- (6) Service life identifying the last date the vessel can be used [55:7.1.4.1.7.4(6)]
- (7) System name or product code that identifies the system by the type of chemistry used in the system [55:7.1.4.1.7.4(7)]

7.1.4.1.8 Temperature Extremes. Metal hydride storage systems, whether full or partially full, shall not be exposed to artificially created high temperatures exceeding 125°F (52°C) or subambient (low) temperatures unless designed for use under the exposed conditions. [55:7.1.4.1.8]

7.1.4.1.9 Falling Objects. Metal hydride storage systems shall not be placed in areas where they are capable of being damaged by falling objects. [55:7.1.4.1.9]

7.1.4.1.10 Refilling of Containers. The refilling of listed or approved metal hydride storage systems shall be in accordance with the listing requirements and manufacturers' instructions. [55:7.1.4.1.11]

7.1.4.1.10.1 Industrial Trucks. The refilling of metal hydride storage systems serving powered industrial trucks shall be in accordance with NFPA 52, *Vehicular Fuel Systems Code*. [55:7.1.4.1.11.1]

7.1.4.1.10.2 Hydrogen Purity. The purity of [GH₂] used for the purpose of refilling containers shall be in accordance with the listing and the manufacturers' instructions. [55:7.1.4.1.11.2]

7.1.4.1.11 Electrical. Electrical components for metal hydride storage systems shall be designed, constructed, and installed in accordance with NFPA 70, *National Electrical Code*. [55:7.1.4.1.12]

7.1.4.2 Portable Containers or Systems.

7.1.4.2.1 Securing Containers. Containers, cylinders, and tanks shall be secured in accordance with 7.1.7.4. [55:7.1.4.2.1]

7.1.4.2.1.1 Use on Mobile Equipment. Where a metal hydride storage system is used on mobile equipment, the equipment shall be designed to restrain containers, cylinders, or tanks from dislodgement, slipping, or rotating when the equipment is in motion. [55:7.1.4.2.1.1]

7.1.4.2.1.2 Motorized Equipment.

(A) Metal hydride storage systems used on motorized equipment shall be installed in a manner that protects valves, pressure regulators, fittings, and controls against accidental impact. [55:7.1.4.2.1.2]

(B) Metal hydride storage systems, including cylinders, containers, tanks, and fittings, shall not extend beyond the platform of the mobile equipment. [55:7.1.4.2.1.2(A)]

7.1.4.2.2 Valves. Valves on containers, cylinders, and tanks shall remain closed except when containers are connected to closed systems and ready for use. [55:7.1.4.2.2]

7.1.5 Containers, Cylinders, and Tanks.

7.1.5.1 Design and Construction. Containers, cylinders, and tanks shall be designed, fabricated, tested, and marked (stamped) in accordance with regulations of DOT, Transport Canada (TC) *Transportation of Dangerous Goods Regulations*, or the ASME *Boiler and Pressure Vessel Code*, "Rules for the Construction of Unfired Pressure Vessels," Section VIII. [55:7.1.5.1]

7.1.5.2 Defective Containers, Cylinders, and Tanks.

7.1.5.2.1 Defective containers, cylinders, and tanks shall be returned to the supplier. [55:7.1.5.2.1]

7.1.5.2.2 Suppliers shall either repair the containers, cylinders, and tanks, remove them from service, or dispose of them in an approved manner. [55:7.1.5.2.2]

7.1.5.3 Supports. Stationary cylinders, containers, and tanks shall be provided with engineered supports of noncombustible material on noncombustible foundations. [55:7.1.5.3]

7.1.5.4 Containers, Cylinders, and Tanks Containing Residual Gas. [GH₂] 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. [55:7.1.5.4]

7.1.5.5 Pressure-Relief Devices.

7.1.5.5.1 When required by 7.1.5.5.2, pressure relief devices shall be provided to protect containers and systems containing [GH₂] from rupture in the event of overpressure from thermal exposure. [55:7.1.5.5.1]

7.1.5.5.2 Pressure relief devices to protect containers shall be designed and provided in accordance with CGAS-1.1, *Pressure Relief Device Standards — Part 1 — Cylinders for Compressed Gases*, for cylinders; CGAS-1.2, *Pressure Relief Device Standards — Part 2 — Cargo and Portable Tanks for Compressed Gases*, for portable tanks; and CGAS-1.3, *Pressure Relief Device Standards — Part 3 — Stationary Storage Containers for Compressed Gases*, for stationary tanks or in accordance with applicable equivalent requirements in the country of use. [55:7.1.5.5.2]

7.1.5.5.3 Pressure relief devices shall be sized in accordance with the specifications to which the container was fabricated. [55:7.1.5.5.3]

7.1.5.5.4 The pressure relief device shall have the capacity to prevent the maximum design pressure of the container or system from being exceeded. [55:7.1.5.5.4]

7.1.5.5.5 Pressure relief devices shall be arranged to discharge unobstructed to the open air in such a manner as to prevent any impingement of escaping gas upon the container, adjacent structures, or personnel. This requirement shall not apply to DOT specification containers having an internal volume of 2.0 ft³ (0.057 m³) or less. [55:7.1.5.5.5]

7.1.5.5.6 Pressure relief devices or vent piping shall be designed or located so that moisture cannot collect and freeze in a manner that would interfere with operation of the device. [55:7.1.5.5.6]

7.1.6 Labeling Requirements.

7.1.6.1 Containers. Individual [GH₂] containers, cylinders, and tanks shall be marked or labeled in accordance with DOT requirements or those of the applicable regulatory agency. [55:7.1.7.1]

7.1.6.2 Label Maintenance. The labels applied by the gas manufacturer to identify the [GH₂] cylinder contents shall not be altered or removed by the user. [55:7.1.7.2]

7.1.6.3 Stationary GH₂ Containers, Cylinders, and Tanks.

7.1.6.3.1 Stationary [GH₂] 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*. [55:7.1.7.3.1]

7.1.6.3.2 Markings shall be visible from any direction of approach. [55:7.1.7.3.2]

7.1.6.4 Piping Systems.

7.1.6.4.1 Except as provided in 7.1.6.4.2, piping systems shall be marked in accordance with ASME A13.1, *Scheme for the Identification of Piping Systems*, or other applicable approved [codes and] standards as follows: [55:7.1.7.4.1]

- (1) Marking shall include the name of the gas and a direction-of-flow arrow. [55:7.1.7.4.1(1)]
- (2) Piping that is used to convey more than one gas at various times shall be marked to provide clear identification and warning of the hazard. [55:7.1.7.4.1(2)]
- (3) Markings for piping systems shall be provided at the following locations: [55:7.1.7.4.1(3)]
 - (a) At each critical process control valve [55:7.1.7.4.1(3)(a)]
 - (b) At wall, floor, or ceiling penetrations [55:7.1.7.4.1(3)(b)]
 - (c) At each change of direction [55:7.1.7.4.1(3)(c)]
 - (d) At a minimum of every 20 ft (6.1 m) or fraction thereof throughout the piping run [55:7.1.7.4.1(3)(d)]

7.1.6.4.2 Piping within gas manufacturing plants, gas processing plants, refineries, and similar occupancies shall be marked in an approved manner. [55:7.1.7.4.2]

7.1.7 Security.

7.1.7.1 General. [GH₂] containers, cylinders, tanks, and systems shall be secured against accidental dislodgement and against access by unauthorized personnel. [55:7.1.8.1]

7.1.7.2 Security of Areas. Storage, use, and handling areas shall be secured against unauthorized entry. [55:7.1.8.2]

7.1.7.3 Physical Protection.

7.1.7.3.1 [GH₂] containers, cylinders, tanks, and systems that could be exposed to physical damage shall be protected. [55:7.1.8.3.1]



7.1.7.3.2 Guard posts or other means shall be provided to protect [GH₂] containers, cylinders, tanks, and systems indoors and outdoors from vehicular damage. (See Section 4.14.) [55:7.1.8.3.2]

7.1.7.3.3 Where guard posts are installed, they shall be in accordance with 4.14.1.2.

7.1.7.4 Securing GH₂ Containers, Cylinders, and Tanks. [GH₂] containers, cylinders, and tanks in use or in storage shall be secured to prevent them from falling or being knocked over by corraling them and securing them to a cart, framework, or fixed object by use of a restraint, unless otherwise permitted by 7.1.7.4.1 and 7.1.7.4.2. [55:7.1.8.4]

7.1.7.4.1 [GH₂] containers, cylinders, and tanks in the process of examination, servicing, and refilling shall not be required to be secured. [55:7.1.8.4.1]

7.1.7.4.2 At cylinder-filling plants and distributors' warehouses, the nesting of cylinders shall be permitted as a means to secure cylinders. [55:7.1.8.4.2]

7.1.8 Valve Protection.

7.1.8.1* General. [GH₂] container, cylinder, and tank valves shall be protected from physical damage by means of protective caps, collars, or similar devices. [55:7.1.9.1]

7.1.8.2 Valve-Protective Caps. Where [GH₂] containers, cylinders, and tanks are designed to accept valve-protective caps, the user shall keep such caps on the [GH₂] containers, cylinders, and tanks at all times, except when empty, being processed, or connected for use. [55:7.1.9.2]

7.1.9 Separation from Hazardous Conditions.

7.1.9.1 General. [GH₂] 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. [55:7.1.10.1.1]

7.1.9.1.1* Clearance from Combustibles and Vegetation. Combustible waste, vegetation, and similar materials shall be kept a minimum of 10 ft (3 m) from [GH₂] containers, cylinders, tanks, and systems. [55:7.1.10.3]

7.1.9.1.1.1 A noncombustible partition without openings or penetrations and extending not less than 18 in. (457 mm) above and to the sides of the storage area shall be permitted in lieu of the minimum distance. [55:7.1.10.3.1]

7.1.9.1.1.2 The noncombustible partition shall either be an independent structure or the exterior wall of the building adjacent to the storage area. [55:7.1.10.3.2]

7.1.9.1.2 Ledges, Platforms, and Elevators. [GH₂] containers, cylinders, and tanks shall not be placed near elevators, unprotected platform ledges, or other areas where [GH₂] containers, cylinders, or tanks could fall distances exceeding one-half the height of the container, cylinder, or tank. [55:7.1.10.4]

7.1.9.1.3* Temperature Extremes. [GH₂] containers, cylinders, and tanks, whether full or partially full, shall not be exposed to temperatures exceeding 125°F (52°C) or subambient (low) temperatures unless designed for use under such exposure. [55:7.1.10.5]

7.1.9.1.4 Falling Objects. [GH₂] containers, cylinders, and tanks shall not be placed in areas where they are capable of being damaged by falling objects. [55:7.1.10.6]

7.1.9.1.5 Heating. [GH₂] 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 125°F (52°C). [55:7.1.10.7]

7.1.9.1.5.1 Electrically Powered Heating Devices. Electrical heating devices shall be in accordance with NFPA 70, *National Electrical Code*. [55:7.1.10.7.1]

7.1.9.1.5.2 Fail-Safe Design. Devices designed to maintain individual [GH₂] containers, cylinders, or tanks at constant temperature shall be designed to be fail-safe. [55:7.1.10.7.2]

7.1.9.1.6 Sources of Ignition. Open flames and high-temperature devices shall not be used in a manner that creates a hazardous condition. [55:7.1.10.8]

7.1.9.1.7 Exposure to Chemicals. [GH₂] containers, cylinders, and tanks shall not be exposed to corrosive chemicals or fumes that could damage containers, cylinders, tanks, or valve-protective caps. [55:7.1.10.9]

7.1.9.1.8 Exposure to Electrical Circuits. [GH₂] containers, cylinders, and tanks shall not be placed where they could become a part of an electrical circuit. [55:7.1.10.10]

7.1.10 Service and Repair. Service, repair, modification, or removal of valves, pressure relief devices, or other [GH₂] container, cylinder, or tank appurtenances shall be performed by trained personnel and with the permission of the container owner. [55:7.1.11]

7.1.11 Unauthorized Use. [GH₂] 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. [55:7.1.12]

7.1.12 Containers, Cylinders, and Tanks Exposed to Fire. [GH₂] 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. [55:7.1.13]

7.1.13 Leaks, Damage, or Corrosion.

7.1.13.1* Removal From Service. Leaking, damaged, or corroded [GH₂] containers, cylinders, and tanks shall be removed from service. [55:7.1.14.1]

7.1.13.2 Replacement and Repair. Leaking, damaged, or corroded [GH₂] systems shall be replaced or repaired. [55:7.1.14.2]

7.1.13.3* Handling of Containers, Cylinders, and Tanks Removed from Service. [GH₂] containers, cylinders, and tanks that have been removed from service shall be handled in an approved manner. [55:7.1.14.3]

7.1.14 Surfaces.

7.1.14.1 To prevent bottom corrosion, containers, cylinders, and tanks shall be protected from direct contact with soil or surfaces where water might accumulate. [55:7.1.15.1]

7.1.14.2 Surfaces shall be graded to prevent accumulation of water. [55:7.1.15.2]

7.1.15 Piping.

7.1.15.1 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. [55:7.3.1.3]

7.1.15.1.1 Integrity. Piping, tubing, pressure regulators, valves, and other apparatus shall be kept gastight to prevent leakage. [55:7.3.1.3.1]

7.1.15.1.2 Backflow Prevention. Backflow prevention or check valves shall be provided where the backflow of hazardous materials could create a hazardous condition or cause the unauthorized discharge of hazardous materials. [55:7.3.1.3.2]

7.1.15.2 Aboveground Piping. (Reserved)

7.1.15.3 Underground Piping.

7.1.15.3.1 Underground piping shall be of welded construction without valves, unwelded mechanical joints, or connections installed underground. [55:7.1.17.1]

7.1.15.3.1.1 Valves or connections located in boxes or enclosures shall be permitted to be installed underground when such boxes or enclosures are accessible from above ground and where the valves or connections contained are isolated from direct contact with earth or fill. [55:7.1.17.1.1]

7.1.15.3.1.2 Valve boxes or enclosures installed in areas subject to vehicular traffic shall be constructed to resist uniformly distributed and concentrated live loads in accordance with the [adopted] building code for areas designated as vehicular driveways and yards, subject to trucking. [55:7.1.17.1.1.1]

7.1.15.3.1.3* Piping installed in trench systems located below grade where the trench is open to above shall not be considered to be underground. [55:7.1.17.1.2]

7.1.15.3.2 Contact with Earth.

7.1.15.3.2.1 Gas piping in contact with earth or other material that could corrode the piping shall be protected against corrosion in an approved manner. [55:7.1.17.2]

7.1.15.3.2.2 When cathodic protection is provided, it shall be in accordance with 7.1.18. [55:7.1.17.2.1]

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

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

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

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

7.1.15.3.7 In areas not subject to vehicle traffic, the pipe trench shall be deep enough to permit a cover of at least 12 in. (300 mm) of well-compacted backfill material. [55:7.1.17.7]

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

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

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

7.1.15.3.11 "As-built" drawings of the underground piping installation shall be maintained by the owner and shall be available upon request by the AHJ.

7.1.16 Valves.

7.1.16.1 Valves utilized on [GH₂] systems shall be designed for the gas or gases and pressure intended and shall be accessible. [55:7.3.1.4.1]

7.1.16.2 Valve handles or operators for required shutoff valves shall not be removed or otherwise altered to prevent access. [55:7.3.1.4.2]

7.1.17 Vent Pipe Termination.

7.1.17.1 Venting of [GH₂] shall be directed to an approved location. [55:7.3.1.5.1]

7.1.17.2 The termination point for piped vent systems serving cylinders, containers, tanks, and gas systems used for the purpose of operational or emergency venting shall be in accordance with Section 6.16. [55:7.3.1.5.2]

7.1.18 Cathodic Protection. Where required, cathodic protection shall be in accordance with 7.1.18. [55:7.1.6]

7.1.18.1 Operation. Where installed, cathodic protection systems shall be operated and maintained to continuously provide corrosion protection. [55:7.1.6.1]

7.1.18.2 Inspection. Container systems equipped with cathodic protection shall be inspected for [proper] operation by a cathodic protection tester. The frequency of inspection shall be determined by the designer of the cathodic protection system. [55:7.1.6.2]

7.1.18.2.1 The cathodic protection tester shall be certified as being qualified by the National Association of Corrosion Engineers, International (NACE). [55:7.1.6.2.1]

7.1.18.3 Impressed Current Systems. Systems equipped with impressed current cathodic protection systems shall be inspected in accordance with the requirements of the design and 7.1.18.2. The design limits shall be available to the AHJ upon request. [55:7.1.6.3]

7.1.18.3.1 The system owner shall maintain the following records to demonstrate that the cathodic protection is in conformance with the requirements of the design: [55:7.1.6.3.1]

- (1) The results of inspections of the system [55:7.1.6.3.1(1)]
- (2) The results of testing that has been completed [55:7.1.6.3.1(2)]

7.1.18.4 Corrosion Expert. Repairs, maintenance, or replacement of a cathodic protection system shall be under the supervision of a corrosion expert certified by NACE. [55:7.1.6.4]

7.1.18.4.1 The corrosion expert shall be certified by NACE as a senior corrosion technologist, a cathodic protection specialist, or a corrosion specialist or shall be a registered engineer with registration in a field that includes education and experience in corrosion control. [55:7.1.6.4.1]

7.1.19 Transfer. Transfer of [GH₂] 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*. [55:7.3.1.9]

7.1.20 Use of GH₂ for Inflation. Inflatable equipment, devices, or balloons shall not be pressurized or filled with GH₂.

7.1.21 Emergency Shutoff Valves.

7.1.21.1 Accessible manual or automatic emergency shutoff valves shall be provided to shut off the GH₂ in case of emergency.

7.1.21.1.1 Emergency shutoff valves on a bulk source or piping systems serving the bulk supply shall be identified by means of a sign.

7.1.21.2 Emergency shutoffs shall be located at the point of use and at the tank, cylinder, or bulk source [and at the point where the system piping enters the building]. [55:7.3.1.11.2]

7.1.22 Excess Flow Control.

7.1.22.1 Where [GH₂] is carried in pressurized piping above a gauge pressure of 15 psi (103 kPa), an approved means of leak detection and emergency shutoff or excess flow control shall be provided. [55:7.3.1.12.1]

7.1.22.1.1 Excess Flow Control Location with Hazardous Material Storage. Where the piping originates from within a hazardous material storage room or area, the excess flow control shall be located within the storage room or area. [55:7.3.1.12.1.1]

7.1.22.1.2 Excess Flow Control Location with Bulk Storage. Where the piping originates from a bulk source, the excess flow control shall be located at the bulk source. [55:7.3.1.12.1.2]

7.1.22.1.3 Location. The location of excess flow control shall be as specified in 7.1.22.1.1 and 7.1.22.2. [55:7.3.1.12.3]

7.1.22.1.3.1 Where piping originates from a source located in a room or area, the excess flow control shall be located within the room or area. [55:7.3.1.12.3.1]

7.1.22.1.3.2 Where piping originates from a bulk source, the excess flow control shall be as close to the bulk source as possible. [55:7.3.1.12.3.2]

7.1.22.1.4 Location Exemptions. The requirements of 7.1.22.1 shall not apply to the following:

- (1) Piping for inlet connections designed to prevent backflow
- (2) Piping for pressure-relief devices
- (3) Systems containing 400 scf (12.7 m³) or less of [GH₂] [55:7.3.1.12.4]

7.1.22.2* The controls required by 7.1.22 shall not be required for the following: [55:7.3.1.12.2]

- (1) Piping for inlet connections designed to prevent backflow at the source [55:7.3.1.12.2(1)]
- (2) Piping for pressure relief devices [55:7.3.1.12.2(2)]
- (3) Where the source of the gas is not in excess of the quantity threshold indicated in Table 6.4.1.1 [55:7.3.1.12.2(3)]

7.1.23 Ignition Source Control. Ignition sources in areas containing [GH₂] shall be in accordance with 7.1.23. [55:7.6.3]

7.1.23.1 Static Producing Equipment. Static producing equipment located in [GH₂] areas shall be grounded. [55:7.6.3.1]

7.1.23.2 No Smoking or Open Flame. Signs shall be posted in areas containing [GH₂] stating that smoking or the use of open flame, or both, is prohibited within 25 ft (7.6 m) of the storage or use area perimeter. [55:7.6.3.2]

7.2* Nonbulk GH₂.

7.2.1 Nonbulk GH₂ General. (Reserved)

7.2.1.1 Incompatible Materials. [GH₂] containers, cylinders, and tanks shall be separated in accordance with Table 7.2.1.1.1. [55:7.1.10.2]

7.2.1.1.1 Bulk GH₂ systems in outdoor storage or use shall be separated from other compressed gases in accordance with Table 7.3.2.3.1.2(a) or Table 7.3.2.3.1.2(b).

Table 7.2.1.1.1 Separation of Gas Containers, Cylinders, and Tanks by Hazard Class [from Nonbulk GH₂ Cylinders, Containers, Tanks, and Systems]

Gas Category	GH ₂ ^a	
	ft	m
Toxic or highly toxic	20	6.1
Pyrophoric	20	6.1
Flammable	—	—
Oxidizing	20	6.1
Corrosive	20	6.1
Unstable reactive Class 2, Class 3, or Class 4	20	6.1
Other gas	NR	NR

NR: No separation required.

[55:7.1.10.2]

^aExtract of flammable gas column from Table 7.1.10.2 of NFPA 55, *Compressed Gases and Cryogenic Fluids Code*.

7.2.1.1.2 The distances shown in Table 7.2.1.1.1 shall be permitted to be reduced without limit [when GH₂] cylinders, tanks, and containers are separated by a barrier of noncombustible construction that has a fire resistance rating of at least 0.5 hour and interrupts the line of sight between the containers. [55:7.1.10.2.1]

7.2.1.1.3 The 20 ft (6.1 m) distance shall be permitted to be reduced to 5 ft (1.5 m) where one of the gases is enclosed in a gas cabinet or without limit where both gases are enclosed in gas cabinets. [55:7.1.10.2.2]

7.2.1.1.4 Cylinders without pressure-relief devices shall not be stored without separation from flammable and pyrophoric gases with pressure-relief devices. [55:7.1.10.2.3]

7.2.1.1.5 Spatial separation shall not be required between cylinders deemed to be incompatible that are connected to manifolds for the purposes of filling and manufacturing procedures, assuming the prescribed controls for the manufacture of gas mixtures are in place. [55:7.1.10.2.4]

7.2.2 Nonbulk GH₂ Storage.

7.2.2.1 General.

7.2.2.1.1 Applicability. The storage of [GH₂] exceeding the quantity thresholds for gases requiring special provisions as specified in Table 6.4.1.1 shall be in accordance with Chapters 1 through 6 [as applicable] and Sections 7.1 through 7.3. [55:7.6.1.1]

7.2.2.1.2 Classification of Weather Protection as an Indoor Versus Outdoor Area. For other than explosive materials and hazardous materials presenting a detonation hazard, a weather

protection structure shall be permitted to be used for sheltering outdoor storage or use areas without requiring such areas to be classified as indoor storage. [55:7.2.1.3]

7.2.2.2 Indoor Storage. Indoor storage of [GH₂] shall be in accordance with the [applicable] provisions of Section 7.1. [55:7.2.2.1]

7.2.2.2.1 Indoor GH₂ systems in control areas with less than the maximum allowable quantities per control area shown in Table 6.4.1.1 shall be located in accordance with the applicable provisions of Table 7.3.2.2.1.

7.2.2.3 Outdoor Storage.

7.2.2.3.1 General. Exterior storage of [GH₂] shall be in accordance with 7.2.1, 7.2.2.1, and 7.2.2.3. [55:7.2.2.1]

7.2.2.3.2 Distance to Exposures. The outdoor storage or use of [GH₂] shall be located from lot lines, public streets, public alleys, public ways, or buildings not associated with the manufacture or distribution of [GH₂] in accordance with Table 7.2.2.3.2. [55:7.6.2]

7.2.2.3.2.1 Fire Barriers.

(A)* Where a protective structure is used to protect [GH₂] systems, the system shall terminate downstream of the source valve. [55:7.6.2.1.1]

(B) The fire barrier wall shall be either an independent structure or the exterior wall of the building adjacent to the storage area. [55:7.6.2.1.2]

(C) The fire barrier wall shall be without openings or penetrations. [55:8.7.2.1.1]

(1) Penetrations of the fire barrier wall by conduit or piping shall be permitted provided that the penetration is protected with a firestop system in accordance with the [adopted] building code. [55:8.7.2.1.1.1]

(D) The configuration of the [fire barrier] shall be designed to allow natural ventilation to prevent the accumulation of hazardous gas concentrations. [55:7.6.2.3]

7.2.2.3.2.2 Air Intakes. Storage and use of [GH₂] shall not be located within 50 ft (15.2 m) of air intakes. [55:7.6.2.4]

7.2.2.3.2.3 Building Openings. Storage and use of [GH₂] outside of buildings shall also be separated from building openings by 25 ft (7.6 m). Fire barriers shall be permitted to be used as a means to separate storage areas from openings or a means of egress used to access the public way. [55:7.6.2.5]

7.2.3 Nonbulk GH₂ Use.

7.2.3.1 General.

7.2.3.1.1 Applicability. The storage or use of [GH₂] exceeding the quantity thresholds for gases requiring special provisions as specified in Table 6.4.1.1 shall be in accordance with Chapters 1 through 6 [as applicable] and Sections 7.1 and 7.2. [55:7.6.1.1]

7.2.3.2 Indoor Use. Indoor use of [GH₂] shall be in accordance with the requirements of Section 7.1. [55:7.3.2.1]

7.2.3.3 Outdoor Use. Exterior use of [GH₂] shall be in accordance with the [applicable] requirements of Section 7.1. [55:7.3.2.2.1]

7.2.4 Nonbulk GH₂ Handling.

7.2.4.1 Applicability. The storage or use of [GH₂] exceeding the quantity thresholds for gases requiring special provisions as specified in Table 6.4.1.1 shall be in accordance with Chapters 1 through 6.1 [as applicable] and Sections 7.1 and 7.2. [55:7.6.1.1]

7.2.4.2 Carts and Trucks.

7.2.4.2.1 Containers, cylinders, and tanks shall be moved using an approved method. [55:7.3.3.2.1]

7.2.4.2.2 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. [55:7.3.3.2.2]

7.2.4.3 Lifting Devices. Ropes, chains, or slings shall not be used to suspend [GH₂] 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. [55:7.3.3.3]

Table 7.2.2.3.2 Distance to Exposures for Nonbulk [GH₂]

Maximum Amount Per Storage Area (ft ³)	Minimum Distance Between Storage Areas (ft)	Minimum Distance to Lot Lines of Property That Can Be Built Upon (ft)	Minimum Distance to Public Streets, or Public Alleys, or Public Ways (ft)	Minimum Distance to Buildings on the Same Property		
				Less Than 2-Hour Construction	2-Hour Construction	4-Hour Construction
0–4225	5	5	5	5	0	0
4226–21,125	10	10	10	10	5	0
21,126–50,700	10	15	15	20	5	0
50,701–84,500	10	20	20	20	5	0
84,501–200,000	20	25	25	20	5	0

For SI units: 1 ft = 304.8 mm; 1 ft³ = 0.02832 m³.

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

[55: Table 7.6.2]



7.3 Bulk GH₂ Systems.

7.3.1* Bulk GH₂ Systems — General.

7.3.1.1 Applicability. The storage, use, and handling of [bulk GH₂] systems shall be in accordance with the provisions of Chapters 1 through 6, as applicable, and Section 7.3. [55:10.1]

7.3.1.2 Design of GH₂ Systems.

7.3.1.2.1* Piping, tubing, valves, and fittings shall be designed and installed in accordance 7.1.15.1 and Sections 704.1.2.3, 704.1.2.4, and 704.1.2.5 of the ICC *International Fuel Gas Code (IFGC)*. Cast-iron pipe, valves, and fittings shall not be used. [55:10.2.1]

7.3.1.2.2 Pressure Relief Devices. Hydrogen-venting systems discharging to the atmosphere shall be in accordance with CGA G-5.5, *Hydrogen Vent Systems*. [55:10.2.2]

7.3.1.2.2.1 Venting from the relief vents from the hydrogen supply piping serving listed fuel cell power systems shall be permitted to be discharged into an enclosure integral to the fuel cell system where the concentration of hydrogen is diluted below 25 percent of the lower flammable limit (LFL) at the outlet of the enclosure. [55:10.2.2.1]

7.3.1.2.2.2 The hydrogen supply piping system shall be designed to isolate the source of hydrogen from the relief vent in the event of loss of dilution ventilation or power. [55:10.2.2.2]

7.3.1.2.3 Piping, Tubing, and Fittings.

7.3.1.2.3.1 In addition to the requirements of 7.1.15.1, brazing materials used for joints in piping and tubing systems shall have a melting point above 1000°F (538°C). [55:10.2.3.1]

7.3.1.2.3.2 Underground piping systems shall be in accordance with 7.1.15.3. [55:10.2.3.2]

7.3.1.2.4 Equipment Assembly.

7.3.1.2.4.1 Valves, gauges, regulators, and other accessories used for hydrogen systems shall be specified for hydrogen service by the manufacturer or the hydrogen supplier. [55:10.2.4.1]

7.3.1.2.4.2 Storage containers, piping, valves, regulating equipment, and other accessories shall be accessible and shall be protected against physical damage and tampering. [55:10.2.4.1.1]

7.3.1.2.4.3 Cabinets or enclosures containing hydrogen control or operating equipment shall be ventilated to minimize accumulation of hydrogen. [55:10.2.4.2]

7.3.1.2.4.4 Mobile hydrogen supply units used as part of a hydrogen system shall be secured to prevent movement. [55:10.2.4.3]

7.3.1.2.4.5 Mobile hydrogen supply units shall be electrically bonded to the storage system before hydrogen is discharged from the supply unit. [55:10.2.4.4]

7.3.1.2.5 Marking.

7.3.1.2.5.1 Hazard identification signs shall be provided in accordance with 4.13.2. [55:10.2.5.1]

7.3.1.2.5.2 In addition, the area in which a hydrogen system is located shall be permanently placarded as follows:

**WARNING: HYDROGEN — FLAMMABLE GAS —
NO SMOKING — NO OPEN FLAMES**

[55:10.2.5.2]

7.3.1.2.6 Bonding and Grounding. The [GH₂] system shall be electrically bonded and grounded. [55:10.2.6]

7.3.1.2.7 Operation and Maintenance.

7.3.1.2.7.1 Prior to acceptance and initial operation, all piping installations shall be inspected and pressure tested in accordance with ICC *International Fuel Gas Code (IFGC)*, Section 705. [55:10.5.1]

7.3.1.2.7.2 Operating Instructions.

(A) For installations that require any operation of equipment by the user, the user shall be instructed in the operation of the equipment and emergency shutdown procedures. [55:10.5.2.1]

(B) Instructions shall be maintained at the operating site at a location acceptable to the AHJ. [55:10.5.2.2]

7.3.1.2.8 Maintenance. Maintenance shall be performed annually by a qualified representative of the equipment owner. The maintenance shall include inspection for physical damage, leak tightness, ground system integrity, vent system operation, equipment identification, warning signs, operator information and training records, scheduled maintenance and retest records, alarm operation, and other safety-related features. Scheduled maintenance and retest activities shall be formally documented and records shall be maintained a minimum of 3 years. [55:10.5.3]

7.3.2 Bulk GH₂ Systems Storage.

7.3.2.1 General Requirements.

7.3.2.1.1 Systems located above ground either at grade or above grade shall be in accordance with 7.3.2. [55:10.3.1.1]

7.3.2.1.2 Systems within 50 ft (15 m) of aboveground storage of all classes of flammable and combustible liquids shall be located on ground higher than such storage, except where dikes, diversion curbs, grading, or separating solid walls are used to prevent accumulation of these liquids under the system. [55:10.3.1.2]

7.3.2.1.3 Compression and Processing Equipment. Compression and gas processing equipment integral to bulk gas storage systems shall be designed for use with GH₂ and for maximum pressures and temperatures to which it can be subjected under normal operating conditions. [55:10.8]

7.3.2.1.3.1 Compression and gas processing equipment shall have pressure relief devices that limit each stage pressure to the maximum allowable working pressure for the compression cylinder and piping associated with that stage of compression. [55:10.8.1]

7.3.2.1.3.2 Where GH₂ compression equipment is operated unattended, it shall be equipped with a high discharge and a low suction pressure automatic shutdown control. [55:10.8.2]

7.3.2.1.3.3 Control circuits that automatically shut down shall remain down until manually activated or reset after a safe shutdown is performed. [55:10.8.3]

7.3.2.1.4 Stationary Compressors.

7.3.2.1.4.1 Valves.

(A) Valves shall be installed such that each compressor can be isolated for maintenance. [55:10.8.4.1.1]

(B) The discharge line shall be equipped with a check valve to prevent the backflow of gas from high-pressure sources located downstream of the compressor. [55:10.8.4.1.2]

7.3.2.1.4.2 Foundations.

(A) Foundations used for supporting equipment shall be designed and constructed to prevent frost heaving. [55:10.8.4.2.1]

(B) The structural aspects of such foundations shall be designed and constructed in accordance with the provisions of the [adopted] building code. [55:10.8.4.2.2]

7.3.2.1.4.3 Emergency Shutdown. When an emergency shutdown system is required, activation of the emergency shutdown system shall shut down operation of all compressors serving a single bulk gas installation. [55:10.8.4.3]

7.3.2.1.4.4 Relief Valves.

(A) Each compressor shall be provided with a vent or relief device that will prevent over-pressurizing of the pump under normal or upset conditions. [55:10.8.4.4.1]

(B) Pressure relief devices used to serve pumps or compression equipment shall be connected to a vent pipe system in accordance with 7.3.1.2.2. [55:10.8.4.4.2]

7.3.2.1.4.5 Pressure Monitoring. The pressure on the compressor discharge shall be monitored by a control system. [55:10.8.4.5]

7.3.2.1.4.6 Protection. Transfer piping and compressors shall be protected from vehicular damage. [55:10.8.4.6]

7.3.2.1.5 Clearance to Combustibles. Clearance to combustibles shall be in accordance with the requirements of 7.1.9.1.1. [55:10.5.4]

7.3.2.1.6* Fire Protection. Fire protection shall be in accordance with the requirements of Section 6.10. [55:10.6]

7.3.2.1.7 Installation in Vaults Above and Below Ground. (Reserved)

7.3.2.2 Indoor Storage.

7.3.2.2.1 The location of hydrogen systems shall be in accordance with Table 7.3.2.2.1. [55:10.3.2.1].

7.3.2.2.2 Detached Buildings.

7.3.2.2.2.1 Detached buildings shall be constructed of non-combustible or limited-combustible materials in accordance with the requirements of Section 6.5. [55:10.4.4.1]

7.3.2.2.2.2 Ventilation shall be provided in accordance with the requirements of Section 6.17. [55:10.4.4.2]

(A) Outlet openings shall be located at the high point of the room in exterior walls or roof. [55:10.4.4.2.1]

(B) Inlet and outlet openings shall each have a minimum total area of 1 ft²/1000 ft³ (1 m²/305 m³) of room volume. [55:10.4.4.2.2]

(C) Discharge from outlet openings shall be directed or conducted to the atmosphere. [55:10.4.4.2.3]

7.3.2.2.2.3* Explosion control shall be provided in accordance with the requirements of Section 6.9. [55:10.4.4.3]

7.3.2.2.2.4 Electrical equipment shall be in accordance with Article 501 of *NFPA 70, National Electrical Code*, for Class I, Division 2 locations. [55:10.4.4.4]

7.3.2.2.2.5 Heating, if provided, shall be by steam, hot water, or other indirect means except that electrical heating shall be permitted to be used if in compliance with 7.3.2.2.2.4. [55:10.4.4.5]

7.3.2.2.3 Hydrogen Gas Rooms.

7.3.2.2.3.1 Floors, walls, and ceilings shall be constructed of noncombustible or limited-combustible materials in accordance with the requirements of the [adopted] building code. [55:10.4.5.1]

(A) Interior walls or partitions shall have a fire resistance rating of not less than 2 hours, shall be continuous from floor to ceiling, and shall be anchored to resist movement. [55:10.4.5.1.1]

(B) Not less than 25 percent of the perimeter wall shall be an exterior wall. [55:10.4.5.1.2]

(C) Openings to other parts of the building shall not be permitted. [55:10.4.5.1.3]

(D) Windows and doors shall be in exterior walls only. [55:10.4.5.1.4]

7.3.2.2.3.2 Ventilation shall be as provided in 6.17. [55:10.4.5.2]

7.3.2.2.3.3 Explosion control shall be provided in accordance with the requirements of Section 6.9. [55:10.4.5.3]

7.3.2.2.3.4 There shall be no sources of ignition from open flames, electrical equipment, or heating equipment. [55:10.4.5.4]

7.3.2.2.3.5* Electrical equipment shall be in accordance with Article 501 of *NFPA 70, National Electrical Code*, for Class I, Division 2 locations. [55:10.4.5.5]

Table 7.3.2.2.1 Location of [GH₂] Systems

Location	Quantity of Hydrogen			
	≤MAQ	>MAQ to <3500 scf (<99 m ³)	≥3500 scf to <15,000 scf (≥99 m ³ to <425 m ³)	≥15,000 scf (≥425 m ³)
In a detached building	A	A	A	A
In a gas room, in accordance with Section 6.4	A	A	A	Detached building required
Not in a gas room	A	A*	A*	NA

A: Allowed. NA: Not allowed.

[* These locations shall meet the requirements of 7.3.2.2.4.]

[55: Table 10.3.2.1]



7.3.2.2.3.6 Heating, if provided, shall be by steam, hot water, or indirect means except that electrical heating shall be permitted to be used if in compliance with 7.3.2.2.3.5. [55:10.4.5.6]

7.3.2.2.4 Indoor Hydrogen System Location.

7.3.2.2.4.1 Hydrogen systems of less than 3500 scf (99 m³) and greater than the MAQ, where located inside buildings, shall be located in the building so that the system will be as follows: [55:10.4.6.1]

- (1) In a ventilated area in accordance with the provisions of Section 6.17 [55:10.4.6.1(1)]
- (2) Separated from incompatible materials in accordance with the provisions of 7.2.1.1 [55:10.4.6.1(2)]
- (3) A distance of 25 ft (7.6 m) from open flames and other sources of ignition [55:10.4.6.1(3)]
- (4) A distance of 50 ft (15 m) from intakes of ventilation, air-conditioning equipment, and air compressors [55:10.4.6.1(4)]
 - (a) The distance shall be permitted to be reduced to 10 ft (3.1 m) where the room or area is protected by a listed detection system as per Article 500.7(K) of *NFPA 70, National Electrical Code*, and the detection system shall shut down the fuel supply in the event of a leak that results in a concentration that exceeds 25 percent of the LFL. [55:10.4.6.1(4)(a)]
 - (b) Isolation valves used to isolate the fuel supply shall be of a fail-safe design. [55:10.4.6.1(4)(b)]
- (5) A distance of 50 ft (15 m) from other flammable gas storage [55:10.4.6.1(5)]
- (6) Protected against damage in accordance with the provisions of 7.1.7.3 [55:10.4.6.1(6)]

7.3.2.2.4.2 Systems Installed in One Room.

(A) More than one system of 3500 scf (99 m³) or less shall be permitted to be installed in the same room or area, provided the systems are separated by at least 50 ft (15 m) or a full-height fire-resistive partition having a minimum fire resistance rating of 2 hours is located between the systems. [55:10.4.6.2.1]

(B) The separation distance between multiple systems of 3500 scf (99 m³) or less shall be permitted to be reduced to 25 ft (7.6 m) in buildings where the space between storage areas is free of combustible materials and protected with a sprinkler system designed for Extra Hazard, Group 1 in accordance with the requirements of Section 6.10. [55:10.4.6.2.2]

7.3.2.3 Outdoor Storage.

7.3.2.3.1 Aboveground Locations.

7.3.2.3.1.1 Minimum Distance for Aboveground Locations.

(A)* The minimum distance from a [GH₂] system [of indicated capacity] located outdoors to specified exposures shall be in accordance with Table 7.3.2.3.1.2(a) or Table 7.3.2.3.1.2(b). (See also Annex I.) [55:10.3.2.2.1]

- (1) **Maximum Internal Diameter of Interconnecting Piping.** The maximum internal diameter of the piping system used for interconnecting piping between the shutoff valve on any single storage container to the point of connection to the system source valve shall not exceed the values shown in Table 7.3.2.3.1.2(a) and Table 7.3.2.3.1.2(b) for the pressure range indicated, except as shown in 7.3.2.3.1.1(A) (1) (b) or 7.3.2.3.1.1(A) (1) (c). [55:10.3.2.2.1.1]

- (a) **Shutoff Valves on the Source of Supply.** When shutoff valves are not connected directly to the source of supply, all interconnecting piping between the source connection and points downstream shall be included in the determination of internal diameter for the piping system. [55:10.3.2.2.1.1(A)]
- (b)* **Alternative Internal Diameters.** The separation distance for piping systems with internal diameters greater than those specified in Table 7.3.2.3.1.2(a) for the pressure range selected shall be permitted with tabular distances determined based on the use of the equations in Table 7.3.2.3.1.2(c) and Table A.3.2.3.1.1(A) (b). [55:10.3.2.2.1.1(B)]
- (c) The separation distance for piping systems with internal diameters less than those specified in Table 7.3.2.3.1.2(a) and Table 7.3.2.3.1.2(b) for the pressure range selected shall be allowed to be reduced with tabular distances determined based on the use of equations in Table 7.3.2.3.1.2(c). [55:10.3.2.2.1.1(C)]
- (d) Separation distances determined based on the use of Table 7.3.2.3.1.2(c) shall be subject to review and approval by the AHJ. [55:10.3.2.2.1.1(D)]
- (e)* **Determination of Internal Diameter.** The internal diameter of the piping system shall be determined by the diameter of the piping serving a storage array with content greater than 400 scf (11.3 m³). The piping system size used in the application of Table 7.3.2.3.1.2(a) and Table 7.3.2.3.1.2(b) shall be determined based on that portion of the system with the greatest maximum internal diameter. [55:10.3.2.2.1.1(E)]
- (f)* **Determination of System Pressure.** The system pressure shall be determined by the maximum operating pressure of the storage array with content greater than 400 scf (11.3 m³), irrespective of those portions of the system elevated to a higher pressure. [55:10.3.2.2.1.1(F)]

(B)* Except for distances to lot lines, operable building openings, air intakes, and overhead utilities, the distances in Table 7.3.2.3.1.2(a) and Table 7.3.2.3.1.2(b) shall not apply where fire barrier walls having a minimum fire resistance rating of 2 hours are located between the system and the exposure. [55:10.3.2.2.2]

- (1) The fire barrier wall shall be without openings or penetrations. [55:8.7.2.1.1]
 - (a) Penetrations of the fire barrier wall by conduit or piping shall be permitted provided that the penetration is protected with a firestop system in accordance with the [adopted] building code. [55:8.7.2.1.1.1]

(C)* The distances in (1), (2), (4), and (10) [inclusive] in Table 7.3.2.3.1.2(a) and Table 7.3.2.3.1.2(b) shall be permitted to be reduced by one-half where fire barrier walls having a minimum fire resistance rating of 2 hours are located between the system and the exposure. [55:10.3.2.2.3]

(D) When fire barrier walls of three sides are used, the walls shall be in accordance with 8.3.2.4.5.1(D). [55:10.3.2.2.4]

(E) Unloading connections on delivery equipment shall not be positioned closer to any of the exposures cited in Table 7.3.2.3.1.2(a) and Table 7.3.2.3.1.2(b) than the distances given for the storage system. [55:10.3.2.3]

7.3.2.3.1.2 Design Requirements at Outdoor Locations.

(A) Where overhead cover is provided, it shall be in accordance with the provisions of Section 6.6. [55:10.4.1.1]

Table 7.3.2.3.1.2(a) Minimum Distance from Outdoor [GH₂] Systems to Exposures (U.S. Units)

Exposure		>15 to ≤250 psi 2.067 in. ID (ft)	>250 to ≤3000 psi 0.747 in. ID (ft)	>3000 to ≤7500 psi 0.312 in. ID (ft)	>7500 to ≤15000 psi 0.282 in. ID (ft)
(1)	Lot lines ^{greater of a or b}	40	45	30	35
(2)	Exposed persons other than those involved in servicing of the system. ^c	20	25	15	15
(3)	Buildings and structures				
	Combustible construction ^d	15	20	10	15
	Noncombustible non-fire-rated construction ^c	15	20	10	15
	Fire-rated construction with a fire resistance rating of not less than 2 hours ^f	5	5	5	5
(4)	Openings in buildings of fire-rated or non-fire-rated construction (doors, windows, and penetrations)				
	Openable ^a				
	Fire-rated or non-fire-rated	40	45	30	35
	Unopenable ^c				
	Fire-rated or non fire-rated	15	20	10	15
(5)	Air intakes (HVAC, compressors, other) ^a	40	45	30	35
(6)	Fire barrier walls or structures used to shield the bulk system from exposures ^f	5	5	5	5
(7)	Unclassified electrical equipment ^g	15	15	15	15
(8)	Utilities (overhead) including electric power, building services, or hazardous materials piping ^d	15	20	10	15
(9)	Ignition sources such as open flames and welding ^a	40	45	30	35ft
(10)	Parked cars ^c	20	25	15	15ft
(11)	Flammable gas storage systems including other hydrogen systems above ground.				
	Nonbulk	15	20	10	15
	Bulk ^h	15	15	15	15
(12)	Aboveground vents or exposed piping and components of flammable gas storage systems including other hydrogen systems below ground ^c				
	Gaseous or Cryogenic	15	20	10	15
(13)	Hazardous materials (other than flammable gases) storage below ground ^c				
	Physical hazard materials or Health hazard materials	15	20	10	15
(14)	Hazardous materials storage (other than flammable gases) above ground. ^d				
	Physical hazard materials or health hazard materials	15	20	10	15
(15)	Ordinary combustibles, including fast-burning solids such as ordinary lumber, excelsior, paper and combustible waste and vegetation other than that found in maintained landscaped areas. ^d	15	20	10	15
(16)	Heavy timber, coal, or other slow-burning combustible solids ^c	15	20	10	15

Note: All pressures are gauge pressures.

^a Unignited jet concentration decay distance to 4 percent mole fraction (volume fraction) hydrogen.

^b D_{rad} – radiation heat flux level of 500 Btu/hr·ft².

^c D_{rad} for heat flux level of 1500 Btu/hr·ft² exposure to employees for a maximum of 3 minutes.

^d The greater of D_{rad} for combustible heat flux level of 6340 Btu/hr·ft² or the visible flame length.

^e The greater of D_{rad} for noncombustible equipment heat flux level of 8000 Btu/hr·ft² or the visible flame length.

^f The minimum clearance between the structure and the system required for access for service-related activities.

^g Equipment classified as meeting Class I, Division 2, Group B requirements of NFPA 70, *National Electrical Code*, when the area is in accordance with NFPA 497, *Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*.

^h Bulk hydrogen storage systems are allowed to integrate (co-locate) other nonliquefied flammable gas systems when the output of the system is designed to deliver a product in which the gases are mixed or blended for delivery into the user's system. The separation distance indicated requires a minimum separation between gaseous and liquid systems integrated into a single system where the liquid source is vaporized, compressed, and stored in the gaseous state.

[55: Table 10.3.2.2.1(a)]



Table 7.3.2.3.1.2(b) Minimum Distance from Outdoor [GH₂] Systems to Exposures (SI Units)

Exposure		>103.4 to ≤172.4 kPa 52.50 mm ID (m)	>1724 to ≤20,684 kPa 18.97 mm ID (m)	>20,684 ≤ to 51,711 kPa 7.92 mm ID (m)	>51,711 to ≤103,421 kPa 7.16 mm ID (m)
(1)	Lot lines ^{greater of a or b}	12.2	13.8	9.2	10.7
(2)	Exposed persons other than those involved in servicing of the system ^c	6.1	7.7	4.6	4.6
(3)	Buildings and structures				
	Combustible construction ^d	4.6	6.1	3.1	4.6
	Noncombustible non-fire-rated construction ^c	4.6	6.1	3.1	4.6
	Fire-rated construction with a fire resistance rating of not less than 2 hours ^f	1.6	1.6	1.6	1.6
(4)	Openings in buildings of fire-rated or non-fire-rated construction (doors, windows, and penetrations)				
	Openable ^d				
	Fire-rated or non-fire-rated	12.2	13.8	9.2	10.7
	Unopenable ^c				
	Fire-rated or non-fire-rated	4.6	6.1	3.1	4.6
(5)	Air intakes (HVAC, compressors, other) ^a	12.2	13.8	9.2	10.7
(6)	Fire barrier walls or structures used to shield the bulk system from exposures ^f	1.6	1.6	1.6	1.6
(7)	Unclassified electrical equipment ^g	4.6	4.6	4.6	4.6
(8)	Utilities (overhead), including electric power, building services, or hazardous materials piping ^d	4.6	6.1	3.1	4.6
(9)	Ignition sources such as open flames and welding ^a	12.2	13.8	9.2	10.7
(10)	Parked cars ^c	6.1	7.7	4.6	4.6
(11)	Flammable gas storage systems, including other hydrogen systems above ground				
	Nonbulk	4.6	6.1	3.1	4.6
	Bulk ^h	4.6	4.6	4.6	4.6
(12)	Aboveground vents or exposed piping and components of flammable gas storage systems including other hydrogen systems, below ground. ^d				
	Gaseous or cryogenic	4.6	6.1	3.1	4.6
(13)	Hazardous materials (other than flammable gases) storage below ground ^d				
	Physical hazard materials or health hazard materials	4.6	6.1	3.1	4.6
(14)	Hazardous materials storage (other than flammable gases) above ground ^d				
	Physical hazard materials or health hazard materials	4.6	6.1	3.1	4.6
(15)	Ordinary combustibles, including fast-burning solids such as ordinary lumber, excelsior, paper, or combustible waste and vegetation other than that found in maintained landscaped areas ^d	4.6	6.1	3.1	4.6
(16)	Heavy timber, coal, or other slow-burning combustible solids ^d	4.6	6.1	3.1	4.6

Note: All pressures are gauge pressures.

^a Unignited jet concentration decay distance to 4 percent mole fraction (volume fraction) hydrogen.

^b D_{rad} – radiation heat flux level of 1577 W/m².

^c The greater of D_{rad} for non-combustible equipment heat flux level of 25,237 W/m² or the visible flame length.

^d The greater of D_{rad} for combustible heat flux level of 20,000 W/m² or the visible flame length.

^e D_{rad} for heat flux level of 4732 W/m² exposure to employees for a maximum of 3 minutes.

^f The minimum clearance between the structure and the system required for access for service related activities.

^g Equipment classified as meeting Class I, Division 2, Group B requirements of NFPA 70, *National Electrical Code* when the area is in accordance with NFPA 497, *Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*.

^h Bulk hydrogen storage systems are allowed to integrate (co-locate) other nonliquefied flammable gas systems when the output of the system is designed to deliver a product in which the gases are mixed or blended for delivery into the user's system. The separation distance indicated requires a minimum separation between gaseous and liquid systems integrated into a single system where the liquid source is vaporized, compressed, and stored in the gaseous state.

[55: Table 10.3.2.2.1(b)]

Table 7.3.2.3.1.2(c) Separation Distance Based on Alternative Pipe or Tube Internal Diameters

Notes*	>15 to ≤250 psi (>103.4 to ≤1724 kPa)	>250 to ≤3000 psi (>1724 to ≤20,684 kPa)	>3000 to ≤7500 psi (>20,684 to ≤51,711 kPa)	>7500 to ≤15,000 psi (>51,711 to ≤103,421 kPa)
(a)	$D_a = 0.23179d^{0.99931}$	$D_a = 0.73903d^{0.99962}$	$D_a = 1.1062d^{0.99959}$	$D_a = 1.4507d^{0.9995}$
(b)	$D_b = 0.091137d^{1.1303} + e^{-0.084081d}(0.087694d^{0.72681} - 0.091137d^{1.1303})$	$D_b = 0.36599d^{1.1152} + e^{-0.10771d}(0.1885d^{1.2531} - 0.36599d^{1.1152})$	$D_b = 0.60173d^{1.1063} + e^{-0.36516d}(-0.00002521d^{5.6078} - 0.60173d^{1.1063})$	$D_b = 0.84053d^{1.1023} + e^{-0.40365d}(-0.000043007d^{5.7146} - 0.84053d^{1.1023})$
(c)	$D_c = 0.075952d^{1.1022} + e^{-0.087589d}(0.076814d^{0.83088} - 0.075952d^{1.1022})$	$D_c = 0.2889d^{1.092} + e^{-0.10392d}(0.18705d^{1.1795} - 0.2889d^{1.092})$	$D_c = 0.45889d^{1.0887} + e^{-0.46723d}(-0.000027772d^{5.8841} - 0.45889d^{1.0887})$	$D_c = 0.6324d^{1.0859} + e^{-0.52477d}(-0.000086234d^{5.8213} - 0.6324d^{1.0859})$
(d)	$D_d = 0.096359d^{0.99928}$	$D_d = 0.3072d^{0.99962}$	$D_d = 0.45967d^{0.99971}$	$D_d = 0.60297d^{0.99956}$
(e)	$D_e = 0.096359d^{0.99928}$	$D_e = 0.3072d^{0.99962}$	$D_e = 0.45967d^{0.99971}$	$D_e = 0.60297d^{0.99956}$

Notes:

(1) Use of this table assumes a leak diameter of 3 percent of the pipe flow area or internal diameter where d = inside diameter (ID) of pipe or tube expressed in millimeters (mm), and $D_{a,b,c,d, \text{ or } e}$ = separation distance in meters (m).

(2) All pressures are gauge pressures.

*Notes are from Table 10.3.2.2.1(a) and Table 10.3.2.2.1(b) as follows:

- (a) Unignited jet concentration decay distance to 4 percent mole fraction (volume fraction) hydrogen
- (b) D_{rad} = radiation heat flux level of 500 Btu/hr·ft² (1577 W/m²)
- (c) D_{rad} for heat flux level of 1500 Btu/hr·ft² (4732 W/m²) exposure to employees for a maximum of 3 minutes
- (d) The greater of D_{rad} for combustible heat flux level of 6340 Btu/hr·ft² (20,000 W/m²) or the visible flame length
- (e) The greater of D_{rad} for noncombustible equipment heat flux level of 8000 Btu/hr·ft² (25,237 W/m²) or the visible flame length

[55:10.3.2.2.1(B)]

(B) Electrical wiring and equipment shall be in accordance with Table 7.3.2.3.1.2(d). [55:10.4.1.2]

(C) Vehicular protection shall be provided in accordance with 4.1.5. [55:10.4.1.3]

7.3.2.4 Underground Systems. [GH₂] systems installed underground where [GH₂] containers are to be buried in contact with earth or fill shall be in accordance with 7.3.2.4. [55:10.4.2]

7.3.2.4.1 Container Design. Pressure [GH₂] containers installed underground using burial methods shall be of seamless construction in accordance with Part UF or Appendix 22 of the ASME *Boiler and Pressure Vessel Code*, Section VIII, Division 1. [55:10.4.2.1]

7.3.2.4.1.1* [GH₂] containers shall be designed to include cyclic pressure life calculations using fracture mechanics methods. [55:10.4.2.1.1]

7.3.2.4.1.2 GH₂ Container Examination.

(A) [GH₂] containers shall be examined for internal and external surface flaws and inclusions before burial, or at the time of manufacture. [55:10.4.2.1.2.1]

(B) [GH₂] containers with flaws or inclusions exceeding the lesser of 5 percent of the wall thickness or 0.12 in. (3 mm) shall not be used. [55:10.4.2.1.2.2]

7.3.2.4.1.3 Composite Containers. (Reserved)

7.3.2.4.2 Corrosion Protection. [GH₂] containers and underground piping shall be protected from corrosion in accordance with 7.1.9.1.7, 7.1.14, [and] 7.1.15.3 as applicable. [55:10.4.2.2]

7.3.2.4.3* Outlet Connections.

7.3.2.4.3.1 Threaded [GH₂] container outlet connections shall be designed with primary and secondary seals that shall be tested for functionality. [55:10.4.2.3.1]

7.3.2.4.3.2 The seal design shall include a method of detecting a leak in the primary seal. [55:10.4.2.3.2]

7.3.2.4.4 Piping Systems.

7.3.2.4.4.1 Joints in the piping system shall be butt welded and 100 percent inspected using nondestructive testing (NDT) methods in accordance with the requirements of ANSI/ASME B31.3, *Process Piping*, or other approved standards. [55:10.4.2.4.1]

7.3.2.4.4.2 Valves, controls, safety devices, and instrumentation shall be above ground and accessible to authorized personnel. [55:10.4.2.4.2]

7.3.2.4.5 Location. [GH₂] containers shall be located in accordance with 7.3.2.4.5.1 through 7.3.2.4.5.5. [55:10.4.2.5]

7.3.2.4.5.1 Underground [GH₂] containers shall not be located beneath buildings. [55:10.4.2.5.1]

7.3.2.4.5.2 [GH₂] containers and associated equipment shall be located with respect to foundations and supports of other structures such that the loads carried by such structures cannot be transmitted to the tank. [55:10.4.2.5.2]

Table 7.3.2.3.1.2(d) Electrical Area Classification

Location	Classification	Extent of Classified Area
Storage equipment excluding the piping system downstream of the source valve	Class I, Division 2	Between 0 ft (0 m) and 15 ft (4.6 m)

[55: Table 10.4.1.2]



7.3.2.4.5.3 GH₂ Container Separation Distances.

(A) The distance from any part of the [GH₂] container to the nearest wall of a basement, pit, cellar, or lot line shall not be less than 10 ft (3 m). [55:10.4.2.5.3.1]

(B) A structure or foundation of a structure on the same property shall not be erected or constructed within 10 ft (3.1 m) of any point on the container surface, unless the footings extend to the bottom of the container or the container's foundation. [55:10.4.2.5.3.2]

7.3.2.4.5.4 A minimum distance of 1 ft (0.3 m), shell to shell, shall be maintained between adjacent underground containers. [55:10.4.2.5.4]

7.3.2.4.5.5* A minimum distance of 3 ft (0.9 m) shall be maintained between [GH₂] containers and buried utilities. [55:10.4.2.5.5]

7.3.2.4.6 Foundations. Underground [GH₂] containers shall be set on foundations constructed in accordance with the adopted building code, and surrounded with not less than 6 in. (152 mm) of noncorrosive inert material. [55:10.4.2.6]

7.3.2.4.7 Depth, Cover, and Fill.

7.3.2.4.7.1 Containers shall be buried such that the top of the container is covered with a minimum of 1 ft (0.3 m) of earth and with concrete a minimum of 4 in. (101 mm) thick placed over the earthen cover. [55:10.4.2.7.1]

7.3.2.4.7.2 The concrete shall extend a minimum of 1 ft (0.3 m) horizontally beyond the footprint of the tank in all directions. [55:10.4.2.7.2]

7.3.2.4.8* Anchorage and Security. [GH₂] containers installed underground in flood hazard areas shall be anchored to prevent flotation, collapse, or lateral movement resulting from hydrostatic loads, including the effects of buoyancy, during conditions of the design flood. [55:10.4.2.8]

7.3.2.4.9 Venting of Underground GH₂ Containers. Vent pipes for underground [GH₂] containers shall be in accordance with 7.3.1.2.1. [55:10.4.2.9]

7.3.2.4.10 Overfill Protection and Prevention Systems. An approved means or method shall be provided to prevent the overfilling of the storage containers. [55:10.4.2.10]

7.3.2.4.11 Physical Protection. Piping and control equipment ancillary to underground containers that is located above ground shall be protected from physical damage in accordance with 7.1.7.3. [55:10.4.2.11]

7.3.3 Bulk GH₂ Systems Use.

7.3.3.1 The use of bulk GH₂ systems shall be in accordance with Section 7.1.

7.3.3.2 Good Practice Standards. Where nationally recognized good practices or standards have been established for the processes employed, such practices and standards shall be followed. [55:8.14.1.4.1]

7.3.4 Handling of Bulk GH₂ Systems.

7.3.4.1 The handling of GH₂ shall be in accordance with 7.2.4.

7.3.4.2 Cargo Transport Unloading.

7.3.4.2.1 Personnel conducting transfer operations from the bulk transport vehicle shall be trained. [52:9.14.13]

7.3.4.2.2 Unloading connections on delivery equipment shall not be positioned closer to any of the exposures cited in Table 7.3.2.3.1.2(a) or Table 7.3.2.3.1.2(b) than the distances given for the storage system. [55:10.7.1]

7.3.4.2.3 During transfer of hydrogen from cargo vehicles, the hand or emergency brake of the vehicle shall be set, and chock blocks shall be used to prevent rolling of the vehicle. [55:10.7.2]

7.3.4.2.4 Cargo vehicles equipped with air-brake interlock in front of the unloading connection to protect against drive-away shall be engaged such that the interlock is activated. [55:10.7.3]

7.3.4.2.5 Mobile hydrogen supply units shall be electrically bonded to the storage system before hydrogen is discharged from the supply unit. [55:10.7.4]

7.3.4.2.6 Transfer System Depressurization.

7.3.4.2.6.1 The transfer systems shall be capable of depressurizing to facilitate disconnection. [55:10.7.5.1]

7.3.4.2.6.2 Bleed connections shall be connected to a hydrogen venting system in accordance with 7.3.1.2.2. [55:10.7.5.2]

7.3.4.2.7 Where required, check valves on delivery systems shall be in accordance with 7.1.15.1.2. [55:10.7.6]

7.3.4.2.8 Prohibitions on smoking or the use of open flame shall be in accordance with 7.1.23.2. [55:10.7.7]

7.3.4.2.9 An emergency shutoff valve shall be provided in accordance with 7.1.21. [55:10.7.8]

Chapter 8 Liquefied Hydrogen

8.1 General. The storage, use, and handling of LH₂ in LH₂ storage systems shall comply with this chapter in addition to other applicable requirements of this code.

8.1.1 Where specific requirements are provided in other chapters, those specific requirements shall apply.

8.1.1.1 Where there is a conflict between a general requirement and a specific requirement, the specific requirement shall be applicable.

8.1.1.2 The occupancy of a building or structure, or portion thereof, where hydrogen is stored or used, shall be classified in accordance with the adopted building code.

8.1.2* Containers — Design, Construction, and Maintenance. Containers employed for the storage or use of [LH₂] shall be designed, fabricated, tested, marked (stamped), and maintained in accordance with DOT regulations; Transport Canada (TC), *Transportation of Dangerous Goods Regulations*; the ASME *Boiler and Pressure Vessel Code*, "Rules for the Construction of Unfired Pressure Vessels"; or regulations of other administering agencies. [55:8.2]

8.1.3 Design. [LH₂] systems shall be designed for the intended use and shall be designed by persons competent in such design. [55:7.1.1.1]

8.1.3.1 Piping Systems. Piping, tubing, fittings, and related components shall be designed, fabricated, and tested in accordance with the requirements of ANSI/ASME B31.3, *Process Piping*, or other approved standards and shall be in accordance with 8.1.3.1.1. [55:8.14.1.4.2]

8.1.3.1.1 Piping and Appurtenances.

8.1.3.1.1.1 Piping systems shall be designed for the use intended through the full range of pressure and temperature to which they will be subjected. [55:8.14.2.1]

8.1.3.1.1.2 Piping systems shall be designed and constructed to allow for expansion, contraction, vibration, settlement, and fire exposure. [55:8.14.2.2]

8.1.3.1.1.2 Joints. Joints in piping and tubing shall be permitted to be made by welding or brazing, or by use of flanged, threaded, socket, slip, or compression fittings. [55:8.14.3]

8.1.3.1.1.3 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. [55:8.14.4]

8.1.3.1.1.4 Shutoff Valves on Containers. Shutoff valves shall be provided on all container connections, except for pressure relief devices. [55:8.14.5]

8.1.3.1.1.4.1 Shutoff valves for containers with multiple pressure relief devices shall be permitted in accordance with 8.1.4.7. [55:8.14.5.1]

8.1.3.1.1.4.2 Shutoff valves shall be accessible and located as close as practical to the container. [55:8.14.5.2]

8.1.3.1.1.5 Shutoff Valves on Piping.

8.1.3.1.1.5.1 Shutoff valves shall be installed in piping containing [LH₂] where needed to limit the volume of liquid discharged in the event of piping or equipment failure. [55:8.14.6.1]

8.1.3.1.1.5.2* Pressure relief valves shall be installed where liquid [or cold gas] can be trapped between shutoff valves in the piping system. (See 8.1.4.) [55:8.14.6.2]

8.1.3.1.1.6 Physical Protection and Support.

8.1.3.1.1.6.1 Aboveground piping systems shall be supported and protected from physical damage. [55:8.14.7.1]

8.1.3.1.1.6.2 Piping passing through walls shall be protected from mechanical damage. [55:8.14.7.2]

8.1.3.1.1.7 Corrosion Protection.

8.1.3.1.1.7.1 Aboveground piping that is subject to corrosion shall be protected against corrosion. [55:8.14.8.1]

8.1.3.1.1.7.2 Belowground piping shall be protected against corrosion. [55:8.14.8.2]

8.1.3.1.1.8 Cathodic Protection. Where required, cathodic protection shall be in accordance with 8.1.3.1.8. [55:8.14.9]

8.1.3.1.1.8.1 Operation. Where installed, cathodic protection systems shall be operated and maintained to continuously provide corrosion protection. [55:8.14.9.1]

8.1.3.1.1.8.2 Inspection.

(A) Container systems equipped with cathodic protection shall be inspected for proper operation by a cathodic protection tester. [55:8.14.9.2.1]

(B) The cathodic protection tester shall be certified as being qualified by the National Association of Corrosion Engineers, International (NACE). [55:8.14.9.2.2]

8.1.3.1.8.3 Impressed Current Systems.

(A) Systems equipped with impressed current cathodic protection systems shall be inspected in accordance with the requirements of the design and 8.1.3.1.8.2. [55:8.14.9.3.1]

(B) The design limits shall be available to the AHJ upon request. [55:8.14.9.3.2]

(C) The system owner shall maintain the following records to demonstrate that the cathodic protection is in conformance with the design: [55:8.14.9.3.3]

(1) The results of inspections of the system [55:8.14.9.3.3(1)]

(2) The results of testing that has been completed [55:8.14.9.3.3(2)]

8.1.3.1.8.4 Corrosion Expert.

(A) Repairs, maintenance, or replacement of a cathodic protection system shall be under the supervision of a corrosion expert certified by NACE. [55:8.14.9.4]

(B) The corrosion expert shall be certified by NACE as a senior corrosion technologist, a cathodic protection specialist, or a corrosion specialist or shall be a registered engineer with registration in a field that includes education and experience in corrosion control. [55:8.14.9.4.1]

8.1.3.1.9 Testing.

8.1.3.1.9.1 Piping systems shall be tested and proved free of leaks after installation as required by the [codes and] standards to which they are designed and constructed. [55:8.14.10.1]

8.1.3.1.9.2 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. [55:8.14.10.2]

8.1.4 Pressure-Relief Devices.

8.1.4.1 General.

8.1.4.1.1 Pressure relief devices shall be provided to protect containers and systems containing [LH₂] from rupture in the event of overpressure. [55:8.2.5.1.1]

8.1.4.1.2 Pressure relief devices shall be designed in accordance with CGA S-1.1, *Pressure Relief Device Standards — Part 1 — Cylinders for Compressed Gases*, and CGA S-1.2, *Pressure Relief Device Standards — Part 2 — Cargo and Portable Tanks for Compressed Gases*, for portable tanks; and CGA S-1.3, *Pressure Relief Device Codes — Part 3 — Stationary Storage Containers for Compressed Gases*, for stationary tanks. [55:8.2.5.1.2]

8.1.4.2 Containers Open to the Atmosphere. Portable containers that are open to the atmosphere and are designed to contain [LH₂] at atmospheric pressure shall not be required to be equipped with pressure relief devices. [55:8.2.5.2]

8.1.4.2.1 Containers shall be equipped with approved controls to prevent the condensation of air within the container.

8.1.4.2.2 Containers located indoors shall be within a zone of local exhaust using a mechanical exhaust system.

8.1.4.2.2.1 The exhaust system shall operate continuously when LH₂ is present and shall be designed in accordance with the mechanical code for the removal of flammable vapors.

8.1.4.2.2.2 The duct system used to exhaust the hydrogen released from open containers shall be considered to be a hazardous exhaust system.

8.1.4.3 Equipment Other Than Containers. Heat exchangers, vaporizers, insulation casings surrounding containers, vessels, and coaxial piping systems in which [LH₂] could be trapped due to leakage from the primary container shall be provided with a pressure relief device. [55:8.2.5.3]

8.1.4.4 Sizing.

8.1.4.4.1 Pressure relief devices shall be sized in accordance with the specifications to which the container was fabricated. [55:8.2.5.4.1]

8.1.4.4.2 The pressure relief device shall have the capacity to prevent the maximum design pressure of the container or system from being exceeded. [55:8.2.5.4.2]

8.1.4.5 Accessibility. Pressure relief devices shall be located such that they are accessible for inspection and repair. [55:8.2.5.5]

8.1.4.5.1* ASME pressure relief valves shall be sealed to prevent adjustment of the set pressure by other than authorized personnel. [55:8.2.5.5.1]

8.1.4.5.2 Non-ASME pressure relief valves shall not be field adjusted. [55:8.2.5.5.2]

8.1.4.6 Arrangement.

8.1.4.6.1 Pressure Relief Devices. Pressure relief devices shall be arranged to discharge unobstructed to the open air in such a manner as to prevent impingement of escaping gas on personnel, containers, equipment, and adjacent structures or its entrance into enclosed spaces. [55:8.2.5.6.1]

8.1.4.6.2 Portable Containers with Volume Less than 2.0 ft³ (0.057 m³).

8.1.4.6.2.1 The arrangement of the discharge from pressure relief devices from DOT-specified containers with an internal water volume of 2.0 ft³ (0.057 m³) or less shall be incorporated in the design of the container. [55:8.2.5.6.2.1]

8.1.4.6.2.2 Additional safeguards regarding placement or arrangement shall not be required. [55:8.2.5.6.2.2]

8.1.4.7 Shutoffs Between Pressure Relief Devices and Containers.

8.1.4.7.1 General. Shutoff valves installed between pressure relief devices and containers shall be in accordance with 8.1.4.7. [55:8.2.5.7.1]

8.1.4.7.2 Location. Shutoff valves shall not be installed between pressure relief devices and containers unless the valves or their use meet the requirements of 8.1.4.7.2.1 or 8.1.4.7.2.2. [55:8.2.5.7.2]

8.1.4.7.2.1 Security. Shutoff valves shall be of a locking type, and their use shall be limited to service-related work performed by the supplier under the requirements of the ASME *Boiler and Pressure Vessel Code*. [55:8.2.5.7.2.1]

8.1.4.7.2.2 Multiple Pressure-Relief Devices. Shutoff valves controlling multiple pressure relief devices on a container shall be installed so that either the type of valve installed or the arrangement provides the full required flow through the minimum number of required relief devices at all times. [55:8.2.5.7.2.2]

8.1.4.8 Temperature Limits. Pressure relief devices shall not be subjected to [LH₂] fluid temperatures except when operating. [55:8.2.5.8]

8.1.5 Pressure Relief Vent Piping.

8.1.5.1 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 8.1.5. [55:8.3.1]

8.1.5.2 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. [55:8.3.2]

8.1.5.3 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. [55:8.3.3]

8.1.5.4 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. [55:8.3.4]

8.1.5.5 Overfilling. Controls shall be provided to prevent overfilling of stationary containers. [55:8.3.5]

8.1.6 Marking.

8.1.6.1 General. [LH₂] containers and systems shall be marked in accordance with nationally recognized codes and in accordance with 8.1.6. [55:8.4.1]

8.1.6.1.1 Portable Containers.

8.1.6.1.1.1 Portable [LH₂] containers shall be marked in accordance with CGA C-7, *Guide to the Preparation of Precautionary Labeling and Marking of Compressed Gas Containers*. [55:8.4.1.1.1]

8.1.6.1.1.2* All DOT-4L/TC-4LM liquid cylinders shall have product identification visible from all directions with minimum 2 in. (51 mm) high letters. [55:8.4.1.1.2]

8.1.6.1.2 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*. [55:8.4.1.2]

8.1.6.1.3 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 [LH₂] is stored, handled, or used. [55:8.4.1.3]

8.1.6.2 Identification of Contents. Stationary containers shall be placarded with the identity of their contents to indicate the name of the material contained. [55:8.4.2]

8.1.6.3 Container Specification. Stationary containers shall be marked with the manufacturing specification and maximum allowable working pressure on a permanent nameplate. [55:8.4.3]

8.1.6.3.1 The nameplate shall be installed on the container in an accessible location. [55:8.4.3.1]

8.1.6.3.2 The nameplate shall be marked in accordance with nationally recognized codes. [55:8.4.3.2]

8.1.6.4 Identification of Container Connections.

8.1.6.4.1 Container inlet and outlet connections, liquid-level limit controls, valves, and pressure gauges shall be identified using one of the methods prescribed by 8.1.6.4.1.1 through 8.1.6.4.1.2. [55:8.4.4.1]

8.1.6.4.1.1 They shall be marked with a permanent tag or label identifying their function. [55:8.4.4.1.1]

8.1.6.4.1.2 They shall be identified by a schematic drawing that indicates their function and designates whether they are connected to the vapor or liquid space of the container. [55:8.4.4.1.2]

(A) When a schematic drawing is provided, it shall be attached to the container and maintained in a legible condition. [55:8.4.4.1.2.1]

8.1.6.5 Identification of Piping Systems. Piping systems shall be identified in accordance with ASME A13.1, *Scheme for the Identification of Piping Systems*. [55:8.4.5]

8.1.6.6 Identification of Emergency Shutoff Valves. Emergency shutoff valves on stationary containers shall be identified, visible, and indicated by means of a sign. [55:8.4.6]

8.1.7 Security.

8.1.7.1 General. [LH₂] containers and systems shall be secured against accidental dislodgement and against access by unauthorized personnel in accordance with 8.1.7. [55:8.6.1]

8.1.7.2 Security of Areas. Areas used for the storage of containers and systems shall be secured against unauthorized entry. [55:8.6.2]

8.1.7.3 Securing of Containers. Stationary containers shall be secured to foundations in accordance with the [adopted] building code. [55:8.6.3]

8.1.7.3.1 Portable containers subject to shifting or upset shall be secured. [55:8.6.3.1]

8.1.7.3.2 Nesting shall be permitted as a means of securing portable containers. [55:8.6.3.2]

8.1.7.4 Securing of Vaporizers. Vaporizers, heat exchangers, and similar equipment shall be secured to foundations, and their connecting piping shall be designed and constructed to provide for the effects of expansion and contraction due to temperature changes. [55:8.6.4]

8.1.7.5 Physical Protection. Containers, piping, valves, pressure relief devices, regulating equipment, and other appurtenances shall be protected against physical damage and tampering. [55:8.6.5]

8.1.8 Separation from Hazardous Conditions.

8.1.8.1 General. [LH₂] 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 8.1.8. [55:8.7.1]

8.1.8.1.1* 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 [LH₂] in the container. [55:8.7.2.3]

8.1.9 Electrical Wiring and Equipment.

8.1.9.1 General. Electrical wiring and equipment shall be in accordance with *NFPA 70, National Electrical Code*, and 8.1.9. [55:8.8.1]

8.1.9.2 Location. Containers and systems shall not be located where they could become part of an electrical circuit. [55:8.8.2]

8.1.9.3 Electrical Ground and Bonding. Containers and systems shall not be used for electrical grounding. [55:8.8.3]

8.1.9.3.1 When electrical grounding and bonding are required, the system shall be in accordance with *NFPA 70, National Electrical Code*. [55:8.8.3.1]

8.1.9.3.2 The grounding system shall be protected against corrosion, including corrosion caused by stray electrical currents. [55:8.8.3.2]

8.1.10 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. [55:8.9]

8.1.10.1 Containers. Containers that have been removed from service shall be handled in an approved manner. [55:8.9.1]

8.1.10.1.1 Testing. Containers, out of service in excess of 1 year shall be inspected and tested as required in 8.1.10.1.2. [55:8.9.1.1]

8.1.10.1.2 The pressure relief devices shall be tested for operability and to determine if they are set at the relief pressure required by the tank design. [55:8.9.1.2]

8.1.10.2 Systems. Service and repair of containers or systems shall be performed by trained personnel in accordance with nationally recognized [codes and] standards and with the permission of the container owner. [55:8.9.2]

8.1.11 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. [55:8.10]

8.1.12 Leaks, Damage, and Corrosion.

8.1.12.1 Leaking, damaged, or corroded containers shall be removed from service. [55:8.11.1]

8.1.12.2 Leaking, damaged, or corroded systems shall be replaced, repaired, or removed from service. [55:8.11.2]

8.1.13 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. [55:8.12]

8.1.14 Emergency Shutoff Valves.

8.1.14.1 Accessible manual or automatic emergency shutoff valves shall be provided to shut off the LH₂ supply in case of emergency.

8.1.14.1.1 Emergency shutoff valves on a bulk source or piping systems serving the bulk supply shall be identified by means of a sign.

8.1.14.1.2 Emergency shutoff valves shall be located at the point of use, at the source of supply, and at the point where the system piping enters the building.

8.1.15 Dispensing Areas. Dispensing of [LH₂] associated with physical or health hazards shall be conducted in approved locations. [55:8.14.11.3.2]

8.1.15.1 Indoor Dispensing Areas. Dispensing indoors shall be conducted in areas constructed in accordance with the [adopted] building code. [55:8.14.11.3.2.1]

8.1.15.2 Ventilation. Indoor areas in which [LH₂] are dispensed shall be ventilated in accordance with the requirements of Section 6.17 and the [adopted mechanical code]. [55:8.14.11.3.2.2]

8.1.15.3 Piping Systems. Piping systems utilized for filling or dispensing of [LH₂] shall be designed and constructed in accordance with 8.2.3.1.2. [55:8.14.11.3.2.3]

8.1.16 Operation.

8.1.16.1 Securing Equipment. Mobile LH₂ supply units used as part of a hydrogen system shall be restrained to resist movement.

8.1.16.2 Bonding and Grounding. The [mobile LH₂ supply units] shall be electrically bonded and grounded. [55:11.2.7]

8.2 Nonbulk LH₂.

8.2.1 Nonbulk LH₂ General. The storage, use, and handling of [LH₂ in LH₂] storage systems shall be in accordance with the provisions of Chapters 1 through 6, and Chapter 8 as applicable. [55:11.1.1]

8.2.1.1 Containers and systems having a total LH₂ content of more than 39.7 gal (150 L) shall be in accordance with Section 8.3.

8.2.2 Nonbulk LH₂ Storage.

8.2.2.1 General.

8.2.2.2 Indoor Storage.

8.2.2.2.1 Installation. Stationary containers stored indoors shall be installed in accordance with Sections 8.1 and 8.2.

8.2.2.2.2 Stationary Containers. Stationary containers shall be in accordance with 8.1.2. [55:8.13.1.2]

8.2.2.2.3 [Storage Locations LH₂]. [LH₂] in stationary or portable containers stored indoors shall be stored in buildings, rooms, or areas constructed in accordance with the [adopted] building code. [55:8.13.1.3]

8.2.2.2.4 Ventilation. Ventilation shall be in accordance with Section 6.17. [55:8.13.1.4]

8.2.2.2.5 Installation of LH₂ Inside Buildings Other Than Detached Buildings and Gas Rooms. Portable LH₂ containers of [39.7 gal (150 L) or less capacity] where housed inside buildings, not located in a gas room, and exposed to other occupancies shall comply with the following minimum requirements: [55:11.3.3]

- (1) Containers shall be located 20 ft (6.1 m) from all classes of flammable or combustible liquids and combustible materials such as excelsior or paper. [55:11.3.3(1)]
- (2) Containers shall be located 25 ft (7.6 m) from ordinary electrical equipment and other sources of ignition, including process or analytical equipment. (See 8.1.8.) [55:11.3.3(2)]
- (3) Containers shall be located 50 ft (15 m) from intakes for ventilation, air-conditioning equipment, or compressors. [55:11.3.3(3)]
- (4) Containers shall be located 50 ft (15 m) from the storage or use of other flammable gases or the storage or use of incompatible gases. [55:11.3.3(4)]
- (5) Containers shall be protected against physical damage in accordance with the requirements of 8.1.7.5. [55:11.3.3(5)]
- (6) Containers shall be secured in accordance with 8.1.7.3. [55:11.3.3(6)]

(7) Welding or cutting operations and smoking shall be prohibited while hydrogen is in the room, and signs shall be provided as required by 4.13.3. [55:11.3.3(7)]

(8) Ventilation shall be provided in accordance with Section 6.17. [55:11.3.3(8)]

(9) Pressure-relief devices on stationary or portable containers shall be vented directly outdoors or to an exhaust hood. (See 8.1.4.6) [55:11.3.3(9)]

8.2.2.3 Outdoor Storage.

8.2.2.3.1 General.

8.2.2.3.1.1 [LH₂] in stationary or portable containers stored outdoors shall be in accordance with 8.2.2.3. [55:8.13.2.1]

8.2.2.3.1.2 Enclosed Courts. [-] containers shall not be installed within [outdoor] enclosed courts. [55:8.13.2.7.1]

8.2.2.3.2 Distance to Exposures.

8.2.2.3.2.1 General. [LH₂] 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 8.2.2.3.2. [55:8.7.1]

8.2.2.3.3 Surfaces Beneath Containers. The surface of the area on which stationary containers are placed, including the surface of the area located below the point at which connections are made for the purpose of filling such containers, shall be compatible with the [LH₂] in the container. [55:8.7.2.3]

8.2.2.3.4 Distance to Exposures. The outdoor use of [LH₂] shall be located from lot lines, public streets, public alleys, public ways, or buildings not associated with the manufacture or distribution of [GH₂] in accordance with Table 8.2.2.3.4. [55:7.6.2]

8.2.2.3.4.1 Fire Barriers. A 2-hour fire barrier wall shall be permitted in lieu of the distances specified by Table 8.2.2.3.4 when in accordance with the provisions of 8.2.2.3.4.1(A) through 8.2.2.3.4.1(E). [55:8.7.3.1]

(A) The fire barrier wall shall be without openings or penetrations. [55:8.7.3.1.1]

(B) Penetrations of the fire barrier wall by conduit or piping shall be permitted provided that the penetration is protected with a firestop system in accordance with the building code. [55:8.7.3.1.1.1]

(C) The fire barrier wall shall be either an independent structure or the exterior wall of the building adjacent to the storage system. [55:8.7.3.1.2]

(D) The fire barrier wall shall be located not less than 5 ft (1.5 m) from any exposure. [55:8.7.3.1.3]

(E) The fire barrier wall shall not have more than two sides at approximately 90 degree (1.57 rad) directions or not more than three sides with connecting angles of approximately 135 degrees (2.36 rad). [55:8.7.3.1.4]

8.2.2.3.4.2 Air Intakes. Storage of [LH₂] shall not be located within 50 ft (15.2 m) of air intakes. [55:7.6.2.4]

8.2.2.3.4.3 Building Openings. Storage of [LH₂] outside of buildings shall also be separated from building openings by 25 ft (7.6 m). Fire barriers shall be permitted to be used as a means to separate storage areas from openings or a means of egress used to access the public way. [55:7.6.2.5]

Table 8.2.2.3.4 Distance to Exposures for [LH₂]^{a, b, c}

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

For SI units: 1 ft = 304.8 mm³ = 0.02832 m³.

Notes:

[(a) For requirements on minimum distance to air intakes, see 8.2.2.3.4.2.]

[(b) For requirements on minimum distance to building openings including exits, see 8.2.2.3.4.3.]

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

[55: Table 7.6.2]

8.2.2.3.5 Access.

8.2.2.3.5.1 Stationary containers shall be located to provide access by mobile supply equipment and authorized personnel. [55:8.13.2.2]

8.2.2.3.5.2 Where exit access is provided to serve areas in which equipment is installed, the minimum width shall be not less than 28 in. (710 mm). [55:8.13.2.2.1]

8.2.2.3.6 Physical Protection.

8.2.2.3.6.1 [LH₂] containers, cylinders, tanks, and systems that could be exposed to physical damage shall be protected. [55:8.13.2.3]

8.2.2.3.6.2 Guard posts or other means shall be provided to protect [LH₂] containers, cylinders, tanks, and systems indoors and outdoors from vehicular damage. (See Section 4.14). [55:8.13.2.3.1]

8.2.2.3.7 Diked Areas Containing Other Hazardous Materials. Containers of [LH₂] shall not be located within diked areas with other hazardous materials. [55:8.13.2.4]

8.2.2.3.8* Areas Subject to Flooding. Stationary containers located in flood hazard areas shall be anchored to prevent flotation during conditions of the design flood as designated by the [adopted] building code. [55:8.13.2.5]

8.2.2.3.8.1 Elevated Tanks. Structures supporting elevated tanks and tanks that are supported at a level above that designated in the design flood shall be anchored to resist lateral shifting due to flood and other hydrostatic effects. [55:8.13.2.5.1]

8.2.2.3.8.2 Underground Tanks. Underground tanks in flood hazard areas shall be anchored to prevent flotation, collapse or lateral movement resulting from hydrostatic loads, including the effects of buoyancy, during conditions of the design flood. [55:8.13.2.5.2]

8.2.2.3.9 Drainage.

8.2.2.3.9.1 The area surrounding stationary and portable containers shall be provided with a means to prevent accidental discharge of [LH₂] from endangering personnel, containers, equipment, and adjacent structures and from entering enclosed spaces in accordance with [the adopted fire prevention code]. [55:8.13.2.6.1]

8.2.2.3.9.2 The stationary container shall not be placed where spilled or discharged [LH₂] will be retained around the container. [See 8.2.2.3.7] [55:8.13.2.6.2]

8.2.2.3.9.3 The provisions of 8.2.2.3.8.2 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: [55:8.13.2.6.3]

- (1) Crushed rock utilized as a heat sink [55:8.13.2.6.3(1)]
- (2) Topographical conditions [55:8.13.2.6.3(2)]
- (3) Nature of occupancy [55:8.13.2.6.3(3)]
- (4) Proximity to structures on the same or adjacent property [55:8.13.2.6.3(4)]
- (5) Capacity and construction of containers and character of fluids to be stored [55:8.13.2.6.3(5)]

8.2.2.3.9.4 Grade.

(A) The grade for a distance of not less than 50 ft (15.2 m) from where [LH₂] storage or delivery systems are installed shall be higher than the grade on which flammable or combustible liquids are stored or used. [55:8.13.2.6.4]

(B)* Drainage Control.

- (1) When the grade differential between the storage or delivery system and the flammable or combustible liquids storage or use area is not in accordance with 8.2.2.3.9.4(A), diversion curbs or other means of drainage control shall be used to divert the flow of flammable or combustible liquids away from the [LH₂] system. [55:8.13.2.6.4.1(A)]



- (2) The means of drainage control shall prevent the flow of flammable or combustible liquid to a distance not less than 50 ft (15.2 m) from all parts of the delivery system. [55:8.13.2.6.4.1(B)]

8.2.3 Nonbulk LH₂ Use.

8.2.3.1 General.

8.2.3.1.1 General. Use and handling of containers and systems shall be in accordance with 8.2.3.1.1 through 8.2.3.1.10.2. [55:8.14.1]

8.2.3.1.1.1 Operating Instructions. Operating instructions shall be provided for installations that require the operation of equipment. [55:8.14.1.1]

8.2.3.1.1.2 Attended Delivery. A qualified person shall be in attendance at all times [LH₂] is transferred from mobile supply units to a storage system. [55:8.14.1.2]

8.2.3.1.1.3 Inspection.

(A) [LH₂] storage systems shall be inspected annually and maintained by a qualified representative of the equipment owner. [55:8.14.1.3.1]

(B) A record of the inspection shall be prepared and provided to the user or the authority having jurisdiction upon request. [55:8.14.1.3.2]

8.2.3.1.1.4 Design.

(A) Nationally Recognized Good Practices. Where nationally recognized good practices or [codes and] standards have been established for the process employed, such practices and [codes and] standards shall be followed. [55:8.14.1.4.1]

(B) Piping Systems. Piping, tubing, fittings and related components shall be designed, fabricated, and tested in accordance with the requirements of ANSI/ASME B31.3, *Process Piping*, or other approved standards and shall be in accordance with 8.2.3.1.2. [55:8.14.1.4.2]

8.2.3.1.2 Piping and Appurtenances.

8.2.3.1.2.1 Piping systems shall be designed for the use intended through the full range of pressure and temperature to which they will be subjected. [55:8.14.2.1]

8.2.3.1.2.2 Piping systems shall be designed and constructed to allow for expansion, contraction, vibration, settlement, and fire exposure. [55:8.14.2.2]

8.2.3.1.3 Joints. Joints in piping and tubing shall be permitted to be made by welding or brazing, or by use of flanged, threaded, socket, slip, or compression fittings. [55:8.14.3]

8.2.3.1.4 Valves and Accessory Equipment. Valves and accessory equipment shall be acceptable for the intended use at the temperatures of the application and shall be designed and constructed to withstand the maximum pressure at the minimum temperature to which they will be subjected. [55:8.14.4]

8.2.3.1.5 Shutoff Valves on Containers. Shutoff valves shall be provided on all container connections, except for pressure relief devices. [55:8.14.5]

8.2.3.1.5.1 Shutoff valves for containers with multiple pressure relief devices shall be permitted in accordance with 8.1.4.7. [55:8.14.5.1]

8.2.3.1.5.2 Shutoff valves shall be accessible and located as close as practical to the container. [55:8.14.5.2]

8.2.3.1.6 Shutoff Valves on Piping.

8.2.3.1.6.1 Shutoff valves shall be installed in piping containing [LH₂] where needed to limit the volume of liquid discharged in the event of piping or equipment failure. [55:8.14.6.1]

8.2.3.1.6.2 Pressure relief valves shall be installed where liquid can be trapped between shutoff valves in the piping system. (See 8.1.4.) [55:8.14.6.2]

8.2.3.1.7 Physical Protection and Support.

8.2.3.1.7.1 Aboveground piping systems shall be supported and protected from physical damage. [55:8.14.7.1]

8.2.3.1.7.2 Piping passing through walls shall be protected from mechanical damage. [55:8.14.7.2]

8.2.3.1.8 Corrosion Protection.

8.2.3.1.8.1 Aboveground piping that is subject to corrosion shall be protected against corrosion. [55:8.14.8.1]

8.2.3.1.8.2 Belowground piping shall be protected against corrosion. [55:8.14.8.2]

8.2.3.1.9 Cathodic Protection. Where required, cathodic protection shall be in accordance with 8.2.3.1.9. [55:8.14.9]

8.2.3.1.9.1 Operation. When installed, cathodic protection systems shall be operated and maintained to continuously provide corrosion protection. [55:8.14.9.1]

8.2.3.1.9.2 Inspection.

(A) Container systems equipped with cathodic protection shall be inspected for proper operation by a cathodic protection tester. [55:8.14.9.2.1]

(B) The cathodic protection tester shall be certified as being qualified by the National Association of Corrosion Engineers, International (NACE). [55:8.14.9.2.2]

8.2.3.1.9.3 Impressed Current Systems.

(A) Systems equipped with impressed current cathodic protection systems shall be inspected in accordance with the requirements of the design and 8.2.3.1.9.2. [55:8.14.9.3.1]

(B) The design limits shall be available to the AHJ upon request. [55:8.14.9.3.2]

(C) The system owner shall maintain the following records to demonstrate that the cathodic protection is in conformance with the design: [55:8.14.9.3.3]

- (1) The results of inspections of the system [55:8.14.9.3.3(1)]
- (2) The results of testing that has been completed [55:8.14.9.3.3(2)]

8.2.3.1.9.4 Corrosion Expert.

8.2.3.1.9.5 Repairs, maintenance, or replacement of a cathodic protection system shall be under the supervision of a corrosion expert certified by NACE. [55:8.14.9.4]

(A) The corrosion expert shall be certified by NACE as a senior corrosion technologist, a cathodic protection specialist, or a corrosion specialist or shall be a registered engineer with registration in a field that includes education and experience in corrosion control. [55:8.14.9.4.1]

8.2.3.1.10 Testing.

8.2.3.1.10.1 Piping systems shall be tested and proven free of leaks after installation as required by the codes to which they are designed and constructed. [55:8.14.10.1]