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2

Hydrogen Technologies Code

2023



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NFPA® 2

Hydrogen Technologies Code

2023 Edition



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NFPA® 2

Hydrogen Technologies Code

2023 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 November 29, 2022, with an effective date of December 19, 2022, and supersedes all previous editions.

This edition of NFPA 2 was approved as an American National Standard on December 19, 2022.

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 hyphen [-] 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 brackets around the differing language and pure deletions of text are shown with [-].

The 2016 edition of NFPA 2 was more closely aligned with the requirements in NFPA 55 for gaseous and liquefied hydrogen systems. Both documents were in the same revision cycle, which allowed the technical committees to work more closely together on revisions to the joint content. The requirements for hydrogen generation systems in NFPA 2 (Chapter 13) were no longer extracted from NFPA 55, and the requirements for hydrogen fueling systems (Chapters 10 and 11) were no longer extracted from NFPA 52. The Technical Committee on Hydrogen Technology had primary responsibility for those requirements.

The 2016 edition had the following changes:

- (1) Significant revisions to Chapter 10, Gaseous Vehicle Fueling Facilities, that reflected significant efforts by the technical committee in improving this chapter
- (2) Clarification and organization of the requirements for gaseous hydrogen systems into three tiers based on the quantity of hydrogen stored: less than or equal to the maximum allowable quantity (MAQ), greater than the MAQ but less than the bulk quantity, and bulk systems
- (3) Changes to the requirements in Chapter 7 for emergency isolation consistent with the changes made to NFPA 55
- (4) New requirements for hydrogen equipment enclosures to address the growing use of these systems in a variety of field applications
- (5) New chapters for parking garages and repair garages for hydrogen fuel cell vehicles

For the 2020 edition of NFPA 2, several updates were made to both Chapter 10, GH_2 Vehicle Fueling Facilities, and Chapter 18, Repair Garage. Changes made to Chapter 10 focused on addressing fueling protocols, authorized fueling, signage, and vehicle to station communication protocols. With the inclusion of these updates, Chapter 10 was restructured to maintain clarity for the user. Chapter 18 was revised to be limited to only apply to LH_2 applications. The changes made

to Chapter 18 enhance the ease of repair garages to accept hydrogen as an alternative motor fuel while properly addressing the additional hazards the repair and servicing of these vehicles can present without reducing the level of protection currently required.

For the 2023 edition, the word “permitted” has been changed to “allowed” throughout the code to avoid misinterpreting the code to require a permit be acquired to align with code requirements. Any language originally extracted from NFPA 55 that has been maintained in the code has had the NFPA 55 extract citation removed, since the scope of this code has primacy for the development of gaseous and liquid hydrogen requirements.

Where mechanical ventilation is being used to reduce the area classification as prescribed in Chapter 6, new requirements have been developed that mandate detection of loss of ventilation be provided.

Chapter 7 has added a new section for GH_2 -filled meteorological and piloted balloons, as well as a new section that identifies minimum design features for courts and enclosed courts that contain bulk gaseous hydrogen gas systems.

Using risk-informed leak size and conservative model assumptions, the separation distances for liquified hydrogen systems in Chapter 8 have been revised. Annex N has been created that explains the methodology utilized to develop these liquid hydrogen separation distances.

In Chapter 10, the vehicle fueling connection nozzle must now be rated to the same or lower pressure class as the fuel supply containers being fueled in order to prevent serious equipment damage. New Section 10.7 addresses compact hydrogen fueling systems (cHFS). These changes require cHFSs to be listed or approved, and a clear delineation has been made between larger hydrogen systems and the smaller cHFS. Additionally, cHFS enclosures must be designed to allow access, inspection, service, repair, and replacement of hardware and cannot be categorized as gas cabinets or gas rooms.

Also in Chapter 10, requirements for the design and construction as it applies to the piping and hoses, vent systems, and buffer capacity for outdoor nonpublic home fueling appliances (HFAs) have been developed. This also includes new requirements for the appliance access and installation of HFAs.

Revisions have been provided in Chapter 10 to clarify the difference between on-demand mobile fueling and outdoor nonpublic mobile fleet fueling. Definitions for *mobile fueling vehicle* and *mobile fueling trailer* have been added to Chapter 3 to add clarity to those revisions.

To provide further guidance for the delivery of hydrogen to fuel stations, additional cargo transport unloading requirements have been added to Chapters 10 and 11.

A new Chapter 19 for hydrogen-powered industrial trucks (HPITs) has been created that applies to the design, construction, and use of HPITs.

Annexes E and I have been consolidated to avoid confusion for NFPA 2 historical references. A new annex, Annex M, has been added that provides guidelines and practices for repairing leaks in hydrogen systems.

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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. This Committee shall be referred to by the Technical Committee on Industrial and Medical Gases for any material on gaseous and liquid hydrogen storage and use.

Contents

Chapter 1 Administration	2- 6	6.17 Vent System Termination.	2- 32
1.1 Scope.	2- 6	6.18 Ventilation.	2- 33
1.2 Purpose.	2- 6	6.19 Gas Cabinets.	2- 33
1.3 Application.	2- 6	6.20 Exhausted Enclosures.	2- 33
1.4 Retroactivity.	2- 6	6.21 Source Valve.	2- 34
1.5 Equivalency.	2- 6	6.22 Cleaning, Purging, and Repairing of Piping Systems.	2- 34
1.6 Units and Formulas.	2- 6		
1.7 Enforcement.	2- 7	Chapter 7 Gaseous Hydrogen	2- 34
Chapter 2 Referenced Publications	2- 7	7.1 General.	2- 34
2.1 General.	2- 7	7.2 Non-Bulk GH ₂	2- 42
2.2 NFPA Publications.	2- 7	7.3 Bulk GH ₂ Systems.	2- 44
2.3 Other Publications.	2- 7	Chapter 8 Liquefied Hydrogen	2- 50
2.4 References for Extracts in Mandatory Sections. ...	2- 8	8.1 General.	2- 50
Chapter 3 Definitions	2- 9	8.2 Non-Bulk LH ₂	2- 54
3.1 General.	2- 9	8.3 Bulk LH ₂ Systems.	2- 57
3.2 NFPA Official Definitions.	2- 9	Chapter 9 Explosion Protection (Reserved)	2- 65
3.3 General Definitions.	2- 9	Chapter 10 GH₂ Vehicle Fueling Facilities	2- 65
3.4 Definitions for Performance-Based Designs.	2- 19	10.1 Scope.	2- 65
Chapter 4 General Fire Safety Requirements	2- 20	10.2 General.	2- 65
4.1 Application.	2- 20	10.3 Design.	2- 66
4.2 Goals and Objectives.	2- 20	10.4 Installation.	2- 68
4.3 Assumptions.	2- 21	10.5 Dispensing.	2- 69
4.4 Compliance Options.	2- 22	10.6 Maintenance.	2- 74
4.5 Permits.	2- 22	10.7 Compact Hydrogen Fueling System (CHFS).	2- 74
4.6 Emergency Plan.	2- 22	10.8 Outdoor Nonpublic Home Fueling Appliances (HFA).	2- 75
4.7 Facility Closure.	2- 22	10.9 Outdoor Nonpublic Mobile Fleet Fueling.	2- 76
4.8 Out-of-Service Stationary Bulk Gas Systems.	2- 22	10.10 On-Demand Mobile Fueling.	2- 76
4.9 Management Plan and Hazardous Materials Documentation.	2- 22	Chapter 11 LH₂ Fueling Facilities	2- 77
4.10 Release of GH ₂ or LH ₂	2- 23	11.1 Scope.	2- 77
4.11 Personnel Training.	2- 23	11.2 General.	2- 78
4.12 Ignition Source Controls.	2- 24	11.3 Dispensing.	2- 80
4.13 Signs.	2- 24	11.4 Storage.	2- 84
4.14 Protection From Vehicular Damage.	2- 24	Chapter 12 Hydrogen Fuel Cell Power Systems	2- 84
4.15 Building Construction Materials.	2- 25	12.1 Scope.	2- 84
Chapter 5 Performance-Based Option	2- 25	12.2 General.	2- 84
5.1 General.	2- 25	12.3 Specific Requirements.	2- 84
5.2 Performance Criteria.	2- 26	12.4 Storage.	2- 85
5.3 Retained Prescriptive Requirements.	2- 27	Chapter 13 Hydrogen Generation Systems	2- 85
5.4 Design Scenarios.	2- 27	13.1 Scope.	2- 85
5.5 Evaluation of Proposed Designs.	2- 28	13.2 General.	2- 85
5.6 Safety Factors.	2- 29	13.3 Electrolyzers.	2- 86
5.7 Documentation Requirements.	2- 29	13.4 Catalytic-Reforming-Based Hydrogen Generation Systems.	2- 86
Chapter 6 General Hydrogen Requirements	2- 29	13.5 Gasifiers.	2- 86
6.1 General.	2- 29	13.6 Storage.	2- 88
6.2 Design and Construction.	2- 29	Chapter 14 Combustion Applications	2- 88
6.3 Control Areas.	2- 29	14.1 Scope.	2- 88
6.4 Occupancy Classification.	2- 30	14.2 General. (Reserved)	2- 88
6.5 Piping.	2- 30	14.3 Use.	2- 88
6.6 Gas Rooms.	2- 31	Chapter 15 Special Atmosphere Applications	2- 89
6.7 Weather Protection.	2- 31	15.1 Scope.	2- 89
6.8 Electrical Equipment.	2- 32	15.2 General. (Reserved)	2- 89
6.9 Employee Alarm System.	2- 32	15.3 Use.	2- 89
6.10 Explosion Control.	2- 32	15.4 Storage.	2- 102
6.11 Fire Protection Systems.	2- 32	Chapter 16 Laboratory Operations	2- 102
6.12 Fire Alarm Systems.	2- 32	16.1 Scope.	2- 102
6.13 GH ₂ Detection Systems.	2- 32		
6.14 Lighting.	2- 32		
6.15 Spill Control, Drainage, and Secondary Containment.	2- 32		
6.16 Shelving.	2- 32		

16.2	General.	2– 102	Annex D	Physical Properties of Hydrogen	2– 171
16.3	Use.	2– 103	Annex E	Explanation of Methodology Utilized to Develop Separation Distances	2– 171
16.4	Storage.	2– 109	Annex F	Example of Class C Furnace Operational and Maintenance Checklist	2– 196
Chapter 17	Parking Garages	2– 109	Annex G	OSHA Requirements for Hydrogen Systems	2– 197
17.1	Scope.	2– 109	Annex H	Information on Explosion Hazards and Protection in Laboratories	2– 199
17.2	Application.	2– 109	Annex I	Safety Tips for Compressed Gas Users	2– 203
17.3	Parking Garages.	2– 109	Annex J	Design Standard References	2– 205
Chapter 18	Repair Garage	2– 110	Annex K	Hydrogen Explosion Control	2– 205
18.1	Scope.	2– 110	Annex L	Hydrogen Detection Systems	2– 211
18.2	Applicability.	2– 110	Annex M	Guidelines and Practices for Repairing Leaks in Hydrogen Systems	2– 212
18.3	General.	2– 110	Annex N	Explanation of Methodology Utilized to Develop Liquid Hydrogen Separation Distances	2– 213
18.4	Light-Duty Hydrogen Motor Vehicle Repair Garages. (Reserved)	2– 112	Annex O	Informational References	2– 216
18.5	Heavy-Duty Hydrogen Motor Vehicle Repair Garages.	2– 112	Index		2– 224
18.6	Hydrogen-Powered Industrial Truck Repair Garages.	2– 112			
Chapter 19	Hydrogen-Powered Industrial Trucks (HPITs)	2– 113			
19.1	Scope.	2– 113			
19.2	General.	2– 113			
19.3	Indoor Use.	2– 113			
19.4	Fueling.	2– 113			
19.5	Maintenance, Service, and Repairs.	2– 113			
Annex A	Explanatory Material	2– 113			
Annex B	Administration	2– 164			
Annex C	Sample Ordinance Adopting NFPA 2	2– 170			

NFPA 2

Hydrogen Technologies Code

2023 Edition

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

Chapter 1 Administration

1.1 Scope. This code shall apply to the production, storage, transfer, and use of hydrogen.

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

1.3.2 The fundamental requirements of Chapters 1 and 4 through 8 shall apply in addition to the use-specific requirements provided in Chapters 9 through 18, as applicable.

Δ 1.3.3 Exemptions. This code shall not apply to the following:

- (1) Design or components related to the transport of hydrogen or propulsion of hydrogen motor vehicles, including onboard hydrogen storage systems
- (2) Mixtures of GH₂ and other gases with a hydrogen concentration of less than 95 percent by volume when in accordance with NFPA 55

- (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 (AHJ) determines that the existing situation presents an unacceptable degree of risk, the AHJ 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 would be impractical in the judgment of the AHJ, and only where it is 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 AHJ to demonstrate equivalency.

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

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 code 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 AHJ 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 where 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*, 2021 edition.
- NFPA 10, *Standard for Portable Fire Extinguishers*, 2022 edition.
- NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam*, 2020 edition.
- NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*, 2022 edition.
- NFPA 12A, *Standard on Halon 1301 Fire Extinguishing Systems*, 2022 edition.
- NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2022 edition.
- NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*, 2019 edition.
- NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*, 2022 edition.
- NFPA 17, *Standard for Dry Chemical Extinguishing Systems*, 2021 edition.
- NFPA 17A, *Standard for Wet Chemical Extinguishing Systems*, 2021 edition.
- NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, 2023 edition.
- NFPA 30, *Flammable and Combustible Liquids Code*, 2021 edition.
- NFPA 30A, *Code for Motor Fuel Dispensing Facilities and Repair Garages*, 2021 edition.
- NFPA 31, *Standard for the Installation of Oil-Burning Equipment*, 2020 edition.
- NFPA 45, *Standard on Fire Protection for Laboratories Using Chemicals*, 2019 edition.
- NFPA 54, *National Fuel Gas Code*, 2021 edition.
- NFPA 55, *Compressed Gases and Cryogenic Fluids Code*, 2023 edition.
- NFPA 58, *Liquefied Petroleum Gas Code*, 2023 edition.
- NFPA 68, *Standard on Explosion Protection by Deflagration Venting*, 2018 edition.
- NFPA 69, *Standard on Explosion Prevention Systems*, 2019 edition.
- NFPA 70®, *National Electrical Code®*, 2023 edition.
- NFPA 72®, *National Fire Alarm and Signaling Code®*, 2022 edition.
- NFPA 77, *Recommended Practice on Static Electricity*, 2019 edition.
- NFPA 79, *Electrical Standard for Industrial Machinery*, 2021 edition.

NFPA 80, *Standard for Fire Doors and Other Opening Protectives*, 2022 edition.

NFPA 86, *Standard for Ovens and Furnaces*, 2023 edition.

NFPA 88A, *Standard for Parking Structures*, 2023 edition.

NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems*, 2021 edition.

NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Particulate Solids*, 2020 edition.

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

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

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

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

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

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

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

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

NFPA 750, *Standard on Water Mist Fire Protection Systems*, 2023 edition.

NFPA 853, *Standard for the Installation of Stationary Fuel Cell Power Systems*, 2020 edition.

NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems*, 2022 edition.

2.3 Other Publications.

2.3.1 AIHA Publications. American Industrial Hygiene Association, 3141 Fairview Park Dr., Suite 777, Falls Church, VA 22042.

ANSI/AIHA Z9.5, *Laboratory Ventilation*, 2012.

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

ANSI/IEEE C2, *National Electrical Safety Code*, 2017.

ANSI Z535.1, *Safety Colors*, 2017.

ANSI Z535.2, *Environmental and Facility Safety Signs*, 2011 (reaffirmed 2017).

ANSI Z535.3, *Criteria for Safety Symbols*, 2011 (reaffirmed 2017).

ANSI Z535.4, *Product Safety Signs and Labels*, 2011 (reaffirmed 2017).

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

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

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

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

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

ASME *Boiler and Pressure Vessel Code*, “Rules for the Construction of Unfired Pressure Vessels,” Section VIII, Division 1, 2019.

2.3.4 ASTM Publications. ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

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

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

ASTM E1529, *Determining Effects of Large Hydrocarbon Pool Fire on Structural Members and Assemblies*, 2016e1.

ASTM E1591, *Standard Guide for Data for Fire Models*, 2020.

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

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

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

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

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

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

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

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

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

2.3.6 CSA Group Publications. CSA Group, 178 Rexdale Boulevard, Toronto, ON M9W 1R3, Canada.

ANSI/CSA FC 1, *Fuel Cell Technologies — Part 3-100: Stationary fuel cell power systems — Safety*, 2014 (reaffirmed 2018).

ANSI/CSA America FC 3, *Portable Fuel Cell Power Systems*, 2004 (reaffirmed 2017).

CSA/ANSI HGV 4.3, *Test Methods for Hydrogen Fueling Parameter Evaluation*, 2019.

2.3.7* CTC Publications. Canadian Transportation Agency, 15 Eddy Street, Gatineau, Quebec J8X 4B3.

Transportation of Dangerous Goods Regulations.

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

International Fire Code (IFC), 2021.

International Fuel Gas Code (IFGC), 2021.

2.3.9 IEC Publications. International Electrotechnical Commission, 3, rue de Varembe, P.O. Box 131, CH-1211 Geneva 20, Switzerland.

IEC 60079-10-1, *Explosive atmospheres — Part 10-1: Classification of areas — Explosive gas atmospheres*, 2020.

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

ISO 16110-1, *Hydrogen generators using fuel processing technologies — Part 1: Safety*, 2016.

ISO 17268, *Gaseous hydrogen land vehicle refuelling connection devices*, 2020.

2.3.11 SAE Publications. SAE International, Society of Automotive Engineers, 901 15th Street, NW, Suite 520, Washington, DC 20005, www.SAE.org.

SAE J2579 201806, *Standard for Fuel Systems in Fuel Cell and Other Hydrogen Vehicles*, 2018.

SAE J2600, *Compressed Hydrogen Surface Refueling Connection Devices*, 2015.

SAE J2601-3, *Fueling Protocol for gaseous Hydrogen Powered Industrial Trucks*, 2013.

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

UL 263, *Fire Tests of Building Construction and Materials*, 2019.

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

UL 61010-1, *Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use — Part 1: General Requirements*, 2019.

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

Title 29, Code of Federal Regulations, Part 1910.1000, “Air contaminants.”

Title 49, Code of Federal Regulations, Parts 100–199, “Pipeline and Hazardous Materials Safety Administration, Department of Transportation.”

Title 49, Code of Federal Regulations, Part 571.108, “Lamps, Reflective Devices, and Associated Equipment.”

2.3.14 Other Publications.

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

UN Global Technical Regulation No. 13, *Global technical regulation on hydrogen and fuel cell vehicles*, 2013.

2.4 References for Extracts in Mandatory Sections.

NFPA 1, *Fire Code*, 2021 edition.

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

NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes*, 2022 edition.

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

NFPA 30A, *Code for Motor Fuel Dispensing Facilities and Repair Garages*, 2021 edition.

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

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

NFPA 54, *National Fuel Gas Code*, 2021 edition.

NFPA 56, *Standard for Fire and Explosion Prevention During Cleaning and Purging of Flammable Gas Piping Systems*, 2020 edition.

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

NFPA 70®, *National Electrical Code®*, 2020 edition.

NFPA 80, *Standard for Fire Doors and Other Opening Protectives*, 2022 edition.

NFPA 86, *Standard for Ovens and Furnaces*, 2023 edition.

NFPA 88A, *Standard for Parking Structures*, 2023 edition.

NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Particulate Solids*, 2020 edition.

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

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

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

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

NFPA 820, *Standard for Fire Protection in Wastewater Treatment and Collection Facilities*, 2020 edition.

NFPA 853, *Standard for the Installation of Stationary Fuel Cell Power Systems*, 2020 edition.

NFPA 921, *Guide for Fire and Explosion Investigations*, 2021 edition.

NFPA 5000®, *Building Construction and Safety Code®*, 2021 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 3.3.238.4.1.

3.3.2 Aboveground Tank. See 3.3.238.1.

3.3.3 Absolute Pressure. See 3.3.197.1.

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, 2019]

▲ **3.3.4.2 Exhaust Air.** Air removed from a space and not reused.

▲ **3.3.4.3 Ventilation Air.** The portion of supply air, the source of which is the outside/outdoors, plus any recirculated air that has been treated and is acceptable for use that can be used for circulation, dilution, and/or primary air applications.

3.3.5 Apparatus. Furniture, chemical fume hoods, centrifuges, refrigerators, and commercial or made-on-site equipment used in a laboratory. [45, 2019]

3.3.6 Attendant. An employee or authorized person who oversees a motor fuel dispensing facility.

3.3.7 Area.

▲ **3.3.7.1 Control Area.** A building or portion of a building or outdoor area within which hazardous materials are allowed to be stored, dispensed, used, or handled in quantities not exceeding the MAQ. [400, 2022]

▲ **3.3.7.2 Indoor Area.** An area that is within a building or structure having overhead cover, other than a structure qualifying as “weather protection.” (See also 3.3.7.5, *Outdoor Area*.)

3.3.7.3 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, 2019]

3.3.7.4 Nonlaboratory Area. Any space within a [laboratory] building not included in a laboratory unit. (See also 3.3.14.2 and 3.3.245.1.) [45, 2019]

▲ **3.3.7.5 Outdoor Area.** An area that is not an indoor area.

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

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

3.3.9 ASTM. American Society for Testing and Materials.

3.3.10 Automatic Emergency Shutoff Valve. See 3.3.252.1.1.

3.3.11 Automatic Fire Detection System. See 3.3.237.1.

3.3.12 Auxiliary Air. See 3.3.4.1.

3.3.13 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, 2021]

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

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

3.3.14.2 Laboratory Building. A structure consisting wholly or principally of one or more laboratory units. (See also 3.3.245.1, *Laboratory Unit*.) [45, 2019]

3.3.15 Building Code. See 3.3.40.1.

3.3.16 Bulk Hydrogen Compressed Gas System. See 3.3.237.2.

3.3.17 Bulk Liquefied Hydrogen Gas System. See 3.3.237.3, Bulk Liquefied Hydrogen (LH₂) System.

3.3.18 Bulk Oxygen System. See 3.3.237.4.

3.3.19 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, 2023]

3.3.20 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, 2023]

3.3.21 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, 2023]

3.3.22 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, 2019]

3.3.23 Cabinet.

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

3.3.23.2 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, 2019]

3.3.24 Canopy. A permanent structure or architectural projection of rigid construction over which a covering is attached that provides weather protection, identity, or decoration.

3.3.25 Canopy Hood. See 3.3.120.1.

3.3.26 Capacity [Vehicular Fuel Container]. The water volume of a container in gallons (liters). [52, 2023]

3.3.27 Cargo Transport Vehicle. A mobile unit designed to transport GH₂ or LH₂.

3.3.28 Cathodic Protection. See 3.3.203.1.

△ **3.3.29 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.

3.3.30 Ceiling Limit. See 3.3.144.1.

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

3.3.32 CGA. Compressed Gas Association. [1, 2021]

3.3.33* Chemical. A substance with one or more of the following hazard ratings as defined in NFPA 704: Health — 2, 3, or 4; Flammability — 2, 3, or 4; Instability — 2, 3, or 4. (See also Section B.2.)

3.3.34 Chemical Fume Hood. See 3.3.120.2.

3.3.35 Class 2 Unstable Reactive Gas. See 3.3.106.12.1.

3.3.36 Class 3 Unstable Reactive Gas. See 3.3.106.12.2.

3.3.37 Class 4 Unstable Reactive Gas. See 3.3.106.12.3.

3.3.38* 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, 2023]

N **3.3.39* Closed Piping System.** An assembly that is made up of either a fully welded construction, continuous tubing, or of unwelded connections that have been tested in accordance with ASME B31.3, *Process Piping*, and proven to, under normal operating conditions, contain all H₂ within its control boundary without transferring H₂ to the atmosphere.

3.3.40 Code.

△ **3.3.40.1 Building Code.** The building or construction code adopted by the jurisdiction.

△ **3.3.40.2 Fire Code.** The fire prevention code adopted by the jurisdiction.

△ **3.3.40.3 Mechanical Code.** The mechanical or mechanical construction code adopted by the jurisdiction.

3.3.41 Combustible. Capable of undergoing combustion. [853, 2020]

3.3.41.1 Limited-Combustible Material. See 4.15.2.

3.3.42 Combustible Liquid. See 3.3.147.1.

3.3.43 Combustion Safeguard. A safety device or system that responds to the presence or absence of flame properties using one or more flame detectors and provides safe start-up, safe operation, and safe shutdown of a burner under normal and abnormal conditions. [86, 2023]

3.3.44 Compact Hydrogen Fueling System (cHFS). A self-contained package or factory-matched package which generates, compresses, stores, and dispenses gaseous hydrogen for public and nonpublic fueling.

3.3.45 Compressed Gas. See 3.3.106.1.

△ **3.3.46 Compressed Gas Container.** See 3.3.50.1

3.3.47 Compressed Gas System. See 3.3.237.5.

3.3.48 Compression Discharge Pressure. See 3.3.197.2.

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

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

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

3.3.50.2 Fuel Supply Container. A container mounted on a vehicle to store LH₂ or GH₂ as the fuel supply to the vehicle.

3.3.51 Control.

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

△ **3.3.51.2* 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.

△ **3.3.51.3 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.

3.3.52 Control Area. See 3.3.7.1.

3.3.53 Controller.

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

3.3.53.2 Temperature Controller. A device that measures the temperature and automatically controls the input of heat into the furnace. [86, 2023]

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

3.3.55 Corrosion Protection. See 3.3.203.2.

3.3.56 Corrosive Gas. See 3.3.106.2.

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

3.3.57.1 Enclosed Court. A court bounded on all sides by walls.

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

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

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

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

3.3.61* Defueling. The controlled discharge of hydrogen from vehicle fuel storage tank systems according to the vehicle manufacturer's instructions, utilizing a nozzle or port supplied by the vehicle or test system manufacturer and equipment that has been listed and labeled, or approved for the intended use.

3.3.62 Detached Building. See 3.3.14.1.

3.3.63 Device.

△ **3.3.63.1 Emergency Shutdown Device (ESD) [Vehicle Fueling].** A device that brings all operations to a fail-safe condition within the fueling facility from either local or remote locations.

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

3.3.63.3 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, 2023]

3.3.64* Distributed Integrated Controls (DIC). Systems or integrated controls used to monitor and control the functions of equipment, systems, or plants. [853, 2020]

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

3.3.66 DOT. U.S. Department of Transportation. [52, 2023]

3.3.67 Duct System. See 3.3.237.6.

3.3.68 Dwelling. Any detached building, or any part of a townhouse, back-to-back townhouse, or stacked townhouse structure that is separated from the remainder of the townhouse structure with fire-resistance-rated assemblies in accordance with local building code, that contains no more than two dwelling units intended to be used, rented, leased, let, or hired out to be occupied or that are occupied for habitation purposes. [13D, 2022]

3.3.69 Emergency Shutdown Device (ESD). See 3.3.63.1.

3.3.70 Emergency Shutoff Valve. See 3.3.252.1.

3.3.71 Enclosed Court. See 3.3.57.1.

3.3.72 Enclosed Parking Structure. See 3.3.186.1.

3.3.73 Engineered and Field-Constructed Fuel Cell Power System. See 3.3.237.7.

3.3.74 Evaluation.

3.3.74.1* 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, 2020]

3.3.75 Excess Flow Control. See 3.3.51.1.

3.3.76 Excess Temperature Limit Controller. See 3.3.53.1.

3.3.77 Exhaust Air. See 3.3.4.2.

3.3.78 Exhaust System. See 3.3.237.8.

Δ 3.3.79* Exhausted Enclosure. An appliance or piece of equipment that consists of a top, a back, and two sides that provides a means of local exhaust for capturing gases, fumes, vapors, and mists.

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

3.3.81 Explosion Control. See 3.3.51.2.

3.3.82 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, 2019]

3.3.83 Facility.

3.3.83.1 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, 2019]

3.3.83.2 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, 2021]

3.3.83.2.1 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, 2021]

3.3.83.2.2 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, 2021]

3.3.83.2.3 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, 2021]

3.3.83.2.4* 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, 2021]

3.3.83.2.5 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, 2021]

• N 3.3.83.3* Home Fueling Appliance (HFA). A self-contained package or factory-matched package of integrated systems or hardware that provides fueling of hydrogen-powered vehicles in residential dwellings with a nominal voltage not exceeding 240 volts ac.

3.3.84* 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.

3.3.85 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, 2021]

3.3.86 Fire Prevention. Measures directed toward avoiding the inception of fire. [801, 2020]

3.3.87 Fire Protection. See 3.3.203.3.

3.3.88 Fire Risk Evaluation. See 3.3.74.1.

3.3.89 Flammable Cryogenic Fluid. See 3.3.58.1.

3.3.90 Flammable Gas. See 3.3.106.3.

3.3.91 Flammable Liquefied Gas. See 3.3.106.4.

3.3.92 Flammable Liquid. See 3.3.147.2, Flammable Liquid (Class I).

3.3.93 Flammable Special Atmosphere. See 3.3.227.1.

3.3.94 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, 2020]

3.3.95 Fleet Vehicle Motor Fuel Dispensing Facility. See 3.3.83.2.2.

3.3.96 Flow Switch. A switch that is activated by the flow of a fluid in a duct or piping system. [86, 2023]

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

3.3.98 Fuel Cell Power System (FCPS). See 3.3.237.9.

3.3.99 Fuel Gas. See 3.3.106.5.

3.3.100 Fuel Line. The pipe, tubing, or hose on a vehicle, including all related fittings, through which hydrogen passes during normal vehicle fueling or operation.

3.3.101 Fuel Supply Container. See 3.3.50.2.

3.3.102 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.

3.3.103 Fueling Protocol.

3.3.103.1* Nonstandard Automotive Fueling Protocol. A fueling protocol that has not been described in a published standard.

3.3.103.2 Standard Automotive Fueling Protocol. A fueling protocol published by a standards developing organization that has been accepted by the automotive fuel supply industries to ensure all hydrogen vehicles can use the protocol without exceeding operating parameters.

3.3.104* 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.

3.3.105 Gallon, U.S. Standard. 1 U.S. gal = 0.833 Imperial gal = 231 in.³ = 3.785 L. [58, 2020]

3.3.106 Gas.

▲ **3.3.106.1* Compressed Gas.** A material, or mixture of materials, that (1) is a gas at 68°F (20°C) or less at an absolute pressure of 14.7 psi (101.3 kPa) and (2) has a boiling point of 68°F (20°C) or less at an absolute pressure of 14.7 psi (101.3 kPa) and that is liquefied, nonliquefied, or in solution, except those gases that have no other health or physical hazard properties are not considered to be compressed gases until the pressure in the packaging exceeds an absolute pressure of 40.6 psi (280 kPa) at 68°F (20°C).

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

▲ **3.3.106.3* 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.

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

3.3.106.5 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, 2020]

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

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

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

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

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

▲ **3.3.106.11 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.

▲ **3.3.106.11.1 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.

▲ **3.3.106.12* 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.

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

▲ **3.3.106.12.2 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.

▲ **3.3.106.12.3 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.

3.3.107 Gas Analyzer. A device that measures concentrations, directly or indirectly, of some or all components in a gas or mixture. [86, 2023]

3.3.108 Gas Cabinet. See 3.3.23.1.

3.3.109 Gas Detection System. See 3.3.237.10.

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

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

3.3.112 Gaseous Hydrogen (GH₂) System. See 3.3.237.11.

▲ **3.3.113 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.

■ **3.3.114 Gasifier Hazard Area.** An area around a gasifier containing hazards such as flammable gases, toxic materials, hot surfaces, and so on.

3.3.115 GH₂. Hydrogen in the gas phase.

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

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

3.3.118 Hazardous Material (Chemical). See 3.3.149.1, Hazardous Material.

3.3.119 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, 2022]

3.3.120 Hood.

3.3.120.1* Canopy Hood. A suspended ventilating device used only to exhaust heat, water vapor, odors, and other nonhazardous materials. [45, 2019]

3.3.120.2* Chemical Fume Hood. A ventilated enclosure designed to contain and exhaust fumes, gases, vapors, mists, and particulate matter generated within the hood interior. [45, 2019]

3.3.121 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, 2019]

3.3.122* Hydrogen Equipment Enclosure (HEE). A prefabricated area designed to protect hydrogen equipment that is confined by at least three walls and a roof not routinely occupied, and has a total area less than 450 ft² (41.8 m²).

3.3.123 Hydrogen Generation System. See 3.3.237.12.

3.3.124 Hydrogen Generator. A packaged or factory-matched hydrogen gas generation device that (1) uses electrochemical reactions to electrolyze water to produce hydrogen and oxygen gas (electrolyzer) or (2) 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).

■ **3.3.125 Hydrogen-Powered Industrial Truck (HPIT).** Hydrogen-powered vehicles including lift trucks, motorized hand trucks, and other specialized industrial trucks.

3.3.126 Incidental Testing Facility. See 3.3.83.1.

3.3.127 Indoor Area. See 3.3.7.2.

3.3.128* Indoor Installation. See 3.3.130.1.

3.3.129 Inert Gas. See 3.3.106.6.

▲ **3.3.130 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.

3.3.130.1 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.

3.3.130.2 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).

▲ **3.3.130.3 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.

3.3.130.4 Rooftop Installation. A power system installation located on the roof of a building. [853, 2020]

3.3.131 Instructional Laboratory Unit. See 3.3.245.1.1.

3.3.132 Interactive System. See 3.3.237.15.

3.3.133 Interlock.

3.3.133.1 1400°F (760°C) Bypass Interlock. A device designed to permit specific permitted logic when the combustion chamber is proved to be above 1400°F (760°C). [86, 2023]

3.3.133.2 Excess Temperature Limit Interlock. A device designed to cut off the source of heat if the operating temperature exceeds a predetermined temperature set point. [86, 2023]

3.3.133.3 Safety Interlock. A device required to ensure safe startup and safe operation and to cause safe equipment shutdown. [86, 2023]

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

3.3.135 Laboratory. A facility as regulated by Chapter 16 that provides controlled conditions in which scientific research, experiments, or measurements are performed.

3.3.136 Laboratory Building. See 3.3.14.2.

3.3.137 Laboratory Equipment. See 3.3.5, Apparatus.

3.3.138 Laboratory Unit. See 3.3.245.1.

3.3.139* Laboratory Work Area. See 3.3.7.3.

3.3.140 Laminar Flow Cabinet. See 3.3.23.2.

3.3.141 Lecture Bottle. A small compressed gas cylinder up to a size of approximately 2 in. × 13 in. (5 cm × 33 cm). [45, 2019]

3.3.142* LH₂. Hydrogen in the liquid phase.

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

3.3.144 Limit.

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

3.3.144.2 Exposure Limit.

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

▲ **3.3.144.2.2* 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).

3.3.144.3 Lower Flammability Limit (LFL). That concentration of a combustible material in air below which ignition will not occur. [52, 2023]

3.3.145 Limited Combustible. See 3.3.41.1, Limited-Combustible Material.

3.3.146 Liquefied Hydrogen System. See 3.3.237.16, Liquefied Hydrogen (LH₂) System.

3.3.147 Liquid.

△ **3.3.147.1* Combustible Liquid.** An ignitable liquid that is classified as a Class I or Class III liquid. (See 4.2.2 and 4.2.3 in NFPA 30.) [30, 2021]

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

3.3.148 Lower Flammability Limit (LFL). See 3.3.144.3.

3.3.149 Material.

3.3.149.1* 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 3.3.119, *Health Hazard Material*, and 3.3.188, *Physical Hazard Material*.) [400, 2022]

3.3.149.2 Noncombustible Material. See 4.15.1.

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

3.3.151 Maximum Allowable Working Pressure (MAWP). See 3.3.197.3.

3.3.152* Maximum Operating Pressure. See 3.3.197.5.1.

3.3.153 Mechanical Code. See 3.3.40.3.

3.3.154 Mechanical Connection. A non-welded or brazed connection.

3.3.155 Mechanical Ventilation. See 3.3.256.2.

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

3.3.157 Metal Hydride Storage System. See 3.3.237.17.

3.3.158 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, 2023]

3.3.159 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.

3.3.160* Mobile [Fueling]. The dispensing of hydrogen from a mobile fueling vehicle or mobile fueling trailer directly into a hydrogen motor vehicle.

N **3.3.160.1 On-Demand Mobile Fueling.** The dispensing of hydrogen into a parked hydrogen motor vehicle from a mobile fueling vehicle or mobile fueling trailer that is driven to the parked vehicle.

N **3.3.161 Mobile Fueling Trailer.** A DOT-approved trailer used for mobile fueling with the fueling equipment and containers mounted directly to the trailer and towed by a motor vehicle.

N **3.3.162 Mobile Fueling Vehicle.** A DOT-approved vehicle used for mobile fueling with the fueling equipment and containers mounted directly to the vehicle.

3.3.163 Mobile Supply Unit. See 3.3.245.2.

3.3.164 Motor Fuel Dispensing Facility. See 3.3.83.2.

3.3.165 Motor Fuel Dispensing Facility Located Inside a Building. See 3.3.83.2.4.

3.3.166 Motor Vehicle. Any self-propelled car, bus, truck, tractor, semitrailer, truck-trailer combination, or other vehicle used for the transportation of passengers or freight for use on public streets, roads, and highways.

3.3.166.1 Hydrogen Vehicle. A vehicle that uses hydrogen as a fuel for propulsion.

3.3.166.2* Light-Duty Hydrogen Motor Vehicle. A hydrogen vehicle that has a gross vehicle weight less than 8,500 lb, as defined by the United States Environmental Protection Agency.

N **3.3.166.3* Heavy-Duty Hydrogen Motor Vehicle.** A hydrogen motor vehicle that has a gross vehicle weight rating greater than 26,001 lbs (11,794 kg) as defined by the United States Department of Transportation Federal Highway Administration.

3.3.167 Natural Ventilation. See 3.3.256.3.

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

3.3.169* Non-Bulk Hydrogen Compressed Gas. Gaseous hydrogen (GH₂) packaged in cylinders, containers, or tanks with a contained volume not exceeding 5000 scf (141.6 Nm³) 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 5000 scf (141.6 Nm³).

3.3.170 Noncombustible. Not capable of igniting and burning when subjected to a fire. [80, 2022]

3.3.171 Noncombustible Material. See 3.3.149.2.

3.3.172 Nonflammable Gas. See 3.3.106.7.

3.3.173 Nonlaboratory Area. See 3.3.7.4.

△ **3.3.174 Normal Cubic Meter (Nm³) of Gas.** A cubic meter of gas at an absolute pressure of 14.7 psi (101.3 kPa) and a temperature of 70°F (21°C).

3.3.175 Normal Temperature and Pressure (NTP). See 3.3.197.4.

3.3.176 Open Parking Structure. See 3.3.186.2.

3.3.177 Operating Pressure. See 3.3.197.5.

3.3.178 Operator [Furnace]. An individual trained and responsible for the start-up, operation, shutdown, and emer-

gency handling of the furnace and associated equipment. [86, 2023]

△ **3.3.179 OSHA.** The Occupational Safety and Health Administration of the U.S. Department of Labor.

3.3.180 Other Gas. See 3.3.106.8.

3.3.181 Outdoor Area. See 3.3.7.5.

3.3.182 Outside or Outdoor Installation. See 3.3.130.2.

3.3.183 Oven. See 3.3.38, Class C Furnace.

3.3.184 Overpressure. See 3.3.197.6.

3.3.185 Oxidizing Gas. See 3.3.106.9.

3.3.186* Parking Structure. A building, structure, or portion thereof used for the parking, storage, or both, of motor vehicles. [88A, 2023]

3.3.186.1 Enclosed Parking Structure. Any parking structure that is not an open parking structure. [88A, 2023]

3.3.186.2 Open Parking Structure. A parking structure that meets the requirements of Section 5.6 of NFPA 88A. [88A, 2023]

3.3.187 Permissible Exposure Limit (PEL). See 3.3.144.2.1.

3.3.188 Physical Hazard Material. A chemical or substance classified as an explosive, flammable cryogen, flammable gas, flammable solid, ignitable (flammable or combustible) liquid, organic peroxide, oxidizer, oxidizing cryogen, pyrophoric, unstable (reactive), or water-reactive material. [400, 2022]

3.3.189 Pilot. A flame that is used to light the main burner. [86, 2023]

3.3.190 Pilot Plant. An experimental assembly of equipment for exploring process variables or for producing semicommercial quantities of materials. [45, 2019]

3.3.191 Piping System. See 3.3.237.20.

3.3.192 Point of Transfer. The location where connections and disconnections are made. [52, 2023]

3.3.193 Portable Fuel Cell [Power System] Installation. See 3.3.130.3.

3.3.194 Portable Tank. See 3.3.238.2.

3.3.195 Pre-engineered and Matched Modular Components Fuel Cell Power System. See 3.3.237.21.

3.3.196 Prepackaged, Self-Contained Fuel Cell Power System. See 3.3.237.22.

3.3.197 Pressure.

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

3.3.197.2 Compression Discharge Pressure. The varying pressure at the point of discharge from the compressor. [52, 2023]

3.3.197.3 Maximum Allowable Working Pressure (MAWP) [GH₂ Fueling Facilities]. The maximum pressure to which a component is designed to be subjected when handling fluid or gas over the range of design temperature. [52, 2023]

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

3.3.197.5 Operating Pressure. The varying pressure in a fuel system component during normal use. [52, 2023]

3.3.197.5.1 Maximum Operating Pressure [GH₂ Vehicular Fueling]. The steady-state gauge pressure at which a part or system normally operates. This value is 1.25 × the pressure.

3.3.197.6 Overpressure. Exceeding the MAWP or a pressure that can cause damage or rupture to a component or container.

△ **3.3.197.7 Service Pressure.** The settled pressure of the fuel container at a uniform gas temperature of 70°F (21°C) and full gas content and for which the container, under normal conditions, has been constructed.

3.3.197.8 Set Pressure. The start-to-discharge pressure for which a relief valve is set and marked. [52, 2023]

3.3.197.9 Settled Pressure. The pressure in a container after the temperature of the gas reaches equilibrium.

3.3.197.10 Storage Pressure. The varying pressure in the storage containers.

3.3.198* Pressure Class. The designation of the service pressure of a fuel supply container. The pressure class is denoted by the letter H followed by the service pressure in MPa.

3.3.199 Pressure Regulator. See 3.3.212.1.

3.3.200 Pressure Relief Device. See 3.3.63.2.

3.3.201 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, 2023]

3.3.202 Pressure Vessel. A container or other component designed in accordance with the ASME *Boiler and Pressure Vessel Code*. [52, 2023]

3.3.203 Protection.

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

△ **3.3.203.2 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.

3.3.203.3 Fire Protection. Methods of providing for fire control or fire extinguishment. [801, 2020]

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

3.3.205* 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, 2023]

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

3.3.207 Pyrophoric Gas. See 3.3.106.10.

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

3.3.209 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, 2019]

3.3.210 Ramp-Type Parking Structure. See 3.3.186, Parking Structure.

▲ **3.3.211 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.

3.3.212 Regulator.

3.3.212.1 Pressure Regulator. A device, either adjustable or nonadjustable, for controlling and maintaining, within acceptable limits, a uniform outlet pressure. [52, 2023]

3.3.213 Remotely Located, Manually Activated Shutdown Control. See 3.3.51.3.

3.3.214 Repair Garages.

▲ **3.3.214.1 Major Repair Garage (Hydrogen Vehicle).** A building or portions of a building for major repairs, such as work on the hydrogen storage system, the fuel system, repairs that require defueling of the hydrogen vehicle, and maintenance or repairs that require open-flame cutting or welding.

3.3.214.2* Minor Repair Garage (Hydrogen Vehicle). A building or portions of a building used for lubrication, inspection, and minor automotive maintenance work, such as engine tune-ups, replacement of parts, fluid changes (e.g., brake fluid, air conditioning refrigerants), brake system repairs, tire rotation, and similar routine maintenance work.

• **3.3.215 Rooftop Installation.** See 3.3.130.4.

3.3.216* Safety Data Sheet (SDS). The document that describes composition of a material, hazardous properties and hazard mitigation, and disposal information. [400, 2022]

3.3.217* Safety Device. See 3.3.63.3.

3.3.218 Safety Interlock. A device required to ensure safe startup and safe operation and to cause safe equipment shutdown. [86, 2023]

3.3.219 Safety Shutoff Valve. See 3.3.252.2.1.

3.3.220 Sash. A movable panel or panels set in the hood entrance. [45, 2019]

3.3.221* 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.

3.3.222 Service Pressure. See 3.3.197.7.

3.3.223 Set Pressure. See 3.3.197.8.

3.3.224 Settled Pressure. See 3.3.197.9.

3.3.225 Short-Term Exposure Limit (STEL). See 3.3.144.2.2.

3.3.226 Source Valve. See 3.3.252.3.

3.3.227* Special Atmosphere. A prepared gas or a gas mixture that is introduced into the heating chamber of a furnace to replace air, generally to protect or intentionally change the surface of the material undergoing heat processing (heat treatment). [86, 2023]

3.3.227.1 Flammable Special Atmosphere. A special atmosphere in which gases are known to be flammable and predictably ignitable where mixed with air. [86, 2023]

3.3.227.2 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, 2023]

▲ **3.3.228 Special Provisions.** Controls required when the maximum allowable quantity in the control area is exceeded.

3.3.229 Sprinkler System. See 3.3.237.23.

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

3.3.231 Stationary. Permanently connected and fixed in place. [853, 2020]

3.3.232 Stationary Tank. See 3.3.238.3.

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

3.3.234 Storage Pressure. See 3.3.197.10.

3.3.235 Storage Tank. See 3.3.238.4.

3.3.236 Synthetic Special Atmosphere. See 3.3.227.2.

3.3.237 System.

▲ **3.3.237.1 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, 2022]

▲ **3.3.237.2* Bulk Hydrogen Compressed Gas System.** A gaseous hydrogen (GH₂) system with a storage capacity of more than 5000 scf (141.6 Nm³) of compressed hydrogen gas.

▲ **3.3.237.3* Bulk Liquefied Hydrogen (LH₂) System.** A liquefied hydrogen (LH₂) system with a storage capacity of more than 39.7 gal (150 L) of liquefied hydrogen.

▲ **3.3.237.4* Bulk Oxygen System.** An assembly of equipment, such as oxygen storage containers, pressure regulators, pressure relief devices, vaporizers, manifolds, and interconnecting piping, that has a storage capacity of more than 20,000 scf (566 Nm³) of oxygen and that terminates at the source valve.

3.3.237.5 Compressed Gas System. An assembly of equipment designed to contain, distribute, or transport compressed gases. [318, 2022]

3.3.237.6 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, 2020]

3.3.237.7* 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, 2020]

3.3.237.8 Exhaust System. An air-conveying system for moving materials from a source to a point of discharge. [91, 2020]

3.3.237.9 Fuel Cell Power System (FCPS). 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, 2020]

△ **3.3.237.10 Gas Detection System.** One or more sensors capable of detecting hydrogen at specified concentrations and activating alarms and safety systems.

△ **3.3.237.11* Gaseous Hydrogen (GH₂) System.** An assembly of equipment that consists of, but is not limited to, storage containers, pressure regulators, pressure relief devices, compressors, manifolds, and piping and that terminates at the source valve.

△ **3.3.237.12 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.

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

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

△ **3.3.237.15 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.

△ **3.3.237.16* Liquefied Hydrogen (LH₂) System.** An assembly of equipment that consists of, but is not limited to, storage containers, pressure regulators, pressure relief devices, compressors, manifolds, and piping and that terminates at the source valve.

△ **3.3.237.17 Metal Hydride Storage System.** A closed system consisting of a group of components assembled as a package to contain metal-hydrogen compounds for which there

exists an equilibrium condition where the hydrogen-absorbing metal alloy(s), hydrogen gas, and the metal-hydrogen compound(s) coexist and where only hydrogen gas is released from the system in normal use.

3.3.237.18 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.

△ **3.3.237.19* Non-Bulk Flammable Gas System.** A system consisting of cylinders or other storage systems, with each individual cylinder and each individual set of connected cylinders having less than 5000 scf (141.6 Nm³).

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

△ **3.3.237.21* 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.

3.3.237.22 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, 2020]

△ **3.3.237.23 Sprinkler System.** A system, commonly activated by heat from a fire and discharges water over the fire area, that consists of an integrated network of piping designed in accordance with fire protection engineering standards that includes a water supply source, a control valve, a waterflow alarm, and a drain. 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. [13, 2022]

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

3.3.238 Tank (Flammable or Combustible Liquid).

3.3.238.1 Aboveground Tank. A storage tank that is installed above grade, at grade, or below grade without backfill. [30, 2021]

△ **3.3.238.2 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.

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

3.3.238.4 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, 2021]

3.3.238.4.1 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, 2021]

3.3.239 Temperature Controller. See 3.3.53.2.

3.3.240* 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).

3.3.241 Toxic Gas. See 3.3.106.11.

3.3.242 TC. Transport Canada.

3.3.243 Treatment System. See 3.3.237.24.

Δ **3.3.244* Tube Trailer.** A truck or semitrailer on which a number of very long compressed gas tubular cylinders have been mounted and manifolded into a common piping system.

3.3.245 Unit.

3.3.245.1* Laboratory Unit. An enclosed space [within a laboratory building] used for experiments or tests. [45, 2019]

3.3.245.1.1 Instructional Laboratory Unit. A laboratory unit, under the direct supervision of an instructor, that is used for the purposes of instruction for students beyond the twelfth grade. [45, 2019]

Δ **3.3.245.2* Mobile Supply Unit.** Any supply source that is equipped with wheels so it is able to be moved around.

Δ **3.3.246 Unpierced Wall.** A wall that is allowed to have pipes or conduits passing through it, or unopenable windows, glazed with safety glass or wired glass, set in it, but such openings are sealed to prevent the flow of air between adjacent rooms.

3.3.247 Unstable Reactive Gas. See 3.3.106.12.

Δ **3.3.248 Use.** To place a material into action, including solids, liquids, and gases.

3.3.249 User (Dispenser). A person who uses a dispenser to fuel a motor vehicle who might or might not be trained.

3.3.250* Vacuum Jacket. A double-walled pressure vessel consisting of an inner and outer vessel that 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.

3.3.251 Vacuum Pump. A compressor for exhausting air and noncondensable gases from a space that is to be maintained at subatmospheric pressure. [86, 2023]

3.3.252 Valve.

Δ **3.3.252.1 Emergency Shutoff Valve.** A designated valve designed to shut off the flow of gases or liquids.

Δ **3.3.252.1.1 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.

3.3.252.2 Shutoff Valve.

3.3.252.2.1* 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, 2023]

Δ **3.3.252.3* 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.

3.3.253* 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.

3.3.254 Vehicle. A device or structure for transporting persons or things; a conveyance (e.g., automobiles, trucks, marine vessels, railroad trains). [52, 2023]

N **3.3.255* Vent System.** A system that provides a means of depressurizing or relieving excess gas pressure and directing the venting gas to a safe location.

3.3.256 Ventilation.

Δ **3.3.256.1 Fixed Natural Ventilation.** The movement of air into and out of a space through permanent openings that are arranged in such a way that the required ventilation cannot be reduced by operating windows, doors, louvers, or similar devices.

3.3.256.2 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, 2020]

3.3.256.3 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, 2020]

3.3.257 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, 2021]

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, 2021]

3.4.2.2 Uncertainty Analysis. An analysis performed to determine the degree to which a predicted value will vary. [5000, 2021]

3.4.3 Data Conversion. The process of developing the input data set for the assessment method of choice. [101, 2021]

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, 2021]

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, 2021]

3.4.8* Fire Model. A structured approach to predicting one or more effects of a fire. [101, 2021]

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, 2021]

3.4.9.1 Design Fire Scenario. A fire scenario selected for evaluation of a proposed design. [101, 2021]

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. [921, 2021]

3.4.11 Incapacitation. A condition under which humans do not function adequately and become unable to escape untenable conditions. [101, 2021]

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, 2021]

3.4.14* Performance Criteria. Threshold values on measurement scales that are based on quantified performance objectives. [101, 2021]

3.4.15* Proposed Design. A design developed by a design team and submitted to the authority having jurisdiction for approval. [101, 2021]

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, 2021]

3.4.17 Safety Factor. A factor applied to a predicted value to ensure that a sufficient safety margin is maintained. [101, 2021]

3.4.18 Safety Margin. The difference between a predicted value and the actual value where a fault condition is expected. [101, 2021]

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, 2021]

3.4.20.2 Input Data Specification. Information required by the verification method. [101, 2021]

3.4.21 Stakeholder. An individual, or representative of same, having an interest in the successful completion of a project. [101, 2021]

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, 2021]

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 where 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 (AHJ).

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

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

Δ **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]

Δ **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]

Δ **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.

Δ **4.2.3.1.1* Safety-from-Fire Goals.** The fire safety goals of this Code shall be as follows:

- (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
- (2) To protect fire fighters and emergency responders

[1:4.1.3.1.1]

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.

Δ 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 effects 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) An unplanned release of [hydrogen]
- (2) A fire impinging upon the [hydrogen piping or containment system] or the involvement of [hydrogen] in a fire
- (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]

4.2.4 Property Protection.

Δ 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.

Δ 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 a fire, explosion, or hazardous materials event. [1:4.1.5.2]

4.3 Assumptions.

4.3.1* Single Fire Source.

Δ 4.3.1.1 The fire protection methods of this *Code* shall assume that 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.

Δ 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) The prescriptive-based provisions per 4.4.1
- (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 18 of this code as applicable.

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]

4.4.3 Where any of the requirements of either compliance method requires records to be kept, they shall comply with all of the following:

- (1) Records shall be maintained on the premises or other approved location.
- (2) Retention of records shall be for not less than three years, or shall comply with the period of time where specified in this code or referenced standards, whichever is longer.
- (3) Records shall be made available for inspection by the AHJ and a copy shall be provided to the AHJ upon request.

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

4.6 Emergency Plan.

△ **4.6.1** An emergency plan shall be prepared and updated whenever 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 AHJ.

△ **4.6.2** The plan shall be available for inspection by the AHJ and shall include the following information:

- (1) The type of emergency equipment available and its location
- (2) A brief description of any testing or maintenance programs for the available emergency equipment
- (3) An indication that hazard identification labeling is provided for each storage area
- (4) The location of posted emergency procedures
- (5) A safety data sheet (SDS) or equivalent for GH₂ or LH₂ stored or used on the site
- (6) A list of personnel who are designated and trained to be liaison personnel for the fire department and who are responsible for the following:

- (a) Aiding the emergency responders in pre-emergency planning
- (b) Identifying the location of the GH₂ and LH₂ stored or used
- (c) Accessing SDSs
- (d) Knowing the site emergency procedures
- (7) A list of the types and quantities of GH₂ and LH₂ found within the facility

4.7 Facility Closure.

4.7.1 Where required by the AHJ, no facility storing hazardous materials listed in 1.1.1 of NFPA 400 shall close or abandon an entire storage facility without notifying the AHJ at least 30 days prior to the scheduled closing. [400:1.9.1]

4.7.2 The AHJ shall be permitted to reduce the 30-day period specified in 4.7.1 where there are special circumstances requiring such reduction. [400:1.9.2]

4.7.3 Facilities Out of Service.

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

4.7.3.2 Facilities Permanently Out of Service. Facilities for which a permit is not kept current or that are not monitored and inspected on a regular basis shall be deemed to be permanently out of service and shall be closed in accordance with 4.7.4.1 through 4.7.4.2. [400:1.9.3.2]

4.7.4 Closure Plan.

4.7.4.1 Where required by the AHJ, the permit holder or applicant shall submit a closure plan to the fire department to terminate storage, dispensing, handling, or use of [GH₂ or LH₂] at least 30 days prior to facility closure. [400:1.9.4.1]

4.7.4.2 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. [400:1.9.4.2]

△ **4.7.4.3** The plan shall be submitted with a permit application for facility closure in accordance with Section 4.5.

△ **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:

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

4.9 Management Plan and Hazardous Materials Documentation.

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

△ **4.9.1.1** The HMMP shall comply with the requirements of the adopted fire code.

4.9.2* Hazardous Materials Inventory Statement. When required by the AHJ, a hazardous materials inventory statement (HMIS) [addressing the GH₂ or LH₂ present] shall be completed and submitted to the AHJ. [400:1.12.1]

4.9.3 Safety Data Sheets. Safety Data Sheets (SDS) shall be available on the premises for [GH₂ or LH₂] regulated by this code. When approved, SDSs shall be permitted to be retrievable by electronic access. [400:6.1.2]

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, a sidewalk, a street, or a highway; or into the atmosphere, unless such release is permitted by the following:

- (1) Federal, state, or local governing regulations
- (2) Pressure relief devices and vents designed as part of a system

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

4.10.3* Records of Unauthorized Releases. Accurate records of the unauthorized releases of [GH₂ or LH₂] shall be kept by the permittee. [400:6.1.3.3]

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

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

4.10.6 Responsibility for Cleanup of Unauthorized Releases.

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

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

4.11* Personnel Training. Persons in areas where [GH₂ or LH₂] are stored, dispensed, handled, or used shall be trained in the hazards of the materials employed and actions required by the emergency plan. The level of training to be conducted shall be consistent with the responsibilities of the persons to be trained in accordance with 4.11.1 through 4.11.4.4. [400:6.1.4]

4.11.1 Awareness. The training provided for persons designated in Section 4.11 shall include awareness training in accordance with 4.11.1.1 through 4.11.1.3. [400:6.1.4.1]

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

4.11.1.2 Hazard Communications. Training shall be provided prior to beginning work in the work area to enable personnel to recognize and identify [GH₂ or LH₂] stored, dispensed, handled, or used on site and where to find hazard safety information pertaining to the hazards of the materials employed. [400:6.1.4.1.2]

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

4.11.2 Operations Personnel. Persons engaged in storing, using, or handling [GH₂ or LH₂] shall be designated as operations personnel and shall be trained in accordance with 4.11.1 and 4.11.2.2 through 4.11.2.7. [400:6.1.4.2]

4.11.2.1 Fueling. Customers performing public motor fuel dispensing of GH₂ vehicles in accordance with Chapter 10 shall not be designated as operations personnel subject to the requirements of 4.11.2.

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

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

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

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

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

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

- (1) Equipment
 - (2) Operations
 - (3) Hazardous Materials
- [400:6.1.4.2.6]

4.11.3 Emergency Response Liaison. [400:6.1.4.3]

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

4.11.3.2 Emergency response liaison personnel shall do the following:

- (1) Aid emergency responders in pre-planning responses to emergencies
- (2) Identify locations where [GH₂ or LH₂] are located
- (3) Have access to safety data sheets
- (4) Be knowledgeable in the site emergency response procedures

[400:6.1.4.3.2]

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

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

4.11.4.2* Response to Incipient Events. Responses to incidental releases of [GH₂ or LH₂] where the material can be absorbed, neutralized, or otherwise controlled at the time of release by employees in the immediate release area, or by maintenance personnel, shall not be considered emergency responses as defined with the scope of this code. [400:6.1.4.4.2]

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

4.11.4.4 Training Mandated by other Agencies. Training required by federal, state, or local regulations that is required based on the quantity or type of [GH₂ or LH₂] stored, dispensed, handled, or used shall be conducted in accordance with the requirements of and under the jurisdiction of the governing agency. [400:6.1.4.5]

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

4.12 Ignition Source Controls.

Δ 4.12.1 Smoking. Smoking shall be prohibited in the following locations:

- (1) Within 25 ft (7.6 m) of outdoor storage or areas, dispensing areas, or open use areas.
- (2) In rooms or areas where [GH₂ or LH₂] are stored or dispensed or used in open systems in amounts requiring a permit in accordance with Section 4.5

[400:6.1.5.1]

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. [400:6.1.5.2]

4.12.3 Energy-Consuming Equipment. Energy-consuming equipment with the potential to serve as a source of ignition shall be listed or approved for use with [GH₂ or LH₂] stored or used. [400:6.1.5.3]

4.12.4 Powered Industrial Trucks. Powered industrial trucks shall be operated and maintained in accordance with NFPA 505. [1:10.17]

4.12.5 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. [400:6.1.8.1.1]

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

4.13.1.3 Maintenance. Signs shall meet the following criteria:

- (1) They shall not be obscured.
- (2) They shall be maintained in a legible condition.
- (3) They shall not be removed, unless for replacement.

[400:6.1.8.1.3]

4.13.2 Hazard Identification Signs.

4.13.2.1 Visible hazard identification signs in accordance with NFPA 704 shall be placed at the following locations, except where the AHJ has received a hazardous materials management plan and a hazardous materials inventory statement in accordance with 4.9.1 and 4.9.2 and has determined that omission of such signs is consistent with safety:

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

[400:6.1.8.2.1]

4.13.2.2 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.

Δ 4.13.2.3 Identification of Gas Rooms and Cabinets. Rooms or cabinets containing compressed gases shall be conspicuously labeled as follows:

COMPRESSED GAS

4.13.3 No Smoking Signs. Where “no smoking” is not applicable to an entire site or building, signs shall be provided as follows:

- (1) In rooms or areas where [GH₂ or LH₂] is stored or dispensed or used in open systems in amounts requiring a permit in accordance with Section 1.8 of NFPA 400
- (2) Within 25 ft (7.6 m) of outdoor storage, dispensing, or open-use areas

[400:6.1.8.3]

4.14 Protection From Vehicular Damage.

4.14.1 Where required, guard posts in accordance with 4.14.1.2 or other approved means shall be provided to protect against physical damage.

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

- (1)* Storage tanks and connected piping, valves, and fittings

- (2) Storage areas containing tanks or portable containers except where the exposing vehicles are powered industrial trucks used for transporting the [GH₂ or LH₂]
- (3) Use areas

[400:6.1.9.1]

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

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

[400:6.1.9.2]

4.15* Building Construction Materials.

Δ 4.15.1* Noncombustible Material. The material complies with any of the following shall be considered a noncombustible material:

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

[5000:7.1.4.1]

Δ 4.15.2* Limited-Combustible Material. A material shall be considered a limited-combustible material where one of the following is met:

- (1) The conditions of 4.15.2.1 and 4.15.2.2, and the conditions of either 4.15.2.3 or 4.15.2.4, shall be met.
- (2) The conditions of 4.15.2.6 shall be met.

[5000:7.1.4.2]

Δ 4.15.2.1 The material shall not comply with the requirements for a noncombustible material, in accordance with 4.15.1. [5000:7.1.4.2.1]

Δ 4.15.2.2 The material, in the form which it is used, exhibits a potential heat value not exceeding 3500 Btu/lb (8141 kJ/kg) where tested in accordance with NFPA 259. [5000:7.1.4.2.2]

Δ 4.15.2.3 The material shall have a structural base of a noncombustible material with a surfacing not exceeding a thickness of 1/8 in. (3.2 mm) where the surfacing exhibits a flame spread index not greater than 50 when tested in accordance with ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials*, or ANSI/UL 723, *Standard for Test for Surface Burning Characteristics of Building Materials*. [5000:7.1.4.2.3]

Δ 4.15.2.4 The material shall be composed of materials that, in the form and thickness used, neither exhibit a flame spread index greater than 25 nor exhibit evidence of continued progressive combustion when tested in accordance with ASTM E84, or ANSI/UL 723, and are of such composition that all surfaces that would be exposed by cutting through the material on any plane would neither exhibit a flame spread index greater than 25 nor exhibit evidence of continued progressive combustion when tested in accordance with ASTM E84 or UL 723. [5000:7.1.4.2.4]

Δ 4.15.2.5 Materials shall be considered limited-combustible materials where tested in accordance with ASTM E2965, *Standard Test Method for Determination of Low Levels of Heat Release Rate for Materials and Products Using an Oxygen Consumption Calorimeter*, at an incident heat flux of 75 kW/m² for a 20-minute exposure and both of the following conditions are met:

- (1) The peak heat release rate shall not exceed 150 kW/m² for longer than 10 seconds.
- (2) The total heat released shall not exceed 8 MJ/m².

[5000:7.1.4.2.5]

Δ 4.15.2.6 Where the term *limited-combustible* is used in this Code, it shall also include the term *noncombustible*. [5000:7.1.4.2.6]

Chapter 5 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 this code in accordance with 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]

Δ 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 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) Minimize the potential occurrence of unwanted releases, fire, or other emergency incidents resulting from the storage, use, or handling of hazardous materials
- (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
- (3) Minimize the potential exposure of people or property to unsafe conditions or events involving an unintended reaction or release of hazardous materials
- (4) Minimize the potential for an unintentional reaction that results in a fire, explosion, or other dangerous condition
- (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

- (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
- (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
- (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
- (9) Maintain ventilation where ventilation is relied upon to minimize the risk of emergency conditions involving hazardous materials
- (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]

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) Design Fire Scenario (See 3.4.9.1.)
- (2) Design Specification (See 3.4.20.1.)
- (3) Design Team (See 3.4.6.)
- (4) Exposure Fire (See 3.4.7.)
- (5) Fire Model (See 3.4.8.)
- (6) Fire Scenario (See 3.4.9.)
- (7) Fuel Load (See 3.4.10.)
- (8) Input Data Specification (See 3.4.20.2.)
- (9) Occupant Characteristics (See 3.4.13.)
- (10) Performance Criteria (See 3.4.14.)
- (11) Proposed Design (See 3.4.15.)
- (12) Safety Factor (See 3.4.17.)
- (13) Safety Margin (See 3.4.18.)
- (14) Sensitivity Analysis (See 3.4.2.1.)
- (15) Stakeholder (See 3.4.21.)
- (16) Uncertainty Analysis (See 3.4.2.2.)
- (17) Verification Method (See 3.4.23.)

[1:5.1.13]

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 prohibition requirements 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 1.5. [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 E1591, *Standard Guide for Obtaining Data for Fire Growth 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 **hazard** 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) The facility was approved as a performance-based design with certain specified design criteria and assumptions.
- (2) Any remodeling, modification, renovation, change in use, or change in the established assumptions requires a re-evaluation and **reapproval**.

[1:5.7.14]

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

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

Δ **6.1.1.3 Occupancy Classification.** 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.

Δ **6.1.1.4 Quantities Less Than or Equal to the MAQ.** Indoor control areas with GH₂ or LH₂ stored or used in quantities less than or equal to those shown in Table 6.4.1.1.1 shall be in accordance with 6.4.1.5 and Sections 6.1, 6.8, 6.9, 6.13, and 6.17.

Δ **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 6.4.1.1.1 shall be in accordance with the requirements of Chapter 6.

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's fire barriers in accordance with the adopted building code.

6.3.2 Number of Control Areas.

6.3.2.1 The maximum number of control areas within a building shall be in accordance with the adopted building code.

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

6.4 Occupancy Classification.

6.4.1 Quantity Thresholds for GH₂ or LH₂ Requiring Special Provisions.

6.4.1.1 Threshold Exceedences.

- △ **6.4.1.1.1** Where the quantities of GH₂ or LH₂ stored or used within an indoor control area exceed those shown in Table 6.4.1.1.1, 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.

6.4.1.1.2 Pressure relief devices or stationary or portable containers shall be vented directly outdoors or to an exhaust hood.

- △ **6.4.1.2 Aggregate Allowable Quantities.** The aggregate quantity in use and storage shall not exceed the quantity listed for storage.

- △ **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, provided 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.

6.4.1.4 Multiple Hazards. GH₂ blended with other gases having multiple hazards shall also comply with NFPA 55.

6.4.1.5 GH₂.

- △ **6.4.1.5.1*** GH₂ shall not be stored or used in other than industrial or storage occupancies, or laboratory work areas of business occupancies.

- △ **6.4.1.5.1.1** Cylinders, containers, or tanks not exceeding 250 scf (7.1 Nm³) content at normal temperature and pressure (NTP) and used for maintenance purposes, patient care, or operation of equipment shall be permitted.

6.4.1.5.1.2 Piping systems used to supply GH₂ in accordance with 6.5.1 shall be allowed.

6.4.1.5.1.3 Hydrogen gas systems located in a hydrogen gas room that meet the requirements of Section 6.6 are permissible in quantities up to those allowed by Table 6.4.1.1.1 for assembly, educational, institutional, residential, or business occupancies.

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.

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.

6.5* Piping.

- △ **6.5.1* Piping Systems.** Piping, tubing, valves, and fittings shall be designed and installed in accordance with applicable sections of ASME B31, *Code for Pressure Piping*, and Sections 704.1.2.3, 704.1.2.4, and 704.1.2.5 of the ICC *International Fuel Gas Code (IFGC)*. Cast, ductile, malleable, or high-silicon iron pipe, valves, and fittings shall not be used.

- △ **6.5.1.1** Prior to acceptance and initial operation, all piping installations shall be inspected and pressure tested in accordance with ASME B31, *Code for Pressure Piping*, and Section 705 of the ICC *International Fuel Gas Code (IFGC)*.

- △ **6.5.1.2** In addition to the requirements of 6.5.1, brazing materials used for joints in piping and tubing systems shall have a melting point above 1000°F (538°C).

- △ **6.5.1.3** Underground piping systems shall be in accordance with 6.5.3.

- △ **6.5.1.4 Integrity.** Piping, tubing, pressure regulators, valves, and other apparatus shall be kept gastight to prevent leakage.

- △ **6.5.1.5 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.

6.5.2 Equipment Assembly.

- △ **6.5.2.1** Valves, gauges, regulators, and other accessories used for hydrogen systems shall be specified for hydrogen service by the manufacturer or the hydrogen supplier.

- △ **6.5.2.2** Storage containers, piping, valves, regulating equipment, and other appurtenances serving hydrogen systems shall be accessible and shall be protected against physical damage and tampering.

- △ **6.5.2.3** Cabinets or enclosures containing hydrogen control or operating equipment shall be ventilated to prevent the accumulation of hydrogen.

△ **Table 6.4.1.1.1 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 scf (26.3 Nm ³)	2000 scf (52.6 Nm ³)	2000 scf (52.6 Nm ³)	4000 scf (105.1 Nm ³)

For SI units: 1 ft = 304.8 mm; 1 scf = 0.02832 Nm³.

Note: None allowed in unsprinklered buildings unless stored or used in gas rooms or in approved gas cabinets or exhausted enclosures, as specified in this code, and pressure-relief devices for stationary or portable containers vented directly outdoors or to an exhaust hood.

*A gas cabinet or exhausted enclosure is required (see also 6.4.1.1.2).

▲ 6.5.2.4 Mobile hydrogen supply units used as part of a hydrogen system shall be secured to prevent movement.

▲ 6.5.2.5 Mobile hydrogen supply units shall be electrically bonded to the storage system before hydrogen is discharged from the supply unit.

6.5.3 Underground Piping.

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

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

▲ 6.5.3.1.2 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.

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

6.5.3.2 Contact with Earth.

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

▲ 6.5.3.2.2 When cathodic protection is provided, it shall be in accordance with 7.1.17.

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

6.5.3.4 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]

6.5.3.5 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]

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

▲ 6.5.3.7 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.

6.5.3.8 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]

6.5.3.9 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]

6.5.3.10 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]

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

▲ 6.6 Gas Rooms. Where a gas room is used to increase the threshold quantity for a gas requiring special provisions or where otherwise required by the material or application specific requirements of Chapters 10 through 18, the room shall meet the requirements of 6.6.1 through 6.6.5.

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

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

▲ 6.6.3 Construction. Gas rooms shall be constructed in accordance with the adopted building code.

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

6.6.5 Limitation on Contents.

▲ 6.6.5.1 The function of compressed gas rooms shall be limited to storage and use of compressed gases and associated equipment and supplies.

6.6.5.2 Where GH_2 or LH_2 is stored and used in gas rooms it shall comply with 6.6.5.1.

6.7 Weather Protection.

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

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

▲ 6.7.1.2 Weather protected areas constructed in accordance with 6.7.1.4 shall be regulated as outdoor storage or use.

▲ 6.7.1.3 Weather protected areas that are not constructed in accordance with 6.7.1.4 shall be regulated as indoor storage or use.

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

- (1) The building or structure shall be constructed of noncombustible materials.
- (2) Walls shall not obstruct more than one side of the structure.
- (3) Walls shall be permitted to obstruct portions of multiple sides of the structure, provided that the obstructed area does not exceed 25 percent of the structure's perimeter area.
- (4) The building or structure shall be limited to a maximum area of 1500 ft² (140 m²), with increases in area allowed by the building code based on occupancy and type of construction.
- (5) The distance from the structure constructed as weather protection to buildings, lot lines, public ways, or means of egress to a public way shall not be less than the distance required for an outside hazardous material storage or use area without weather protection based on the hazard classification of the materials contained.
- (6) Reductions in separation distance shall be permitted based on the use of fire barrier walls where permitted for

specific materials in accordance with the requirements of Chapters 7 and 8.

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

6.8.1 Standby Power.

△ **6.8.1.1** Where the following systems are required by this code for the storage or use of GH_2 or LH_2 that exceed the quantity thresholds for gases requiring special provisions, such systems shall be connected to a standby power system in accordance with *NFPA 70*:

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

△ **6.8.1.2** The requirements of 6.8.1.1 shall not apply where emergency power is provided in accordance with 6.8.2 and *NFPA 70*.

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

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

△ **6.9* Employee Alarm System.** Where required by government regulations, an employee alarm system shall be provided to allow warning for necessary emergency action as called for in the emergency action plan required by 4.6.1, or for reaction time for safe egress of employees from the workplace or the immediate work area, or both.

6.10* Explosion Control.

6.10.1 Explosion control shall be provided where the quantity of GH_2 or LH_2 in storage or use exceeds the quantity thresholds requiring special provisions as listed in Table 6.4.1.1.1 or where otherwise required.

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

- (1) Explosion prevention in accordance with 6.10.3
- (2) Deflagration venting in accordance with 6.10.4

6.10.3* Explosion Prevention. Where provided, explosion prevention shall be in accordance with one or more of the methods specified in *NFPA 69*.

6.10.4 Deflagration Venting. Where provided, explosion protection by the use of deflagration venting shall be in accordance with *NFPA 68*.

6.11 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*.

△ **6.11.1 Sprinkler System Design.** When sprinkler protection is required, the area in which GH_2 or LH_2 is stored or used shall be protected with a sprinkler system designed to be not less

than that required by 11.2.3.11 of *NFPA 13* for the Extra Hazard Group 1 density/area curve.

6.12 Fire Alarm Systems.

6.12.1 A manual fire alarm system shall be provided in accordance with the adopted building code.

6.12.2 The system shall be designed, installed, and maintained in accordance with *NFPA 72*.

6.13* GH_2 Detection Systems.

6.13.1 Gas detection equipment shall be listed or approved.

6.13.2 Where GH_2 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

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

6.13.2.1.1* Testing shall be conducted at least annually.

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

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

6.15 Spill Control, Drainage, and Secondary Containment.

△ **6.15.1 GH_2 .** Spill control, drainage, and secondary containment shall not be required for GH_2 .

△ **6.15.2 LH_2 .** Diking shall not be used to contain an LH_2 spill.

△ **6.15.2.1 LH_2** Diking or berms shall be permitted to direct the spill away from exposures.

6.16 Shelving.

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

△ **6.16.2** Shelves and containers shall be secured from overturning.

△ **6.17* Vent System Termination.** Hydrogen-venting systems serving pressure relief devices discharging hydrogen to the atmosphere shall be in accordance with *CGA G-5.5, Hydrogen Vent Systems*.

6.17.1 Exits of vent stacks shall be located outdoors and away from personnel areas, ignition sources, air intakes, building openings, and overhangs.

N **6.17.2*** The area classifications and extent of the hazardous (classified) volume surrounding the vent pipe termination shall be determined using IEC 60079-10-1, *Explosive atmospheres — Part 10-1: Classification of areas — Explosive gas atmospheres*.

N **6.17.3** The vertical dimension of the vent exit elevation shall be the greatest of the following:

- (1) The thermal radiation and impingement distance determined in Section 6.17
- (2) The extent of the hazardous area determined in 6.17.2
- (3) A minimum of 10 ft (3 m) above grade, 2 ft (0.61 m) above adjacent equipment, or 5 ft (1.5 m) above rooftops

N 6.17.4* The horizontal separation distance from the vent pipe termination to Exposures Group 1 and Exposures Group 2 in Table 7.3.2.3.1.2(B) (a) shall be the greatest of the following:

- (1) The horizontal component of the thermal radiation and impingement distance determined in Section 6.17
- (2) The horizontal component of the extent of the hazardous (classified) area determined in 6.17.2

Δ 6.18* Ventilation. Indoor storage and use areas and storage buildings for GH_2 and LH_2 shall be provided with mechanical exhaust ventilation or fixed natural ventilation, where natural ventilation is shown to be acceptable for the GH_2 or LH_2 as stored.

Δ 6.18.1 Ventilation Rate. Mechanical exhaust or fixed natural ventilation shall be provided at a rate of not less than 1 scf/min/ft² (0.0051 m³/sec/m²) of floor area over the area of storage or use.

6.18.2 Mechanical Exhaust Ventilation.

Δ 6.18.2.1 Ventilation Systems. In addition to the requirements of Section 6.18, ventilation systems shall be designed and installed in accordance with the requirements of the adopted mechanical code.

Δ 6.18.2.1.1 Continuous Operation. When operation of ventilation systems is required, systems shall operate continuously unless an alternative design is approved by the AHJ.

Δ 6.18.2.1.2 Shutoff Controls. Where powered ventilation is provided, a manual shutoff switch shall be provided outside the room in a position adjacent to the principal access door to the room or in an approved location.

Δ 6.18.2.1.3 Manual Shutoff Switch. The switch shall be the breakglass or equivalent type and shall be labeled as follows:

WARNING:

VENTILATION SYSTEM EMERGENCY SHUTOFF

6.18.2.1.4 Exhaust System.

Δ 6.18.2.1.4.1 The exhaust ventilation system design shall take into account the density of the potential gases released.

Δ 6.18.2.1.4.2 For gases that are lighter than air, exhaust shall be taken from a point within 12 in. (305 mm) of the ceiling. The use of supplemental inlets shall be allowed to be installed at points below the 12 in. (305 mm) threshold level.

6.18.2.1.4.3* The inlets to the exhaust systems shall be either designed to prevent blockage due to debris, foliage, ice, snow, and so on, or the exhaust system shall detect and react to the blockage.

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

Δ 6.18.2.1.6 Exhaust ventilation shall not be recirculated.

6.18.2.1.7* Ventilation Discharge. Ventilation discharge systems conveying hydrogen mixtures exceeding 25 percent LFL in any normal or emergency operating mode shall terminate at a point outdoors not less than 30 ft (9.1 m) from property lines, 10 ft (3 m) from operable openings into buildings and public access, 6 ft (1.8 m) from exterior walls and roofs,

30 ft (9.1 m) from combustible walls and operable openings into buildings that are in the direction of the exhaust discharge, and 10 ft (3 m) above adjoining grade.

N 6.18.2.1.8 Ventilation Failure.

N 6.18.2.1.8.1* Where a mechanical ventilation system is used to reduce the area classification, it shall include a means to detect the loss of air flow.

N 6.18.2.1.8.2 Upon detection of loss of air flow or other ventilation failure, the system shall accomplish the following:

- (1) Stop all hydrogen generation processes
- (2) Close all supply valves that feed hydrogen or other flammable materials to the ventilated area
- (3) De-energize all ignition sources in the ventilated area that are not suitable for the area classification that would apply without ventilation.

N 6.18.2.1.8.3* The components of the ventilation system, detection system, and the circuit or system that accomplishes 6.18.2.1.8.2 shall be suitable for the area classification that would apply without ventilation.

Δ 6.19 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 6.19.1 through 6.19.4.

6.19.1 Construction.

Δ 6.19.1.1 Materials of Construction. The gas cabinet shall be constructed of not less than 0.097 in. (2.46 mm) (12 gauge) steel.

Δ 6.19.1.2 Access to Controls. The gas cabinet shall be provided with self-closing limited access ports or noncombustible windows to give access to equipment controls.

Δ 6.19.1.3 Self-Closing Doors. The gas cabinet shall be provided with self-closing doors.

Δ 6.19.2 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.

Δ 6.19.3 Quantity Limits. Gas cabinets shall contain not more than three cylinders, containers, or tanks.

Δ 6.19.4 Separation of Incompatibles. Incompatible gases, as defined by Table 7.2.1.1, shall be stored or used within separate gas cabinets.

6.20 Exhausted Enclosures.

Δ 6.20.1 Ventilation Requirements. Where an exhausted enclosure is required or used to increase the threshold quantity for a gas requiring special provisions, the exhausted enclosure shall be provided with an exhaust ventilation system designed to operate at a negative pressure in relationship to the surrounding area.

6.20.2 Separation of Incompatible Gases within Enclosures.

Δ 6.20.2.1 Cylinders, containers, and tanks within enclosures shall be separated in accordance with Table 7.2.1.1.

Δ 6.20.2.2 Incompatible gases, as defined by Table 7.2.1.1, shall be stored or used within separate exhausted enclosures.

△ **6.20.3 Fire Protection.** Exhausted enclosures shall be internally sprinklered.

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

△ **6.21.1** The source valve shall be marked.

△ **6.21.2** The source valve shall be designated on the design drawings for the installation.

N **6.21.3*** If the source valve has a remote source of actuation, the energy source and isolation device shall be clearly labeled.

6.22 Cleaning, Purging, and Repairing of Piping Systems.

6.22.1 General.

△ **6.22.1.1** Hydrogen systems shall be cleaned and purged in accordance with the requirements of Section 6.22 when one or more of the following conditions exist:

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

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

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

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

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

△ **6.22.1.3.2** The completed written procedure shall be:

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

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

△ **6.22.1.3.4** Generic procedures shall be reviewed when originally published or when the procedure or operation is changed.

6.22.1.4 Written procedures to manage change to process materials, technology, equipment, procedures, and facilities shall be established and implemented.

6.22.1.4.1 The management-of-change procedures shall ensure that the following issues are addressed prior to any change:

- (1) The technical basis for the proposed change
- (2) The safety and health implications
- (3) Whether the change is permanent or temporary
- (4) Modifications to the cleaning and purging procedures
- (5) Employee training requirements
- (6) Authorization requirements for the proposed change

[56:4.6.1]

6.22.1.4.2* Implementation of the management-of-change procedures shall not be required for replacements-in-kind. [56:4.6.2]

6.22.1.4.3 The written cleaning and purging procedure, as required by 6.22.1.3, shall be updated to incorporate the change. [56:4.6.3]

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

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

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

N **6.22.1.6*** Manual and automatic shutoff valves required for isolation shall be closed, locked, and tagged prior to repairs involving disconnecting piping or piping components.

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.

△ **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.

7.1.2.3 Controls.

Δ **7.1.2.3.1** GH_2 system controls shall be designed to prevent materials from entering or leaving the process at an unintended time, rate, or path.

Δ **7.1.2.3.2** Automatic controls shall be designed to be fail-safe.

7.1.2.4 GH_2 shall not be used to operate any device or equipment that has not been designed for GH_2 service.

Δ **7.1.3 Listed or Approved Hydrogen Equipment.** Listed or approved hydrogen-generating and hydrogen-consuming equipment shall be in accordance with the listing requirements and manufacturers' instructions.

7.1.4* Metal Hydride Storage Systems.**7.1.4.1 General.**

Δ **7.1.4.1.1 Metal Hydride Storage System Requirements.** The storage and use of metal hydride storage systems shall be in accordance with 7.1.4.

Δ **7.1.4.1.2 Metal Hydride Systems Storing or Supplying GH_2 .** Those portions of the system that are used as a means to store or supply GH_2 shall also comply with Sections 7.2 or 7.3 as applicable.

Δ **7.1.4.1.3 Classification.** The hazard classification of the metal hydride storage system, as required by 5.1.1 and 5.1.3 of NFPA 55, shall be based on the GH_2 stored without regard to the metal hydride content.

Δ **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.

Δ **7.1.4.1.5 Design and Construction of Containers.** GH_2 cylinders, containers, and tanks used for metal hydride storage systems shall be designed and constructed in accordance with 7.1.5.1.

Δ **7.1.4.1.6 Service Life and Inspection of Containers.** Metal hydride storage system cylinders, containers, and tanks shall be inspected at intervals not to exceed 5 years.

Δ **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.

Δ **7.1.4.1.7.1 System Marking.** Metal hydride storage systems shall be marked with the following:

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

Δ **7.1.4.1.7.2 Valve Marking.** Metal hydride storage system valves shall be marked with the following:

- (1) Manufacturer's name

- (2) Service life indicating the last date the valve can be used
- (3) Metal hydride service in which the valve can be used or a product code that is traceable to this information

Δ **7.1.4.1.7.3 Pressure Relief Device Marking.** Metal hydride storage system pressure relief devices shall be marked with the following:

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

Δ (A) 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.

Δ **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:

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

Δ **7.1.4.1.8 Temperature Extremes.** Metal hydride storage systems, whether full or partially full, shall not be exposed to temperatures exceeding the range stipulated by the manufacturer.

Δ **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.

Δ **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.

7.1.4.1.10.1 Industrial Trucks. The refilling of metal hydride storage systems serving powered industrial trucks shall be in accordance with the requirements of Chapter 10.

Δ **7.1.4.1.10.2 Hydrogen Purity.** The purity of GH_2 used for the purpose of refilling containers shall be in accordance with the listing and the manufacturers' instructions.

Δ **7.1.4.1.11 Electrical.** Electrical components for metal hydride storage systems shall be designed, constructed, and installed in accordance with NFPA 70.

7.1.4.2 Portable Containers or Systems.

Δ **7.1.4.2.1 Securing Containers.** Cylinders, containers, and tanks shall be secured in accordance with 7.1.7.4.

Δ **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 cylinders, containers, or tanks from dislodgement, slipping, or rotating when the equipment is in motion.

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.

△ (B) Metal hydride storage systems, including cylinders, containers, tanks, and fittings, shall not extend beyond the platform of the mobile equipment.

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

7.1.5 Cylinders, Containers, and Tanks.

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

7.1.5.2 Defective Cylinders, Containers, and Tanks.

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

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

△ 7.1.5.2.3 Cylinders, containers, and tanks shall be repaired or removed from service and disposed of in an approved manner.

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

△ 7.1.5.4 Cylinders, Containers, and Tanks Containing Residual Gas. GH₂ cylinders, containers, and tanks containing residual product shall be treated as full except when being examined, serviced, or refilled by a gas manufacturer, authorized cylinder requalifier, or distributor.

7.1.5.5 Pressure Relief Devices.

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

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

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

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

△ 7.1.5.5.5 Pressure relief devices shall be arranged to discharge unobstructed to the open air in such a manner as to prevent

any impingement of escaping gas upon the container, adjacent structures, or personnel. This requirement shall not apply to DOT specification containers having an internal volume of 2.0 scf (0.057 Nm³) or less.

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

7.1.6 Labeling Requirements.

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

△ 7.1.6.2 Label Maintenance. The labels applied by the gas manufacturer to identify the liquefied or nonliquefied GH₂ cylinder contents shall not be altered or removed by the user.

7.1.6.3 Stationary GH₂ Cylinders, Containers, and Tanks.

△ 7.1.6.3.1 Stationary GH₂ cylinders, containers, and tanks shall be marked in accordance with NFPA 704.

△ 7.1.6.3.2 Markings shall be visible from any direction of approach.

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:

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

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

7.1.6.5 Marking.

△ 7.1.6.5.1 Hazard identification signs shall be provided in accordance with 4.13.2.

△ 7.1.6.5.2 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

7.1.7 Security.

△ 7.1.7.1 General. GH₂ cylinders, containers, tanks, and systems shall be secured against accidental dislodgement and against access by unauthorized personnel.

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

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

7.1.7.3 Physical Protection.

▲ **7.1.7.3.1** GH₂ cylinders, containers, tanks, and systems that could be exposed to physical damage shall be protected.

▲ **7.1.7.3.2** Guard posts or other means shall be provided to protect GH₂ cylinders, containers, tanks, and systems indoors and outdoors from vehicular damage in accordance with Section 4.14.

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 Cylinders, Containers, and Tanks.** GH₂ cylinders, containers, and tanks in use or in storage shall be secured to prevent them from falling or being knocked over by corralling them and securing them to a cart, framework, or fixed object by use of a restraint, unless otherwise permitted by 7.1.7.4.1 and 7.1.7.4.2.

▲ **7.1.7.4.1** GH₂ cylinders, containers, and tanks in the process of examination, servicing, and refilling shall not be required to be secured.

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

7.1.8 Valve Protection.

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

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

▲ **7.1.8.1.1.1** Valve protection of individual valves shall not be required on cylinders, containers, or tanks that comprise bulk or non-bulk gas systems where the containers are stationary, or portable equipped with manifolds, that are provided with physical protection in accordance with 4.1.4 and 7.1.7.3 or other approved means. Protective systems required by DOT for over the road transport shall provide an acceptable means of protection.

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

7.1.9 Separation from Hazardous Conditions.

▲ **7.1.9.1 General.** GH₂ cylinders, containers, tanks, and systems in storage or use shall be separated from materials and conditions that present exposure hazards to or from each other.

▲ **7.1.9.1.1* Clearance from Combustibles and Vegetation.** Combustible waste, vegetation, and similar materials shall be

kept a minimum of 10 ft (3.1 m) from GH₂ cylinders, containers, tanks, and systems.

▲ **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.

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

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

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

▲ **7.1.9.1.3.1** GH₂ cylinders, containers, and tanks that have not been designed for use under elevated temperature conditions shall not be exposed to direct sunlight outdoors where ambient temperatures exceed 125°F (52°C). The use of a weather protected structure or shaded environment for storage or use shall be permitted as a means to protect against direct exposure to sunlight.

▲ **7.1.9.1.4 Falling Objects.** GH₂ cylinders, containers, and tanks shall not be placed in areas where they are capable of being damaged by falling objects.

▲ **7.1.9.1.5 Heating.** GH₂ cylinders, containers, and tanks, whether full or partially full, shall not be heated by devices that could raise the surface temperature of the container, cylinder, or tank to above 125°F (52°C).

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

▲ **7.1.9.1.5.2 Fail-Safe Design.** Devices designed to maintain individual GH₂ cylinders, containers, and tanks at constant temperature shall be designed to be fail-safe.

▲ **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.

▲ **7.1.9.1.7 Exposure to Chemicals.** GH₂ cylinders, containers, and tanks shall not be exposed to corrosive chemicals or fumes that could damage cylinders, containers, tanks, or valve-protective caps.

▲ **7.1.9.1.8 Exposure to Electrical Circuits.** GH₂ cylinders, containers, and tanks shall not be placed where they could become a part of an electrical circuit.

▲ **7.1.9.1.8.1*** Electrical devices mounted on GH₂ piping, cylinders, containers, or tanks shall be installed, grounded, and bonded in accordance with the methods specified in *NFPA 70* (NEC).

▲ **7.1.10 Service and Repair.** Service, repair, modification, or removal of valves, pressure relief devices, or other GH₂ cylinder, container, and tank appurtenances shall be performed by

trained personnel and with the permission of the container owner.

▲ **7.1.11 Unauthorized Use.** GH₂ cylinders, containers, and tanks shall not be used for any purpose other than to serve as a vessel for containing the product for which it was designed.

▲ **7.1.12 Cylinders, Containers, and Tanks Exposed to Fire.** GH₂ cylinders, containers, and tanks exposed to fire shall not be used or shipped while full or partially full until they are requalified in accordance with the pressure vessel code under which they were manufactured.

7.1.13 Leaks, Damage, or Corrosion.

▲ **7.1.13.1* Removal From Service.** Leaking, damaged, or corroded GH₂ cylinders, containers, and tanks shall be removed from service.

▲ **7.1.13.2 Replacement and Repair.** Leaking, damaged, or corroded GH₂ systems shall be replaced or repaired.

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

7.1.14 Surfaces.

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

▲ **7.1.14.2** Surfaces shall be graded to prevent accumulation of water.

7.1.15 Valves.

▲ **7.1.15.1** Valves utilized on GH₂ systems shall be designed for the gas or gases and pressure intended and shall be accessible.

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

▲ **7.1.16 GH₂ Venting Systems.** Hydrogen-venting systems serving pressure relief devices discharging GH₂ to the atmosphere shall be in accordance with CGA G-5.5, *Hydrogen Vent Systems*.

▲ **7.1.16.1** Venting from the relief vents from the hydrogen supply piping serving listed fuel cell systems shall be permitted to be discharged into an enclosure integral to the fuel cell system where the concentration of hydrogen is diluted below 25 percent of the lower flammable limit (LFL) at the outlet of the enclosure.

▲ **7.1.16.1.1** The hydrogen supply piping system shall be designed to isolate the source of hydrogen from the relief vent in the event of loss of dilution ventilation or power.

7.1.16.2 Vent Pipe Termination.

▲ **7.1.16.2.1** Venting of GH₂ shall be directed to an approved location.

▲ **7.1.16.2.2** 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 6.17.

▲ **7.1.17 Cathodic Protection.** Where required, cathodic protection shall be in accordance with 7.1.17.

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

▲ **7.1.17.2 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.

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

▲ **7.1.17.3 Impressed Current Systems.** Systems equipped with impressed current cathodic protection systems shall be inspected in accordance with the requirements of the design and 7.1.17.2.

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

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

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

▲ **7.1.17.4 Corrosion Expert.** Repairs, maintenance, or replacement of a cathodic protection system shall be under the supervision of a corrosion expert certified by NACE.

▲ **7.1.17.4.1** 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.

▲ **7.1.18 Transfer.** Transfer of GH₂ between cylinders, containers, and tanks shall be performed by qualified personnel using equipment and operating procedures in accordance with CGA P-1, *Safe Handling of Compressed Gases in Containers*.

▲ **7.1.19 Compression and Processing Equipment.** Compression and gas processing equipment integral to hydrogen compressed 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.

▲ **7.1.19.1** 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.

▲ **7.1.19.2** Where GH₂ compression equipment is operated unattended, it shall be equipped with a high discharge and a low suction pressure automatic shutdown control.

▲ **7.1.19.3** When an automatic shutdown control shuts down a system, the system shall remain out of service until personnel authorized by the owner determines the cause of the shutdown and that the system is safe to restart.

7.1.20 Stationary Compressors.

7.1.20.1 Valves.

▲ (A) Valves shall be installed such that each compressor is able to be isolated for maintenance.

△ (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.

7.1.20.2 Foundations.

△ (A) Foundations used for supporting equipment shall be designed and constructed to prevent frost heaving.

△ (B) The structural aspects of such foundations shall be designed and constructed in accordance with the provisions of the adopted building code.

△ **7.1.20.3 Emergency Shutdown.** When an emergency shutdown system (ESS) is required, activation of the ESS shall shut down operation of all compressors serving a single gas installation.

7.1.20.4 Relief Valves.

△ (A) Each compressor shall be provided with a vent or relief device that will prevent overpressurizing of the compressor under normal or upset conditions.

△ (B) Pressure relief devices used to serve pumps or compression equipment shall be connected to a vent pipe system in accordance with 7.1.16.

7.1.20.5 Pressure Monitoring.

△ **7.1.20.5.1** The pressure on the compressor discharge shall be monitored by a control system.

△ **7.1.20.5.2** Discharge pressures in excess of the equipment maximum operating pressure shall cause the compressor to shut down.

△ **7.1.20.6 Protection.** Transfer piping and compressors shall be protected from vehicular damage.

7.1.21 Use of GH₂ for Inflation. Inflatable equipment, devices, or balloons shall not be pressurized or filled with GH₂ unless the balloon is designed specifically for hydrogen as a lift gas.

■ **7.1.21.1** Balloons used for meteorological sounding flights and inflated with hydrogen shall comply with 7.1.21.1.

■ **7.1.21.1.1** Hydrogen-filled meteorological balloons shall meet the following:

- (1) Be inflated indoors in a purpose-built, dedicated area, room, or building
- (2) Lift only meteorological sounding instrument(s)
- (3)* Not be intended to land

■ **7.1.21.1.2*** Hydrogen inflation facilities for meteorological balloons shall be certified as meeting the requirements of this code and being adequately safe by qualified engineer(s) with expertise and competence in hydrogen balloon inflation and hydrogen fire safety.

■ **7.1.22** Piloted balloons shall be permitted to be filled with GH₂ when all of the following are met:

- (1) The piloted balloon is designed and approved for use with GH₂.
- (2)* The piloted balloon is operated, maintained, and inspected in accordance with applicable aviation regulations and is registered with a recognized national aviation authority.

(3)* The piloted balloon's structural conductive components and inflation system are bonded together via means recommended by the balloon's manufacturer.

(4)* The piloted balloon inflation system is bonded to the GH₂ supply container(s) and grounded via a grounding electrode conductor connected to a grounding electrode installed into the earth.

(5) The piloted balloon inflation assembly bonded elements have a resistance less than 106 ohms between the grounding electrode and the diffuser.

(6) The piloted balloon is filled outdoors, within an established inflation safety zone that meets the following conditions:

- (a)* It is marked or delineated by signage to prevent public access.
- (b) It is restricted to authorized personnel necessary for the inflation.
- (c) All potential ignition sources within the inflation safety zone, including vehicles, are prohibited during the inflation process.

(7)* The piloted balloon GH₂ source is immobile or has been rendered immobile.

(8) The piloted balloon inflation hose is described as follows:

- (a) Designed for GH₂ service at the flow rates used for inflation
- (b) Rated with a hydrostatic pressure appropriate for the GH₂ source
- (c) Electrically conductive or static dissipative with a smooth-bore liner
- (d) Visually inspected for damage prior to use
- (e) Purged of air, filled with GH₂, pressurized, and leak-checked prior to inflation

(9) Each piloted balloon inflation is coordinated by a single designated person who is responsible for the following:

- (a)* Being certificated or licensed as a pilot of GH₂ balloons by a recognized national aviation authority
- (b) Providing a safety briefing to all personnel involved in the inflation
- (c) Ensuring that the gas supply main shut-off valve is staffed at all times by an operator trained in GH₂ safety
- (d) Maintaining continuous visual contact with the gas supply's main shut-off valve operator when gas is flowing

7.1.23 Hydrogen Equipment Enclosures.

△ **7.1.23.1** Hydrogen equipment enclosures (HEEs) shall be in accordance with the approved building code or 7.1.23 when the total quantity of hydrogen stored in or piped into the enclosure exceeds 1000 scf (28.3 Nm³) or where the enclosure contains hydrogen processing or generating equipment.

△ **7.1.23.1.1** Subsection 7.1.23 shall not apply to any of the following:

- (1) Gas cabinets in accordance with Section 6.19
- (2) Exhausted enclosures in accordance with Section 6.20
- (3) Ventilated enclosures with sufficient dilution to maintain an unclassified area in the interior in accordance with Section 4.12
- (4) Enclosures integral to fuel cell systems that are listed or approved in accordance with Chapter 12
- (5) Enclosures integral to hydrogen generators that are listed or approved in accordance with Chapter 13

Table 7.1.23.9.1 Protection Features Based on Use

HEE or a compartment in an HEE contains:	GH ₂ storage	GH ₂ storage	Hydrogen generation, compression and/or processing equipment	Support equipment room (in an HEE)
Enclosure Volume:	<200 ft ³	≥200 ft ³	Not limited	Not limited
Contains or is connected to a source of hydrogen:	Yes	Yes	Yes	No
Automatic isolation from GH ₂ storage	Not required	Not required	Required	Not applicable
Ventilation	Natural or mechanical	Natural or mechanical	Mechanical	No additional requirement
Storage compartment separation	Not applicable	Not applicable	Required	Required
Electrical equipment	Per <i>NFPA 70</i> , Chapter 5	Per <i>NFPA 70</i> , Chapter 5	Per <i>NFPA 70</i> , Chapter 5	Unclassified
Bonding/grounding	Required	Required	Required	Per <i>NFPA 70</i>
Explosion control	Not required	Required	Required	Not required
Detection	Loss of ventilation*	GH ₂ , Loss of ventilation*	GH ₂ , Fire and Loss of ventilation	GH ₂ if necessary to meet the requirements of 7.1.23.10.3.1

*Where mechanical ventilation is provided

7.1.23.1.2 HEE shall be constructed of noncombustible materials.

7.1.23.2 HEE grounding and equipment bonding within the enclosure shall comply with all of the following:

- (1) The HEE structure shall be grounded in accordance with *NFPA 70*.
- (2) All conductive parts of the enclosure shall be grounded or bonded.
- (3) Hydrogen piping and equipment shall be bonded to the HEE structure to prevent static discharge.

7.1.23.3 Hydrogen Vent Systems.

7.1.23.3.1 GH₂ shall not be vented within the HEE or to compartments within an HEE.

7.1.23.3.2 Vent pipes shall be in accordance with **Section 6.17** and 7.1.16.

7.1.23.3.3 Pressure relief devices and valves discharging to the atmosphere shall be vented in accordance with 7.1.5.5.5.

7.1.23.4 Oxygen Deficiency. An HEE that can be entered and contains or is connected to a source of GH₂ shall be evaluated for the potential of an oxygen-deficient atmosphere during normal or off-normal conditions.

7.1.23.4.1 Alarms.

7.1.23.4.1.1 Where the potential exists for an oxygen-deficient atmosphere, detection and notification appliances shall be provided to warn personnel of an oxygen-deficient atmosphere.

7.1.23.4.1.2 Notification appliances shall produce a distinctive audible and visual alarm and be located outside the entrance to all locations where the oxygen-deficient condition could exist.

7.1.23.4.1.3 If a GH₂ detection system is provided in accordance with Section 6.13, oxygen detectors are not required.

7.1.23.5 Security.

7.1.23.5.1 Exterior access doors for a HEE shall be secured against unauthorized entry.

7.1.23.5.1.1 Exterior access doors shall not be required to be secured if a secured perimeter fence or wall is provided to prevent unauthorized entry.

7.1.23.5.2 Locks or latches shall not require the use of a key, a tool, or special knowledge or effort for the operation from the egress side.

7.1.23.6* Means of egress for a HEE shall be in accordance with 7.1.23.6.1, unless the HEE cannot be entered.

7.1.23.6.1 Not fewer than two means of egress shall be provided from each equipment enclosure or equipment compartment, unless all of the following criteria are met:

- (1) Undivided HEE or equipment compartments do not exceed 200 ft² (18.6 m²).
- (2) HEE or equipment compartments have a travel distance to the room or compartment exit door(s) not exceeding 15 ft (4.6 m).

7.1.23.6.1.1 The means of egress shall have the following:

- (1) A minimum of 28 in. (710 mm) clear width
- (2) A minimum headroom of not less than 6 ft 8 in. (2030 mm) along the entire designated means of egress path

7.1.23.7 A means shall be provided to isolate, depressurize, and make equipment and piping systems safe prior to replacement, maintenance, or service.

7.1.23.8 A HEE shall be secured to a structure or foundation in a manner approved by the authority having jurisdiction (AHJ).

7.1.23.9 Isolation of GH₂ Storage.

7.1.23.9.1 Where required by Table 7.1.23.9.1, a means for isolation of GH₂ storage shall be provided in accordance with 7.1.23.9.

7.1.23.9.2* GH₂ storage shall be equipped with automatic emergency shutoff valves to isolate the source of hydrogen from the delivery piping system.

7.1.23.9.3 Automatic emergency shutoff valves shall be located within the same compartment as the hydrogen storage.

7.1.23.9.4 Automatic emergency shutoff valves shall operate on GH_2 detection alarms, fire alarms, and ESS activations.

7.1.23.9.5 Automatic emergency shutoff valves shall be fail-safe to close upon loss of power or air pressure.

7.1.23.9.6 GH_2 generation and compression equipment within an HEE that supplies hydrogen to external storage containers shall be equipped with either an external automatic emergency shutoff valve or non-return valve on the exit piping outside the enclosure or compartment.

7.1.23.10 Ventilation.

7.1.23.10.1 Where required by Table 7.1.23.9.1, ventilation shall be provided in accordance with 7.1.23.10.

7.1.23.10.2 A HEE and compartments within an HEE that contain GH_2 storage, equipment, or piping shall be provided with ventilation in accordance with Section 6.18.

7.1.23.10.3 Natural ventilation openings and air intakes for mechanical ventilation systems shall be separated from non-bulk sources of GH_2 in accordance with 7.2.2.3.2.4 and from bulk sources of GH_2 in accordance with 7.3.2.3.1.2.

7.1.23.10.3.1 Air intakes and ventilation openings shall not be required to meet the requirements of Section 6.18 and 7.1.23.10.3 where the compartment is provided with GH_2 detection in accordance with 7.1.23.14, which initiates the emergency shutdown system (ESS) for the equipment within the enclosure upon detection of 25 percent of the LFL.

7.1.23.11 Storage Area Separation.

7.1.23.11.1 Where required by Table 7.1.23.9.1, storage area separation shall be provided in accordance with 7.1.23.11.

7.1.23.11.2 Fuel cell equipment, compressors, hydrogen generators, electrical distribution equipment, and similar appliances shall be separated from bulk GH_2 storage areas within the HEE by a one-hour fire-rated barrier that is also capable of preventing gas transmission.

7.1.23.12 Electrical Equipment.

7.1.23.12.1 All electrical equipment in an HEE that has GH_2 piping, storage, generation, or processing equipment shall be selected and installed in accordance with Articles 500 through 505 of *NFPA 70*.

7.1.23.12.2* Electrical equipment within 15 ft (4.6 m) of any natural ventilation opening or required exhaust discharge of an HEE shall be selected and installed in accordance with the requirements of Articles 500 through 505 of *NFPA 70*.

7.1.23.13 Emergency Shutdown System (ESS).

7.1.23.13.1 An ESS shall be provided for the HEE.

7.1.23.13.1.1 The ESS shall operate on GH_2 detection alarms, fire alarms, and loss of ventilation alarms, where these are required by Table 7.1.23.9.1.

7.1.23.13.1.2 The ESS shall operate upon activation of a manual emergency shutdown device (ESD).

7.1.23.13.1.3 The ESS shall operate across all interconnected HEE at a common site.

7.1.23.13.1.4 Where activated, the ESS shall de-energize unclassified electrical equipment inside compartments containing hydrogen or other flammable gases and close all automatic shutoff control valves on piping into and from interconnected HEE and HEE compartments containing hydrogen equipment.

7.1.23.13.1.5 A manual ESD shall be accessible, located exterior to the HEE, and in the immediate area of each HEE that is interconnected to the hydrogen system.

(A) The ESD shall be identified by a sign located at the exterior of the equipment enclosure.

7.1.23.13.1.6 A remote emergency shutdown shall be located not less than 25 ft (7.6 m) and not more than 100 ft (30 m) from HEE equipped with individual ESDs.

7.1.23.13.1.7 Activation of the ESS shall be indicated by a visible notification device mounted on the exterior of the HEE.

7.1.23.14 Detection.

7.1.23.14.1 Where required by Table 7.1.23.9.1, GH_2 detection, fire detection, and loss of ventilation detection shall be provided in accordance with 7.1.23.14.

7.1.23.14.2 GH_2 Detection.

7.1.23.14.2.1 GH_2 detection shall be provided in accordance with Section 6.13.

7.1.23.14.2.2 Detection of hydrogen above 25 percent of the LFL shall result in activation of the ESS.

7.1.23.14.3 Fire Detection.

7.1.23.14.3.1 Fire detection shall be provided.

7.1.23.14.3.2 The type of detection shall be as determined by a risk assessment.

7.1.23.14.3.3 Fire detection shall comply with both of the following:

- (1) Be in accordance with *NFPA 72*
- (2) Activate the ESS

7.1.23.14.4 Ventilation Detection.

7.1.23.14.4.1 A device shall be provided to detect failure of the ventilation system.

7.1.23.14.4.2 The device shall activate the ESS when airflow drops below 75 percent of the required flow.

7.1.23.15 Explosion Control.

7.1.23.15.1 Where required by Table 7.1.23.9.1, explosion control shall be provided in accordance with Section 6.10.

7.1.23.15.1.1 Explosion vents, where used, shall not discharge into adjacent HEE compartments.

7.1.23.16 HEE Walls Used for Separation Distance Reductions.

7.1.23.16.1 Where a wall of an HEE is constructed as a fire barrier and used to reduce separation distances per 7.3.2.3.1.4, in 7.1.23.16.1.1 through 7.1.23.16.1.5 shall apply.

7.1.23.16.1.1 Penetrations.

△ (A) The fire barrier wall shall be without openings or penetrations.

△ (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 adopted building code.

△ 7.1.23.16.1.2* Fire barrier walls shall have a minimum fire resistance rating of not less than 2 hours.

△ 7.1.23.16.1.3 The fire barrier wall shall interrupt the line of sight between the bulk hydrogen compressed gas system and the exposure.

7.1.23.16.1.4 Only one fire barrier wall of an HEE shall be allowed to be used to reduce separation distances per 7.3.2.3.1.4.

7.1.23.16.1.5 Fire barrier walls shall be designed and constructed in accordance with the requirements of the adopted building code.

7.1.24 Emergency Shutoff Valves.

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

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

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

7.1.25 Emergency Isolation.

△ 7.1.25.1 Where GH₂ from sources in excess of the quantity threshold in Table 6.4.1.1.1 is carried in pressurized piping above a gauge pressure of 15 psi (103 kPa), an approved method of emergency isolation shall be provided.

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

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

△ 7.1.25.3 The requirements of 7.1.25 shall not be required for the following:

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

△ 7.1.25.4 **Location Exemptions.** The requirements of 7.1.25.1 shall not apply to the following:

- (1) Piping for inlet connections designed to prevent backflow
- (2) Piping for pressure relief devices
- (3) Systems containing 430 scf (12.7 Nm³) or less of GH₂

△ 7.1.26 **Ignition Source Control.** Ignition sources in areas containing GH₂ shall be in accordance with 7.1.26.

△ 7.1.26.1 **Static Producing Equipment.** Static producing equipment located in GH₂ areas shall be grounded.

△ 7.1.26.2 **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.

7.1.27 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.

△ (B) Instructions shall be maintained at the operating site at a location acceptable to the AHJ.

7.2 Non-Bulk GH₂.**7.2.1 General.**

△ 7.2.1.1* **Incompatible Materials.** GH₂ cylinders, containers, and tanks shall be separated in accordance with Table 7.2.1.1.

7.2.1.1.1 GH₂ systems in outdoor storage or use shall be separated from other compressed gases in accordance with Table 7.3.2.3.1.2(B)(a).

△ 7.2.1.1.2 Subparagraph 7.2.1.1.1 shall not apply to GH₂ contained within closed piping systems.

△ 7.2.1.1.3 The distances shown in Table 7.2.1.1 shall be permitted to be reduced without limit where GH₂ cylinders, containers, and tanks 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.

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

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

△ 7.2.1.1.6 Spatial separation shall not be required between cylinders deemed to be incompatible in gas production facilities.

△ **Table 7.2.1.1 Separation of Gas Cylinders, Containers, and Tanks by Hazard Class from Non-Bulk GH₂ Cylinders, Containers, Tanks, and Systems**

Gas Category	GH ₂ *	
	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.

*See flammable gas column from Table 7.1.10.2 of NFPA 55.

ties where cylinders are connected to manifolds for the purposes of filling, analysis of compressed gases, or manufacturing procedures, assuming the prescribed controls for the manufacture of gas mixtures are in place.

▲ **7.2.1.2 Bonding and Grounding.** The hydrogen compressed gas system shall be electrically bonded and grounded.

▲ **7.2.1.2.1** Mobile hydrogen supply units shall be electrically bonded to the storage system before hydrogen is discharged from the supply unit.

7.2.2 Non-Bulk 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 6.4.1.1.1 shall be in accordance with Chapters 1 through 6 as applicable and Sections 7.1 through 7.2.

▲ **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.

▲ **7.2.2.2 Indoor Storage.** Indoor storage of GH₂ shall be in accordance with the applicable provisions of Section 7.1.

7.2.2.2.1 Indoor GH₂ systems in control areas with less than the maximum allowable quantities per control area shown in Table 6.4.1.1.1 shall be located in accordance with the applicable provisions of Table 7.2.1.1.

7.2.2.2.2 Indoor Hydrogen System Location.

▲ **7.2.2.2.2.1** Hydrogen systems of less than 5000 scf (141.6 Nm³) and greater than the MAQ, where located inside buildings, shall be in accordance with the following:

- (1) In a ventilated area in accordance with the provisions of Section 6.18
- (2) Separated from incompatible materials in accordance with the provisions of 7.2.1.1
- (3) A distance of 25 ft (7.6 m) from open flames and other sources of ignition
- (4) A distance of 50 ft (15 m) from intakes of ventilation, air-conditioning equipment, and air compressors located in the same room or area as the hydrogen system
 - (a) The distance shall be permitted to be reduced to 10 ft (3.1 m) where the room or area in which the hydrogen system is installed is protected by a listed detection system per Article 500.7(K) of *NFPA 70* and the detection system shuts down the fuel supply in the event of a leak that results in a concentration that exceeds 25 percent of the LFL.
 - (b) Emergency shutoff valves shall be provided in accordance with 7.1.24.
- (5) A distance of 50 ft (15 m) from other flammable gas storage
- (6) Protected against damage in accordance with the provisions of 7.1.7.3

7.2.2.2.2.2 Systems Installed in One Room.

▲ (A) More than one system of 5000 scf (141.6 Nm³) 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.

▲ (B) The separation distance between multiple systems of 5000 scf (141.6 Nm³) 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 occupancies in accordance with the requirements of Section 6.11.

▲ (C) The required separation distance between individual portable systems in the process of being filled or serviced in facilities associated with the manufacture or distribution of hydrogen and its mixtures shall not be limited by 7.2.2.2.2.2(A) or 7.2.2.2.2.2(B) when such facilities are provided with Protection Level 2 controls and the applicable requirements of Chapters 1 through 7.

7.2.2.3 Outdoor Storage.

▲ **7.2.2.3.1 General.** Exterior storage of GH₂ shall be in accordance with the material-specific provisions of 7.2.1, 7.2.2.1, and 7.2.2.3.

▲ **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.

7.2.2.3.2.1 The minimum required distances in Table 7.2.2.3.2 shall not apply when fire barriers without openings or penetrations having a minimum fire resistive rating of two hours interrupt the line of sight between the storage and the exposure.

7.2.2.3.2.2 The configuration of the fire barriers in Table 7.2.2.3.2 shall be designed to allow natural ventilation to prevent the accumulation of hazardous gas concentrations.

7.2.2.3.2.3 Fire Barriers.

▲ (A)* Where a fire barrier is used to protect GH₂ systems, the system shall terminate downstream of the source valve.

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

▲ (C) The fire barrier wall shall be without openings or penetrations.

(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.

▲ (D) The configuration of the fire barrier shall be designed to allow natural ventilation to prevent the accumulation of hazardous gas concentrations.

▲ **7.2.2.3.2.4 Air Intakes.** Storage and use of GH₂ shall not be located within 20 ft (6 m) of air intakes.

▲ **7.2.2.3.2.5 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.

Table 7.2.2.3.2 Distance to Exposures for Non-Bulk 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, Public Alleys, or Public Ways (ft)	Minimum Distance to Buildings on the Same Property		
				Less Than 2-Hour Construction	2-Hour Construction	4-Hour Construction
0–4225	5	5	5	5	0	0
4226–21,125	10	10	10	10	5	0
21,126–50,700	10	15	15	20	5	0
50,701–84,500	10	20	20	20	5	0
84,501–200,000	20	25	25	20	5	0

For SI units: 1 ft = 304.8 mm; 1 scf = 0.02832 Nm³.

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

7.2.3 Non-Bulk GH₂ Use.

7.2.3.1 General.

7.2.3.1.1 Applicability. The use of GH₂ exceeding the quantity thresholds for gases requiring special provisions as specified in Table 6.4.1.1.1 shall be in accordance with Chapters 1 through 6 as applicable and Sections 7.1 and 7.2.

7.2.3.2 Indoor Use. Indoor use of GH₂ shall be in accordance with the requirements of Section 7.1.

7.2.3.3 Outdoor Use. Exterior use of GH₂ shall be in accordance with the applicable requirements of Section 7.1.

7.2.4 Non-Bulk 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 6.4.1.1.1 shall be in accordance with Chapters 1 through 6 as applicable and Sections 7.1 and 7.2.

7.2.4.2 Carts and Trucks.

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

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

7.2.4.3 Lifting Devices. Ropes, chains, or slings shall not be used to suspend GH₂ cylinders, containers, and tanks unless provisions at time of manufacture have been made on the cylinder, container, or tank for appropriate lifting attachments, such as lugs.

7.2.4.4 Cargo Transport Unloading. Cargo transport unloading shall be in accordance with 7.3.4.2.

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 applicable provisions of Chapters 1 through 6, and Section 7.3.

7.3.1.2 Bonding and Grounding. The bulk hydrogen compressed gas system shall be electrically bonded and grounded.

7.3.2 Bulk GH₂ Systems Storage.

7.3.2.1 General.

7.3.2.1.1 Bulk Hydrogen Compressed Gas. Systems located above ground either at grade or above grade shall be in accordance with 7.3.2.

7.3.2.1.2* Fire Protection. Fire protection shall be in accordance with the requirements of Section 6.11.

7.3.2.1.3 Installation in Vaults Above and Below Ground. Generation, compression, storage, and dispensing equipment for compressed gases shall be allowed to be located in either abovegrade or belowgrade vaults in accordance with 5303.16 of the *International Fire Code*.

7.3.2.2 Indoor Storage.

7.3.2.2.1 The location of bulk GH₂ systems shall be in accordance with Table 7.3.2.2.1.

7.3.2.2.2 Detached Buildings.

7.3.2.2.2.1 Detached buildings shall be constructed of noncombustible or limited-combustible materials in accordance with the requirements of Section 6.6.

7.3.2.2.2.2 Ventilation shall be provided in accordance with the requirements of Section 6.18.

(A) Outlet openings shall be located at the high point of the room in exterior walls or the roof.

(B) Inlet and outlet openings shall each have a minimum total area of 1 ft²/1000 ft³ (1 m²/305 m³) of room volume.

(C) Discharge from outlet openings shall be directed or conducted to the atmosphere.

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

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

Table 7.3.2.2.1 Location of GH₂ Systems

Location	Quantity of Hydrogen	
	≥5000 scf to <15,000 scf (≥142 Nm ³ to <425 Nm ³)	≥15,000 scf (≥425 Nm ³)
In a detached building in accordance with Section 6.5	A	A
In a Protection Level 2 occupancy, in accordance with Section 6.4	A	Detached building required in accordance with Section 6.5
Not in a Protection Level 2 occupancy	N/A	Detached building required in accordance with Section 6.5

A: Allowed. N/A: Not allowed.

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.

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.

(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.

(B) Not less than 25 percent of the perimeter wall shall be an exterior wall.

(C) Openings to other parts of the building shall not be permitted.

(D) Windows and doors shall be in exterior walls only.

7.3.2.2.3.2 Ventilation shall be as provided in Section 6.18.

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

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

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

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.

7.3.2.3 Outdoor Storage.

7.3.2.3.1 Aboveground Locations.

7.3.2.3.1.1* The minimum distance to exposure for individual components of the bulk hydrogen compressed gas system shall be taken from Table 7.3.2.3.1.2(B)(a), Table 7.3.2.3.1.2(B)(b), and Table 7.3.2.3.1.2(B)(c) based on the maximum internal diameter and respective system design in which they are installed.

7.3.2.3.1.2* Minimum Distance for Aboveground Locations. The minimum distance from a GH₂ system located outdoors to specified exposures shall be in accordance with Table 7.3.2.3.1.2(B)(a), Table 7.3.2.3.1.2(B)(b), or Table 7.3.2.3.1.2(B)(c).

(A) The vent stack shall not be considered part of the bulk hydrogen compressed gas system for determining separation distances in 7.3.2.3.1.1.

(B) 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 be required to be in accordance with the values shown in Table 7.3.2.3.1.2(B)(a) when in accordance with Table 7.3.2.3.1.2(B)(b) or Table 7.3.2.3.1.2(B)(c).

(1) The separation distance for piping systems with internal diameters other than those specified in Table 7.3.2.3.1.2(B)(a) for the pressure range selected shall be permitted with tabular distances determined based on the use of Table 7.3.2.3.1.2(B)(b) or Table 7.3.2.3.1.2(B)(c).

(2) Separation distances determined based on the use of Table 7.3.2.3.1.2(B)(b) or Table 7.3.2.3.1.2(B)(c) shall be subject to review and approval by the AHJ.

(3) The separation distance shall be measured from the part of the bulk hydrogen compressed gas system closest to the exposure.

(4)* **Determination of Internal Diameter.** The internal diameter of the piping system shall be determined by the diameter of the piping serving that portion of a storage array with content greater than 5000 scf (141.6 Nm³). The piping system size used in the application of Table 7.3.2.3.1.2(B)(a), Table 7.3.2.3.1.2(B)(b) or Table 7.3.2.3.1.2(B)(c) shall be determined based on that portion of the system with the greatest maximum internal diameter.

(5)* **Determination of System Pressure.** The system pressure shall be determined by the maximum operating pressure of the storage array with content greater than 5000 scf (141.6 Nm³), irrespective of those portions of the system elevated to a higher pressure.

7.3.2.3.1.3 Distances in Table 7.3.2.3.1.2(B)(a) to air intakes shall apply only to mechanical piping connections or potential leak points that are part of the outdoor bulk hydrogen compressed gas system.

7.3.2.3.1.4* Reduction of Distance by Mitigation Means. Fire barrier walls located and constructed per 7.3.2.3.1.4(A) shall not permit the reduction of distances to air intakes.

(A)* Passive Means. The distances to Group 1 and 2 exposures shown in Table 7.3.2.3.1.2(B)(a), Table 7.3.2.3.1.2(B)(b), and Table 7.3.2.3.1.2(B)(c) are permitted to be reduced to 0 ft (0 m) where fire barrier walls are located between the system

Table 7.3.2.3.1.2(B)(a) Minimum Distance (D) from Outdoor Bulk Hydrogen Compressed Gas Systems to Exposures — Typical Maximum Pipe Size

Pressure	>15 to ≤250 psig		>250 to ≤3000 psig		>3000 to ≤7500 psig		>7500 to ≤15000 psig	
Internal Pipe Diameter (ID)	>103.4 to ≤1724 kPa		>1724 to ≤20,684 kPa		>20,684 to ≤51,711 kPa		>51,711 to ≤103,421 kPa	
d _{mm}	d = 52.5 _{mm}		d = 18.97 _{mm}		d = 7.31 _{mm}		d = 7.16 _{mm}	
Exposures Group 1	m	ft	m	ft	m	ft	m	ft
Lot lines	5	16	6	20	4	13	5	16
Air intakes (HVAC, compressors, other)								
Operable openings in buildings and structures								
Ignition sources such as open flames and welding								
Exposures Group 2	m	ft	m	ft	m	ft	m	ft
Exposed persons other than those servicing the system	5	16	6	20	3	10	4	13
Parked cars								
Exposures Group 3	m	ft	m	ft	m	ft	m	ft
Buildings of non-combustible non-fire-rated construction	4	13	5	16	3	10	4	13
Buildings of combustible construction								
Flammable gas storage systems above or below ground								
Hazardous materials storage systems above or below ground								
Heavy timber, coal, or other slow-burning combustible solids								
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								
Unopenable openings in building and structures								
Encroachment by overhead utilities (horizontal distance from the vertical plane Below the nearest overhead electrical wire of building service)								
Piping containing other hazardous materials								
Flammable gas metering and regulating stations such as natural gas or propane.								

and the exposure and constructed in accordance with **all of** the following:

- (1) The fire barrier wall shall be without openings or penetrations.
 - (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.
- (2) Fire barrier walls shall have a minimum fire resistance rating of not less than 2 hours.
- (3) The fire barrier wall shall interrupt the line of sight between the bulk hydrogen compressed gas system and the exposure.
- (4) The configuration of the fire barrier shall allow natural ventilation to prevent the accumulation of hazardous gas concentrations.
- (5) The wall shall not have more than two sides at 90 degree (1.57 rad) directions or not more than three sides with connecting angles of 135 degrees (2.36 rad), except as provided in **7.3.2.3.1.4(A)(5)**.

- (6)* The connecting angles between fire barrier walls shall be permitted to be reduced to less than 135 degrees (2.36 rad) for installations consisting of three walls when in accordance with 8.3.2.3.1.5(D).

- (7) Where the number of fire barrier walls creates a court or enclosed court, the requirements of 7.3.2.5 shall apply

- (8) Fire barrier walls shall be designed and constructed as a structure in accordance with the requirements of the building code without exceeding the specified allowable stresses for the materials of construction utilized and shall be designed to resist the overturning effects or failure caused by lateral forces due to deflagration, overpressure, wind, soil, flood, and seismic events.

- (9) The fire barrier wall shall be either an independent structure or the exterior wall of the building adjacent to the storage or use area when the exterior building wall meets the requirements for fire barrier walls.

- (10) The construction of a fire barrier wall that is part of a hydrogen equipment enclosure and used to reduce separation distances shall be in accordance with 7.1.23.16.