HYDROGEN
Safety Panel

Hydrogen Equipment Certification Guide

Listing, Labeling, and Approval Considerations

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DISCLAIMER

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Use of the Guide

The purpose of this guide is to assist users of codes and standards that apply to hydrogen application and use in understanding and applying the *approval*, *certification*, *listing*, and *labeling* provisions of the codes and standards, in any application where the required *certification*, *listing*, and *labeling* of services, methods, or equipment has not yet been established or achieved.

Safe practices in the production, storage, distribution, and use of hydrogen are essential for developing hydrogen and fuel cell technologies. Codes and standards applicable to the design, fabrication, installation, and operation of facilities, systems, equipment, and components for the production, storage, distribution, and use of hydrogen are important to establishing these safe practices, and although codes and standards have been developed for hydrogen use, hydrogen's use in fuel cells and associated fuel storage, distribution, and dispensing systems is still relatively new. These new hydrogen technologies and the associated knowledge base for safe practices are rapidly and continuously evolving, and the knowledge, methods, and equipment for satisfying the code and standard requirements for *approval*, *certification*, *listing*, and *labeling* are not yet well established or understood.

Typical definitions of these terms from the model codes used to regulate hydrogen are as follows:

- *Approved* – Acceptable to the *authority having jurisdiction (AHJ)*.[a]
- *Certified* – To attest as being true or as represented or as meeting a standard.[b]
- *Listed* – Equipment, materials, or services included in a list published by an organization that is acceptable to the *AHJ* 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.[c]
- *Labeled* – Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the *AHJ* 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.[d]

This guide focuses on the application of the primary model codes, as identified in Chapter 1, to hydrogen fuel facilities and technologies, including those associated with hydrogen fuel storage, distribution, dispensing facilities and equipment, and fuel cell applications. Background information is provided in Chapter 2 of this guide on the *approval*, *certification*, *listing*, and *labeling* processes to provide

[a] NFPA 2, *Hydrogen Technologies Code*, 2011 Edition, National Fire Protection Association, Quincy, MA 02169.
[b] NFPA 2 does not define *certified* or *certification*. *Merriam-Webster's Collegiate Dictionary*, 11th Edition Merriam-Webster, Inc., Springfield, MA 2003, which is designated by Section 3.1 of NFPA 2 as establishing the ordinary meaning of a term in the absence of a code definition, defines *certified* as "to attest as being true or as represented or as meeting a standard."
[c] NFPA 2, *Hydrogen Technologies Code*
[d] Ibid, NFPA 2

additional understanding of the terms as applied in the codes and standards. In Chapter 4, each applicable provision of the primary model codes that contains the terms *approved*, *certified*, *listed*, or *labeled* is provided with narrative guidance, applicable references, and other information to assist the user in meeting the provision of the codes. Both required and informational references are cited in the guide to support application of the methods within this guide to meet the subject code requirements. The required references, provided in Appendix A.1, are those needed by users of this guidance in the design or the *approval* process. Additional informational references are provided for further reading and greater understanding of a particular subject.

In addition to providing a greater understanding of the use of specific code provisions for designers and owners where the terms *approval*, *certification*, *listing*, and *labeling* are used, this guide is intended to be used by *AHJs* to support their determination of *approval* where required in the codes, and specifically in those instances where the code requires *certification*, *listing*, or *labeling* of services, methods, or equipment, and the *certification*, *listing*, or *labeling* necessary to meet the code is not established or otherwise available. While this guide provides methods for the *AHJ* to evaluate alternative approaches to *certification*, *listing*, and *labeling* requirements, it is not intent of this guide to circumvent *certification* and *listing* if the *AHJ* determines it to be necessary for *approval*.

This guide is also intended to be used by designers, manufacturers, fabricators, installers, operators, distributors, or other users in the application of the model codes to hydrogen fuel storage, distribution, dispensing, and use as well as for requirements that are applicable to a multitude of industrial uses. Use of the guide can assist these users in meeting the necessary requirements to ensure safe use of hydrogen as an industrial gas or fuel and to obtain the necessary *AHJ approvals* of facilities, systems, equipment, and services that require *approval*, *certification*, *listing*, or *labeling*.

Limitations: This guide has been designed to follow the organization of the applicable code, beginning with the requirements of NFPA 2 followed by applicable requirements of the International Codes (I-Codes). Requirements are listed in code order and are not sorted by subject. Users CANNOT use this guide alone as a substitute to the code, nor can it be assumed that the explanatory material included in this guide can be used standalone. Requirements and explanations must be applied in accordance with the context within the source code or document referenced.

When the user encounters a section in the code that raises a question as to intent, or where special considerations may be needed to satisfy the requirements of the code, the user can quickly find (1) the applicable code, (2) the code section, and (3) advisory comments along with needed references behind statements that have been included in the narrative or reference documents.

Acronyms and Abbreviations

AHJ	authority having jurisdiction
ANSI	American National Standards Institute
API	American Petroleum Institute
ASTM	ASTM International (formerly American Society of Testing and Materials)
ATEX	ATmospheric EXplosible
ATI	Architectural Testing, Inc.
CE	Conformité Européene, which translates to “European Conformity”
CGA	Compressed Gas Association
CSA	CSA Group (formerly Canadian Standards Association)
CSL	Curtis-Straus, LLC.
DIS	Draft International Standard
EC	European Community
EU	European Union
FM	FM Approvals, LLC. (formerly Factory Mutual Research Corporation)
GH_2	gaseous hydrogen
HMMP	Hazardous Materials Management Plan
IBC	International Building Code®
ICAO	International Civil Aviation Organization
ICC	International Code Council®
IEC	International Electrotechnical Commission
IFC	International Fire Code®
IFGC	International Fuel Gas Code®
IMC	International Mechanical Code®
IRC	International Residential Code®
ISO	International Organization for Standardization
ITSNA	Intertek Testing Services NA, Inc. (formerly ETL)
LH_2	liquid hydrogen
MAQ	maximum allowable quantity
MET	MET Laboratories, Inc.
NACE	National Association of Corrosion Engineers
NEC	National Electrical Code®
NEMA	National Electrical Manufacturers Association
NFPA®	National Fire Protection Association®
NIST	National Institute of Standards and Technology
NRTL	Nationally Recognized Testing Laboratory
NSF	NSF International
NTS	National Technical Systems, Inc.
OSHA	Occupational Safety and Health Administration
PLC	programmable logic controller
PRV	pressure relief valve
QPS	QPS Evaluation Services Inc.
QR	Quick Response code
SAE	SAE International (formerly Society of Automotive Engineers)
SCFM	standard cubic feet per minute
SGSUS	SGS U.S. Testing Company, Inc. (formerly UST-CA)

SWRI	Southwest Research Institute
TUV	TÜV Rheinland of North America, Inc.
TUVAM	TÜV SÜD America, Inc.
TUVPSG	TÜV SÜD Product Services GmbH
TUVPTL	TÜV Rheinland PTL, LLC
UL	Underwriters Laboratories, Inc.

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Chapter 1. Introduction

Chapter 1. Introduction

Safe practices in the production, storage, distribution, and use of hydrogen are essential for developing hydrogen and fuel cell technologies. Codes and standards applicable to the design, fabrication, installation, and operation of facilities, systems, equipment, and components for the production, storage, distribution, and use of hydrogen are important to establishing these safe practices. Inherent in the provisions of codes and standards are requirements for *approved*, *certified*, *listed*, and *labeled* methods and equipment. Typical definitions of these terms from the model codes used to regulate hydrogen are:

- *Approved* – Acceptable to the *authority having jurisdiction* (*AHJ*).[e]
- *Certified* – To attest as being true or as represented or as meeting a standard.[f]
- *Listed* – Equipment, materials, or services included in a list published by an organization that is acceptable to the *AHJ* and is 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.[g]
- *Labeled* – Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the *AHJ* and is 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.[h]

Although codes and standards have been developed for storage and use of hydrogen, hydrogen's use in fuel cells and associated fuel storage, distribution, and dispensing systems is still relatively new. These new hydrogen technologies and the associated knowledge base for safe practices are rapidly and continuously evolving, and knowledge, methods, and equipment for satisfying the code and standard requirements for *approval*, *certification*, *listing*, and *labeling* are not yet well established or consistently applied.

Code and standard requirements for *approvals*, as well as *certified*, *listed*, and *labeled* equipment, provide assurances that a facility, system, equipment, or component is properly designed, fabricated, manufactured, and installed and will reliably perform its safety function as required. In the absence of sufficient knowledge and experience within the code enforcement or user community because of the rapidly changing and evolving hydrogen fuel technologies, additional guidance is needed to address

[e] NFPA 2, *Hydrogen Technologies Code*, 2011 Edition, National Fire Protection Association, Quincy, MA 02169.
[f] NFPA 2 does not define *certified* or *certification per se*. *Merriam-Webster's Collegiate Dictionary*, 11th Edition Merriam-Webster, Inc., Springfield, MA 2003, which is designated by Section 3.1 of NFPA 2 as establishing the ordinary meaning of a term in the absence of a code definition, defines *certified* as "to attest as being true or as represented or as meeting a standard."
[g] NFPA 2, *Hydrogen Technologies Code*
[h] Ibid, NFPA 2

these inherent elements of the code that ensure these technologies can be deployed safely within the community.

1.1 Purpose

This guide supplements the use of hydrogen-related codes and standards by providing additional guidance and information to support compliance with codes and standards for those provisions that require specific *approval*, *certification*, *listing,* or *labeling* as applicable to facilities, systems, equipment, and components where hydrogen is used or stored. Use of *approved*, *certified*, *listed*, and *labeled* equipment provides assurance that facilities, systems, equipment, and services associated with the use of hydrogen are safely designed, manufactured, fabricated, installed, and operated.

These guidelines are intended to assist code officials, designers, manufacturers, installers, owners, evaluators, and other stakeholders in the application of the codes and standards identified in Section 1.2. This guide provides information and considerations to support *AHJs* in determinations of *approval* where required by the codes, and specifically in those cases where the codes require *certification* or *listing* of services, methods, or equipment. The guidelines provide information and considerations to support designers, manufacturers, installers, distributors, and other users associated with hydrogen and hydrogen fuel technology applications in meeting the provisions of the codes and obtaining *AHJ approvals*. This publication provides guidance only; it is not a regulatory document and is not intended to provide any formal interpretations or positions on compliance with the codes and standards addressed herein, which can only be provided by the code development organizations.

1.2 Scope

The guidelines herein support the application of the following model codes to facilities, systems, equipment, and components used for the storage, handling, and use of hydrogen in gaseous or liquid (cryogenic) form in commercial, industrial, and residential environments. The model codes given below were the current editions at the time this guide was published.

- *2015 International Fire Code* (IFC)
- *2015 International Building Code* (IBC)
- *2015 International Fuel Gas Code* (IFGC)
- *2015 International Residential Code* (IRC)
- *2015 International Mechanical Code* (IMC)
- *2011 and 2016 NFPA 2 Hydrogen Technologies Code*[i]
- *2015 NFPA 1 Fire Code* (as used by NFPA 2 as a source document for requirements relevant to hydrogen as established by NFPA 55[j])

[i] Requirements for the 2011 and 2016 Editions of NFPA 2 are included in Chapters 4 through 18.

[j] The first edition of NFPA 2 was published in 2011. NFPA 2 is dependent in part for requirements and definitions found in NFPA 55, which was being published under a different code cycle. Recognizing the need for close coordination between NFPA 2 and NFPA 55, NFPA's Standards Council has placed these two documents on the same schedule for updating the publications. The correlation between the two documents now under the same code revision cycle has eliminated questions as to applicability, thereby avoiding confusion for the user where the year of issuance of one or the other document when used as a reference may be different.

- *2013 and 2016 NFPA 55 Compressed Gases and Cryogenic Fluids Code* (as used by NFPA 2 as a source document for requirements relevant to hydrogen)[k]

This guide will be updated periodically as new code editions are released or additional codes are evaluated and added to the guide. Provisions for use with both the 2011 and 2016 Editions of NFPA 2 have been included in this first edition of the guide in recognition of recent adoptions that reference the 2011 Edition. References to NFPA 52 that may remain are applicable to compressed or liquefied natural gas. The use of extract text under NFPA's extract policy allows the use of a requirement in NPFA 2. With the exception of a reference to the term *certified* as used in Chapter 3 of this guide, NFPA 52 is no longer referenced.[l]

1.3 Background

The majority of the model codes governing the built community in the United States, and included in this guide, are developed and published by two principal publishing organizations: the International Code Council (ICC) and the National Fire Protection Association (NFPA). The codes published by these organizations are called "model codes" because they provide a model for adoption by a legal entity for use in regulating properties within the community, including facilities, processes, and operations for storing and using various materials. The adopting entity, or jurisdiction, may amend a model code to address local or regional concerns, or to add or delete provisions to tailor the code based on local needs, for example, due to climatic, seismic, or geographic conditions.

Once formally adopted by law or ordinance, codes establish enforceable requirements that can be used by a jurisdiction such as a state, county, city, or local entity in permitting (or *approval*) processes, inspections, and legal actions to ensure that provisions of the code are met and facilities, equipment, and components are designed, constructed, installed, and operated safely. If not formally adopted, codes may be used as best practices, and the use of the code can support regulatory *approval* as an established method, but the provisions are not enforceable.

Codes frequently contain references to other standards, guidelines, and recommended practices developed by independent standards development organizations, trade associations, or manufacturers. Standards, guidelines, and recommended practices referenced by the model codes may be either informative or normative depending on the use within the code. Informative documents, including guidelines and recommended practices, help the code user better understand a subject, but they do not establish requirements. Normative documents, such as standards written in enforceable language, create supplemental code requirements.

The principal model codes used to regulate the storage and use of hydrogen are prescriptive, and the requirements are written to lead the user to implementing designs and installations where there is little

[k] Requirements for the 2011 and 2016 Editions of NFPA 2 are included in Chapters 4 through 18.

[l] The 2011 Edition of NFPA 2 was partially based on requirements found in the 2010 Edition of NFPA 52, *Vehicular Gaseous Fuel Systems Code.* Requirements contained in this guide using brackets [ ] containing a reference to NFPA 52 indicate the use of NFPA 52 as the source document. With the publication of the 2013 Edition of NFPA 52, all requirements for hydrogen have been removed from NFPA 52 and they have been retained, modified, or deleted by the NFPA 2 Technical Committee in the 2016 Edition of the code. There may be several requirements found in NFPA 2 as extract text where a reference using the bracketed notation remains.

question about the applicability or purpose of the prescriptive requirement. These same codes offer a performance-based approach as an alternative to the prescriptive requirements in which designs must meet pre-determined performance standards that involve the use of third party assessment to fulfill failure scenarios described by the code. The prescriptive codes also contain requirements where qualified *approval* is needed to satisfy the code provisions. In some cases, qualified *approval* can be granted by using *listed* materials and equipment that can be accepted or *approved* by the *AHJ* as a way to comply with the code. *Listed* or *certified* materials and equipment have been verified by third party testing or other methods to meet established standards of performance and may be *labeled* to indicate that the manufacturer adheres to the testing/*certification* organization's standards. The *AHJ* uses *labeling* (to a *listing* or *certification* of compliance with code requirements) to verify that the installations, materials, or equipment meet the requirements of the code or *listing* standard as expected.

The majority of prescriptive code requirements are easily interpreted by system or facility designers, and by the *AHJ* for permitting and *approval* of the installation. However, some requirements can be satisfied only by using materials, methods, or equipment that have been *listed* in a directory or other publication by a third party agency. In cases where *listed* materials and equipment are required and such equipment is not available, or where special *approval* is required, such *approval* can only be granted when the *AHJ* finds that the design or equipment meets the code intent and is satisfactory for the intended use.

In new uses and processes where equipment and designs evolve with an expanding market, such as hydrogen as a fuel for commercial and private use, there is typically a lack of *listing* standards because there hasn't been enough time to standardize the equipment and facilities being designed, fabricated, installed, and operated. When the codes governing any new use of materials or processes are developed, provisions may, in some cases, be included in the code to use either *listed* or *approved* equipment or materials, even though the listings may not yet be available. *Approval* in this case allows the *AHJ* to determine the acceptability of compliance absent the availability of *listed* equipment. The code development organization includes these provisions because the requirement is considered necessary for safety, and with the anticipation that use and application of the code will result in manufacturers seeking *certification* or *listing* of their materials or equipment.

There may be cases where the *AHJ* wants assurance that a design or product has met the code requirements. In these cases, it is not uncommon for the *AHJ* to request that the design or product be *certified* as meeting the code requirements. In some instances, self-*certification* may be appropriate, and in others, *certification* by a third party may be required. The complexities of the design, product, or installation are all considerations for *certification*. The installation's location and potential impact on the public may raise the level of concern enough to possibly warrant third-party *certification*.[m,n] The term

[m] Self-*certification* may in fact be allowed by the codes that are applicable. For example, the ASME Codes referenced by portions of the installation such as *piping systems* when constructed in compliance with the ASME Code for Pressure Piping, B31. *Certification* may be provided by the "owner's inspector" who may represent the manufacturer, fabricator or erector. The *AHJ* must constantly use judgment as to the complexity of any system and whether the requirements are such that the use of self-*certification* should be accepted in instances where self-*certification* is allowed, or where *certification* by the designer may be acceptable.

[n] ASME B31.12-2014, *Hydrogen Piping and Pipelines*, American Society of Mechanical Engineers, New York, Chapter GR-4.

approved places a burden on the *AHJ* when the criteria for *approval* may not be fully known or where a *listing* may not be available. These guidelines provide further insight and guidance for the *AHJ* to consider in determining *approval* absent the availability of *listed*, *certified*, and *labeled* materials or equipment. These guidelines can also be applied by the code user or equipment designer to anticipate the needs of the *AHJ* and to develop an acceptable approach to compliance absent the availability of *listed*, *certified*, or *labeled* equipment or methods.

Chapter 2. Overview of the Certification Process

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2.1 Equipment Listing Organizations and Standards

Recent requirements in the codes that support hydrogen use as an alternative fuel mandate the use of *listed* equipment as well as *listed* or *approved* equipment in several cases. The following discussion is meant to facilitate greater understanding of the *listing* process, the use of *listing* standards, and the expectations for designers and the *approval* authorities when *listed* equipment or components are required.

This discussion is presented in four parts: (1) U.S. recognized *listing* organizations and standards, (2) international and foreign recognized *listing* organizations and standards, (3) non-recognized *certification* organizations, and (4) manufacturer self-*certification*.

2.1.1 U.S. Recognized Equipment Listing Organizations and Standards

Many U.S. federal, state, and municipal agencies only recognize particular equipment *certification* organizations for various categories of equipment. In the case of equipment and products to be *certified* for use in U.S. workplaces, the Occupational and Safety and Health Administration (OSHA) has a Nationally Recognized Testing Laboratory (NRTL) accreditation program to designate certain non-government testing organizations as having the necessary qualifications and facilities to perform safety testing and *certification* of certain categories of equipment. These categories include electrical equipment, fire protection equipment, automotive service station dispensing equipment, and industrial trucks used in *hazardous locations*.[o]

Many testing organizations apply for NRTL designation. The 2013 list of OSHA-designated NRTLs is as follows.

- CSA Group (formerly Canadian Standards Association)
- Curtis-Straus LLC (CSL)
- FM Approvals (FM) (formerly Factory Mutual Research Corporation)
- Intertek Testing Services NA, Inc. (ITSNA) (formerly ETL)
- MET Laboratories, Inc. (MET)
- Nemko-CCL, Inc. (formerly Communication Certification Laboratory, Inc.)
- NSF International (NSF)
- National Technical Systems, Inc. (NTS)
- QPS Evaluation Services, Inc. (QPS)
- SGS U.S. Testing Company, Inc. (SGSUS) (formerly UST-CA)
- Southwest Research Institute (SWRI)
- TÜV Rheinland PTL, LLC (TUVPTL)

[o] The complete list of equipment required to be *certified* by an OSHA NRTL is given at https://www.osha.gov/dts/otpca/nrtl/prodcatg.html.

- TÜV SÜD America, Inc. (TUVAM)
- TÜV SÜD Product Services GmbH (TUVPSG)
- TÜV Rheinland of North America, Inc. (TUV)
- Underwriters Laboratories, Inc. (UL)

NRTL *certification* evaluations are based on equipment examination and testing standards generated either by (1) the testing labs themselves, (2) national (U.S.) standards developed by American National Standards Institute (ANSI)[p] accredited organizations such as professional societies or industry trade associations, or (3) international standards bodies.

The scope of the NRTL standards can usually be found on the individual NRTL websites, but in many cases the standards have to be purchased from the NRTL. Some of these standards also include provisions for factory quality control audits that require ongoing monitoring to confirm that the manufacturing practices continue to produce equipment that meets the requirements of the *listing* standard.

The OSHA NRTL Program and NTRL equipment evaluations include authorizing manufacturers to apply *certification* marks or labels to their *certified* products. Typical NRTL marks/labels are shown in Figure 1.

[p] ANSI coordinates and monitors the U.S. voluntary consensus standards development system to include a conformity assessment program and the standards development process. ANSI does not develop the individual standards per se.

Figure 1. OSHA NRTL marks/labels.

Since these marks/labels do not identify the product category or standard for which the product has been *certified*, some NRTLs have additional requirements to include a code, identifying number, or other description that can be used for such identifications. At least one organization (UL) asks that certain product categories use enhanced labels with unique identifying numbers that can be entered into websites or mobile applications to get product-specific information on the *certification*. Another approach is to use so-called "smart labels" containing a QR (Quick Response) code that can be scanned to readily access the descriptive information about the *certification*.

Most NRTLs have a web access port for finding the manufacturer and product *listings* for a particular standard or equipment category. For example, the UL, CSA, and FM *certification listings* can be accessed from the following websites:

- http://database.ul.com/cgi-bin/XYV/template/LISCANADA/1FRAME/index.html
- http://www.csagroup.org/us/en/services/testing-and-certification/certified-product-listing
- http://www.approvalguide.com/CC_host/pages/public/custom/FM/login.cfm

The California State Fire Marshal's Office publishes a list of organizations that have facilities equipped to perform tests in accordance with the fire marshal's testing procedures. This criterion differs from the OSHA NRTL criteria in that it designates the specific tests associated with each organization. Type A and A1 organizations on the fire marshal's list "are qualified and equipped to conduct tests and examinations, have a *labeling* program, and conduct factory inspections of the materials." The user should confirm whether the organization referenced is qualified to perform the *certification* required without limitation. As of February 2015, these organizations as published in the list are as follows:[q]

[q] The State Fire Marshal's list includes the specific tests that are acceptable for each laboratory. See http://osfm.fire.ca.gov/strucfireengineer/pdf/lab/approvedtestinglabs.pdf.

- Intertek Testing Services
- Underwriters Laboratories, Inc. (UL)
- Architectural Testing, Inc. (ATI) for certain fire tests
- Applied Research Laboratories for gas and oil fired equipment
- CSA International/American Gas Association for gas and oil fired equipment
- FM Approvals
- QAI Laboratories
- Southwest Research Institute

Although there are hydrogen-specific tests and equipment qualification standards, there are many more standards and *listings* for generic *flammable gas* equipment and instrumentation, including electrical equipment and components used in hazardous *flammable gas* atmospheres. Criteria for determining such *flammable gas hazardous locations* are described in the U.S. *National Electrical Code* (NEC), published by NFPA as NFPA 70. *Flammable gas hazardous locations* are designated as Class I locations, and are further classified into groups (i.e., A, B, C, or D) based on the properties of the gases or vapors present. Hydrogen, whether gaseous or cryogenic, is a Class I, Group B material. For a generic *flammable gas listing* to apply hydrogen in *hazardous locations* governed by the NEC, the *listing* label or plate on the equipment must explicitly state that it covers Class I, Group B materials recognizing that there may be other site-specific factors including ambient rating, Division, and temperature classifications to be considered.

In the case of hydrogen-specific and fuel cell standards, the primary North American *listing* organizations are CSA and UL. Both organizations develop their equipment examination and testing standards using group communications and voting that includes representatives from potential manufacturers and users of the equipment as well as other interested parties. The CSA hydrogen-specific *listing* standards include 10 standards (HGV 4.1 to HGV 4.10) on equipment used in refueling stations, including the hydrogen dispenser. Although most of these standards were published between January and April 2013, as of May 2015 there is no single *listing* to any of the 10 HGV standards. Likewise, there have been no CSA *listings* for hydrogen *pressure relief devices* (CSA HPRD1) and no UL *listings* for fuel-cell-powered industrial trucks (UL 2267) in the several years these *listing* standards were available for submittals. There have been several successful *listings* to the CSA FC 1 standard on stationary *fuel cell power systems*.

The apparent lack of pursuit to acquire a *listing* for hydrogen fueling station equipment and fuel cell industrial trucks may be due to one or more factors: 1) reservations on the part of the equipment manufacturers about the *listing* standards, 2) business decisions based on the size of the potential user market, and 3) the cost of authorizing the *listing* organization, in an early market, to conduct a full *listing* evaluation requiring many types of tests. As the hydrogen equipment markets continue to grow and mature, one can envision evolving *listing* standards and practices and the successful pursuit of more *listings* by equipment manufacturers.

The absence of NRTL *listings* in certain hydrogen and fuel cell equipment categories[r] can cause difficulties for *AHJs* who seek such *listings* as the sole criterion for *approval* of the equipment or facility. It is also an issue for the permittee who needs to use un*listed* equipment where *listed* equipment is required by the installation/application code. Using un*listed* equipment where *listed* equipment is required is only allowed by installation codes through the general equivalency provision, e.g., NFPA 2, Section 1.5. To implement this provision, the applicant would have to provide documentation to the *AHJ*, possibly including a third-party review (if requested), to show that the un*listed* equipment proposed is equivalent to *listed* equipment in terms of safety, reliability, effectiveness, quality, fire or explosion resistance, and any special considerations for the proposed use of the equipment in the facility. The *AHJ* would then decide if the submitted documentation is adequate to grant *AHJ approval* for use in the facility.

2.1.2 International and Foreign Listing Organizations and Equipment Certification Standards

The International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC) issue many product and equipment *certification* standards pertinent to hydrogen and fuel cell applications, but these international organizations do not provide accreditation of the *listing* organizations that implement the *certification* standards. Instead, the individual ISO member nations often establish national *certifying* bodies to determine how the ISO and IEC *certification* standards will be implemented and which organizations will do the *certifications*. As of 2012, there were 74 national *certifying* bodies and 382 *certifying* body testing laboratories.[s] ISO/IEC 17065, first published in 2012, describes conformity assessment requirements for *certifying* bodies. The six U.S. national *certifying* bodies for electrical products are given below. UL and IEC are authorized to issue an IECEx Conformity Mark indicating that items of electrical equipment or enclosure are appropriate for use in a *hazardous location* when it is determined that they will not produce an uncontained electrical discharge.[t]

- Entela
- FM Approvals
- Intertek Testing Services
- MET Labs
- TUV Rhineland North America
- Underwriters Laboratories

European *certifying* bodies that perform conformity assessments pertinent to European standards are called notified bodies, which are analogous to U.S. *listing* organizations. Individual European Community (EC) member states establish these notified bodies, with each notified body being responsible for implementing specific European directives. An example of a European directive is the ATEX (ATmospheric EXplosible) Directive, originally 94/9/EC but now updated as Directive 2014/34/EU, pertinent to products and equipment used in potentially explosive atmospheres. Implementation of this

[r] As of this writing, there are no *listings* for fuel-cell-powered industrial trucks or any fuel gas dispensing system components.
[s] ISO CASCO WG 29 PowerPoint Presentation on ISO/IEC 17065:2012
[t] http://www.iecex.com/.

directive is described in a series of editions of ATEX guidelines. The latest (December 2013) edition of the ATEX guidelines is available on the following EC website: http://ec.europa.eu/enterprise/sectors/mechanical/files/atex/guide/atex-guidelines_en.pdf.

Some hydrogen fueling station equipment and instrumentation and fuel cell power equipment is manufactured by European-based companies for European and North American customers.

The ATEX regulation and guidelines delineate safety requirements for the following equipment categories:

- Potential ignition sources in (electrical and non-electrical) equipment intended for use in potentially explosive atmospheres, including in equipment that can generate its own explosive atmosphere within
- Automatic and independent protective systems intended to come into operation following an explosion, with the prime objective to halt the explosion immediately and/or limit the effects of explosion flames and pressures
- *Safety devices* intended to contribute to the safe functioning of such equipment with respect to ignition source and to the safe functioning of autonomous protective systems
- Components of the preceding categories of equipment

Electric motors and controllers are examples of electrical equipment with potential ignition sources. Standalone fans and *compressors* are examples of non-electrical equipment with a potential ignition source (frictional or compressive heating). Examples of protective systems/equipment include flame arresters, explosion vent panels, and rupture disks. A hydrogen sensor would be an example of a component intended for use in a protective system, such as a hydrogen detection/monitoring and alarm system.

The ATEX and other EC directive notified bodies are authorized to examine, at the expense of the equipment manufacturers, the particular equipment and can be authorized to examine the manufacturing facilities. The *certification* documentation issued by a notifying body to a manufacturer includes an EC declaration of conformity. This declaration of conformity identifies the equipment and its manufacturer, describes the equipment function, and identifies the relevant provisions or functions fulfilled by the equipment, the testing/examination standards used by the notifying body in its assessment, and the name and EC examination certificate of the notifying body. Manufacturers of equipment intended for use in Europe should be able to provide this declaration of conformity (signifying compliance with a specified EC directive) to *AHJs* in the U.S. as well as Europe. In addition, such equipment should have a readily visible EC or CE (Conformité Européene, which translates to "European Conformity") marking (label) designating that the equipment complies with the EC 94/9 ATEX or other directive. Figure 2 shows the CE label. Hydrogen is a Group IIC gas in ATEX labels. Besides authorizing use of CE labels, the notified bodies maintain *listings* of the products for which they have issued EC directive *certifications*.

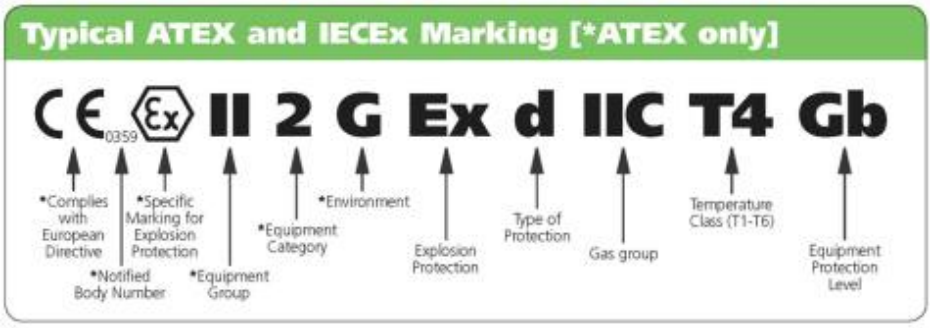

Figure 2. Typical CE ATEX label.

Many other countries have their own equipment *certification* and *listing* requirements. Some of these have been modeled after North American or European/ATEX or ISO standards and practices, but others were developed independently. International and national equipment *certification* standards applicable to hydrogen and fuel cell vehicle applications can be found at http://www.fuelcellstandards.com/vehicle_apps.html.

The *listing* includes several Korean and Taiwanese standards as well as ISO and EC standards.

2.1.3 Non-recognized Certification Organizations

In addition to U.S. NRTLs and EC notified bodies, other independent organizations and agencies offer equipment *certification* services, sometimes with *listing* and *labeling* provisions. For example, there are some new organizations that have applied for NRTL recognition but have not yet received it. Many other testing laboratories can conduct standardized tests on products and issue reports documenting successful results of those tests. NIST (National Institute of Standards and Technology) Special Publication 903 lists over 100 of these laboratories. The ASTM Directory of Testing Laboratories lists over 1000 laboratories that conduct tests using at least one ASTM test method.

Unfortunately, there are also disreputable organizations and manufacturers that produce counterfeit labels for products. Many of the NRTLs have programs to identify and alert users to these counterfeit product labels, and they welcome inquiries by *AHJs* regarding counterfeit *listings* for a specific product.

2.1.4 Manufacturer Self-Certification

In some applications, a manufacturer may self-*certify* that its equipment has been manufactured and tested in compliance with a published standard or specification. For example, NEMA (National Electrical Manufacturers Association) allows electrical enclosure manufacturers to self-*certify* their products to at least some of the NEMA enclosure ratings. The *certification* is indicated by a NEMA label on the product without any indication of the *certifying* organization. This NEMA label is not an alternative to an independent *listing* organization's label for enclosures rated as explosion proof for *flammable gas* applications.

Another example of self-*certification* and self-*labeling* is the ATEX *labeling* of products for certain *hazardous location* atmospheres, including Zone 2, in which the *flammable gas* mixtures are unlikely to occur during normal operation, and if they did occur would do so only for short periods. Manufacturers

performing such self-declarations are required to produce and maintain a technical dossier including drawings, hazard analysis, and a user manual in the local language. Presumably, the pertinent European *AHJ* reviews this dossier before accepting the self-*certified* ATEX equipment for Zone 2 applications.

Since the ATEX/IEC *flammable gas* zone classification scheme for *hazardous locations* is recognized by the NEC as an alternative to the traditional Division 1 and Division 2 classification scheme, *AHJs* in the U.S. may encounter applications in which equipment has been self-*certified* for Zone 2 areas. In this case, the *AHJ* needs to check the Zone 2 classification designation using NEC Article 505 or NFPA 497 Zone 2 classification criteria. According to NFPA 497-2012, paragraph 5.3.3.2, this classification usually refers to areas in which *flammable gases* are used but which would become hazardous only in case of an accident or unusual operating conditions. If the area should be more appropriately classified as Zone 0 or Zone 1, then self-*certification* is not permitted, even by ATEX regulations. Even if the Zone 2 area designation is appropriate, the prudent *AHJ* should request and review the manufacturer's self-classification dossier, and possibly consult with an independent third party.

Chapter 3. Selected Definitions

Chapter 3. Selected Definitions

3.1 Introduction to Chapter 3

Definitions used by the various model codes that regulate the use of hydrogen in operations of interest are provided in this guide. The definitions for the terms that have been defined by one or more codes that have been included in Chapter 4 appear in Chapter 3. The reader is advised that the definition of like terms may be different between documents published by the ICC compared with those published by NFPA. In cases where the 2011 Edition of NFPA 2 is used, definitions may be different from those found in the 2016 Edition of the same document. In some cases, the 2016 Edition of NPFA 2 contains definitions not found within the 2011 Edition. For example, the term *hydrogen equipment enclosure (HEE)* was introduced in the 2016 Edition. In other cases, the definition for a term found in an earlier edition of a document has been changed with a new definition found in a later edition. Refer to the term *compressor* for an example. The definition in the 2011 Edition of NFPA 2 is similar to the definition in the 2016 Edition. When the 2011 Edition of the document is being used as the regulatory document, the use of the 2011 definition is appropriate as this definition has been harmonized with the 2011 publication. The user may find little difference between the two definitions, but from a regulatory standpoint the harmonized definitions should be used.

Defined terms appear in italics to indicate that a definition for the term can be found within this guide. The reader should refer to the definitions used in Chapter 3 appropriate to the code being applied when referring to the use of the term within the context of Chapter 4, keeping in mind that Chapter 3 does not contain a complete set of definitions as found in the code; rather, the definitions included are those pertinent to application to those sections of the code referenced or as they may appear in the accompanying narrative and explanatory material.

Definition	Source Document
APPLIANCE. A device or apparatus that is manufactured and designed to utilize energy and for which this code provides specific requirements.	2015 IMC 2015 IRC
APPROVED. Acceptable to the *authority having jurisdiction (AHJ)*.	2011 & 2016 NFPA 2
APPROVED. Acceptable to the *building official*.	2015 IRC
APPROVED. Acceptable to the *fire code official*.	2015 IFC
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.	2011 & 2016 NFPA 2

Definition	**Source Document**
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.	2011 & 2016 NFPA 2
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.	2016 NFPA 2
BULK GAS SYSTEM. A system in which *compressed gas* is delivered, stored, and discharged in the gaseous form to a *piping system*. The threshold quantity used to define a *bulk gas system* is determined based on material-specific requirements. The *compressed gas system* terminates at the point where *compressed gas* at service pressure first enters the distribution *piping system*.	2013 NFPA 55
BULK GAS SYSTEM. A system in which *compressed gas* is delivered, stored, and discharged in the gaseous form to a *piping system*. The threshold quantity used to define a *bulk gas system* is determined based on material-specific requirements. The *compressed gas* system terminates at the source valve.	2016 NFPA 55
BULK HYDROGEN COMPRESSED GAS SYSTEM. An assembly of equipment that consists of, but is not limited to, storage *containers*, *pressure regulators*, *pressure relief devices*, *compressors*, manifolds, and *piping*, a storage capacity of more than 400 scf (11 m^3) of compressed hydrogen gas, including unconnected reserves on hand at the site, and that terminates at the source valve.	2011 NFPA 2
BULK HYDROGEN COMPRESSED GAS SYSTEM. An assembly of equipment that consists of, but is not limited to, storage *containers*, *pressure regulators*, *pressure relief devices*, *compressors*, manifolds, and *piping*, a storage capacity of more than 5000 scf (141.6 Nm^3) of compressed hydrogen gas and that terminates at the source valve.	2013 NFPA 55
BULK HYDROGEN COMPRESSED GAS SYSTEM. A GH_2 system with a storage capacity of more than 5000 scf (141.6 Nm^3) of compressed hydrogen gas.	2016 NFPA 55 2016 NFPA 2
BULK LIQUEFIED HYDROGEN GAS SYSTEM. An assembly of equipment that consists of, but is not limited to, storage *containers*, *pressure regulators*, *pressure relief devices*, vaporizers, liquid pumps, *compressors*, manifolds, and *piping*, with a storage capacity of more than 39.7 gal (150 L) of liquefied hydrogen, including unconnected reserves on hand at the site, that terminates at the source valve.	2011 NFPA 2

Definition	**Source Document**
BULK LIQUEFIED HYDROGEN SYSTEM. An assembly of equipment that consists of, but is not limited to, storage *containers*, *pressure regulators*, *pressure relief devices*, vaporizers, liquid pumps, *compressors*, manifolds, and *piping*, with a storage capacity of more than 39.7 gal (150 L) of liquefied hydrogen that terminates at the source valve.	2013 NFPA 55 2016 NFPA 2
LIQUEFIED HYDROGEN SYSTEM. An assembly of equipment that consists of, but is not limited to, storage *containers*, *pressure regulators*, *pressure relief devices*, vaporizers, liquid pumps, *compressors*, manifolds, and *piping* and that terminates at the source valve.	2016 NFPA 2
CANOPY. A permanent structure or architectural projection of rigid construction over which a covering is attached that provides weather protection, identity, or decoration.	2016 NFPA 2
CATHODIC PROTECTION. A technique to resist the corrosion of a metal surface by making the surface the cathode of an electrochemical cell.	2011 & 2016 NFPA 2
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.	2011 & 2016 NFPA 2
CERTIFIED. *Approved* or endorsed authoritatively.	2012 NFPA 1125
CERTIFIED. A formally stated recognition and *approval* of an acceptable level of competency, acceptable to the *AHJ*.	2013 NFPA 52 (See 2011 NFPA 2:10.2.1.1)
CERTIFIED. Officially *approved* as having met a standard. to attest authoritatively: as a : confirm b : to present in formal communication c : to attest as being true or as represented or as meeting a standard	Webster's Collegiate Dictionary, 11th Edition
COMBUSTIBLE GAS DETECTOR. An instrument that samples the local atmosphere and indicates the presence of ignitable vapors or gases within the flammable or explosive range expressed as a volume percent in air.	2015 IFC

Definition	**Source Document**
COMPRESSED GAS. A material, or mixture of materials that: 1. Is a gas at 68°F (20°C) or less at 14.7 psia (101 kPa) of pressure; and 2. Has a *boiling point* of 68°F (20°C) or less at 14.7 psia (101 kPa) which is either liquefied, nonliquefied or in solution, except those gases which have no other *health*- or *physical-hazard* properties are not considered to be compressed until the pressure in the packaging exceeds 41 psia (282 kPa) at 68°F (20°C). The states of a *compressed gas* are categorized as follows: 1. Nonliquefied *compressed gases* are gases, other than those in solution, which are in a packaging under the charged pressure and are entirely gaseous at a temperature of 68°F (20°C). 2. Liquefied *compressed gases* are gases that, in a packaging under the charged pressure, are partially liquid at a temperature of 68°F (20°C). 3. *Compressed gases* in solution are nonliquefied gases that are dissolved in a solvent. 4. *Compressed gas* mixtures consist of a mixture of two or more *compressed gases* contained in a packaging, the hazard properties of which are represented by the properties of the mixture as a whole.	2015 IFC

Definition	**Source Document**
COMPRESSED GAS. A material, or mixture of materials, that (1) is a gas at 68°F (20°C) or less at 14.7 psia (101.3 kPa) of pressure, and (2) has a boiling point of 68°F (20°C) or less at 14.7 psia (101.3 kPa) that is either liquefied, nonliquefied, or in solution, except those gases that have no other health or *physical hazard* properties are not considered to be compressed until the pressure in the packaging exceeds 41 psia (282.5 kPa) at 68°F (20°C).	2011 NFPA 2
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 either 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).	2016 NFPA 2
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.	2011 & 2016 NFPA 2
COMPRESSED GAS SYSTEM. An assembly of equipment designed to contain, distribute, or transport *compressed gases*.	2011 & 2016 NFPA 2
COMPRESSED GAS SYSTEM. An assembly of equipment designed to contain, distribute, or transport *compressed gases*. It can consist of a *compressed gas container* or *containers*, reactors and appurtenances, including pumps, *compressors*, and connecting *piping* and tubing.	2015 IFC
COMPRESSOR. A device used for increasing the pressure and the density of a gas.	2011 NFPA 2
COMPRESSOR. A mechanical device used to increase the pressure and the resultant density of a gas through the act of compression.	2016 NFPA 2
CONTAINER. A vessel of 60 gallons (227 L) or less in capacity used for transporting or storing hazardous materials. Pipes, *piping system*s, engines and engine fuel tanks are not considered to be *containers*.	2015 IFC
CONTAINER. A vessel, such as a *cylinder*, *portable tank*, or *stationary tank*, that varies in shape, size, and material of construction.	2011 & 2016 NFPA 2
CONSTANTLY ATTENDED LOCATION. A designated location at a facility staffed by trained personnel on a continuous basis where alarm or supervisory signals are monitored and facilities are provided for notification of the fire department or other emergency services.	2015 IFC

Definition	**Source Document**
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.	2011 & 2016 NFPA 2
CRYOGENIC CONTAINER. A cryogenic vessel of any size used for the transportation, handling or storage of *cryogenic fluids*.	2015 IFC
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).	2011 & 2016 NFPA 2
CRYOGENIC FLUID. A fluid having a boiling point lower than -130°F (-89.9°C) at 14.7 pounds per square inch atmosphere (psia) (an absolute pressure of 101.3 kPa).	2015 IFC
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.	2011 & 2016 NFPA 2 2015 IFC
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.	2016 NFPA 2
DWELLING UNIT. A single unit providing complete, independent living facilities for one or more persons, including permanent provisions for living, sleeping, eating, cooking, and sanitation.	2015 IMC
ENVIRONMENTAL AIR. Air that is conveyed to or from occupied areas through ducts which are not part of the heating or air-conditioning system, such as *ventilation* for human usage, domestic kitchen range exhaust, bathroom exhaust, domestic clothes dryer exhaust, and parking garage exhaust.	2015 IMC
EXCESS FLOW CONTROL. A *fail-safe* system or other *approved* means designed to shut off flow caused by a rupture in pressurized *piping system*s.	2011 & 2016 NFPA 2 2015 IFC
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.	2011 & 2016 NFPA 2

Definition	**Source Document**
FAIL-SAFE. A design condition incorporating a feature for automatically counteracting the effect of an anticipated possible source of failure; also, a design condition eliminating or mitigating a hazardous condition by compensating automatically for a failure or malfunction.	2015 IFC
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.	2011 & 2016 NFPA 2
FIRE CODE. The fire prevention code adopted by the jurisdiction.	2016 NFPA 2
FLAMMABLE CRYOGENIC FLUID. A *cryogenic fluid* that forms flammable mixtures in air when in its vapor state.	2016 NFPA 2 & NFPA 55
FLAMMABLE GAS. A material which is a gas at 68°F (20°C) or less at 14.7 pounds per square inch atmosphere (psia) (101 kPa) of pressure [a material that has a *boiling point* of 68°F (20°C) or less at 14.7 psia (101 kPa)] which: 1. Is ignitable at 14.7 psia (101 kPa) when in a mixture of 13 percent or less by volume with air; or 2. Has a flammable range at 14.7 psia (101 kPa) with air of not less than 12 percent, regardless of the lower limit. The limits specified shall be determined at 14.7 psi (101 kPa) of pressure and a temperature of 68°F (20°C) in accordance with ASTM E 681.	2015 IFC
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	2011 & 2016 NFPA 2
FLAMMABLE LIQUID (Class I). Any liquid having a closed-cup flash point not exceeding 100°F (37.8°C).	2011 & 2016 NFPA 2
FLAMMABLE LIQUID. A liquid having a closed cup flash point below 100°F (38°C). *Flammable liquids* are further categorized into a group known as Class I liquids. The Class I category is subdivided as follows: **Class IA.** Liquids having a flash point below 73°F (23°C) and having a *boiling point* below 100°F (38°C).	2015 IFC

Definition	Source Document
Class IB. Liquids having a *flash point* below 73°F (23°C) and having a *boiling point* at or above 100°F (38°C).	
Class IC. Liquids having a *flash point* at or above 73°F (23°C) and below 100°F (38°C).	
The category of *flammable liquids* does not include *compressed gases* or *cryogenic fluids*.	
FLAMMABLE VAPOR OR FUMES. Mixtures of gases in air at concentrations equal to or greater than the LFL and less than or equal to the upper flammability limit (UFL).	2015 IMC
FLAMMABLE VAPORS OR FUMES. The concentration of flammable constituents in air that exceeds 25 percent of their *lower flammable limit* (*LFL*).	2015 IFC
FLOOD HAZARD AREA. The greater of the following two areas:	2015 IBC
1. The area within a flood plain subject to a 1-percent or greater chance of flooding in any year.	
2. The area designated as a *flood hazard area* on a community's flood hazard map, or otherwise legally designated.	
FUEL CELL CARTRIDGE. A removable article that contains and supplies fuel to the micro fuel cell power unit or internal reservoir.	2011 & 2016 NFPA 2
FUEL CELL POWER SYSTEM. A generator system that converts the chemical energy of reactants (a fuel and oxidant) by an electrochemical process to electric energy (direct current or alternating current electricity) and thermal energy.	2011 & 2016 NFPA 2
FUEL SUPPLY CONTAINER. A *container* mounted on a vehicle to store liquid hydrogen (LH_2) or GH_2 as the fuel supply to the vehicle.	2011 & 2016 NFPA 2
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.	2011 & 2016 NFPA 2
GAS DETECTION SYSTEM. One or more sensors capable of detecting hydrogen at specified concentrations and activating alarms and safety systems.	2011 & 2016 NFPA 2

Definition	Source Document
GAS DETECTION SYSTEM, CONTINUOUS. A *gas detection system* where the analytical instrument is maintained in continuous operation and sampling is performed without interruption. Analysis is allowed to be performed on a cyclical basis at intervals not to exceed 30 minutes.	2015 IFC
GASEOUS HYDROGEN SYSTEM. An assembly of *piping*, devices, and apparatus designed to generate, store, contain, distribute, or transport a nontoxic, gaseous hydrogen containing mixture having at least 95-percent hydrogen gas by volume and not more than 1-percent oxygen by volume. *Gaseous hydrogen systems* consist of items such as *compressed gas containers*, reactors and appurtenances, including *pressure regulators*, *pressure relief devices*, manifolds, pumps, *compressors* and interconnecting *piping* and tubing and controls.	2015 IBC 2015 IFC 2015 IFGC
GASEOUS HYDROGEN SYSTEM. A system in which hydrogen is delivered, stored, and discharged in the gaseous form to a *piping system*. The *gaseous hydrogen system* terminates at the point where hydrogen at service pressure first enters the distribution *piping*.	2011 NFPA 2
GASEOUS HYDROGEN 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.	2016 NFPA 2
GH_2. Hydrogen in the gas phase.	2011 NFPA 2
HAZARDOUS LOCATION. Any location considered to be a fire hazard for *flammable vapors*, dust, combustible fibers or other highly combustible substances. The location is not necessarily categorized in the International Building Code as a high-hazard use group classification.	2015 IMC
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.	2011 & 2016 NFPA 2
HEALTH HAZARD. A classification of a chemical for which there is statistically significant evidence that acute or chronic health effects are capable of occurring in exposed persons. The term *health hazard* includes chemicals that are toxic, highly toxic, and *corrosive*.	2015 IFC
HYDROGEN EQUIPMENT ENCLOSURE (HEE). A prefabricated area designed to protect hydrogen equipment that is confined by at least 3 walls, not routinely occupied, and has a total area less than 450 ft^2 (41.8 m^2)	2016 NFPA 2
HYDROGEN FUEL GAS ROOM. A room or space that is intended exclusively to house a *gaseous hydrogen system*.	2015 IBC 2015 IFC 2015 IFGC

Definition	**Source Document**
HYDROGEN-GENERATING APPLIANCE. A self-contained package or factory-matched packages of integrated systems for generating gaseous hydrogen. *Hydrogen-generating appliances* utilize electrolysis, reformation, chemical or other processes to generate hydrogen.	2015 IFGC 2015 IRC
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.	2011 & 2016 NFPA 2
LABELED. Equipment, materials or products to which have been affixed a label, seal, symbol or other identifying mark of a nationally recognized testing laboratory, *approved* agency or other organization concerned with product evaluation that maintains periodic inspection of the production of the *labeled* items and whose *labeling* indicates either that the equipment, material or product meets identified standards or has been tested and found suitable for a specified purpose.	2015 IFC
LH_2. Hydrogen in the liquid phase.	2011 & 2016 NFPA 2
LIQUEFIED HYDROGEN (LH_2) SYSTEM. An assembly of equipment that consists of, but is not limited to, storage *containers*, *pressure regulators*, *pressure relief devices*, vaporizers, liquid pumps, *compressors*, manifolds, and *piping* and that terminates at the *source valve*.	2016 NFPA 2
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.	2011 & 2016 NFPA 2
LISTED. Equipment, materials, products or services included in a list published by an organization acceptable to the [insert applicable code official] 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 either that the equipment, material, product or service meets identified standards or has been tested and found suitable for a specified purpose.	2015 IBC 2015 IFC 2015 IMC 2015 IRC

Definition	**Source Document**
LISTED. For the purposes of this Code (B31), describes a material or component which conforms to a specification in Appendix A, Appendix B, or Appendix K or to a standard in Table 326.1, A326.1, or K326.1.	1999 through 2000 Addenda B31.3
LOWER FLAMMABLE LIMIT (LFL). The minimum concentration of vapor in air at which propagation of flame will occur in the presence of an ignition source. The *LFL* is sometimes referred to as "LEL" or "lower explosive limit."	2015 IBC 2015 IFC
MAJOR REPAIR GARAGE. Hydrogen Fuel Cell Vehicle. A building or portions of a building for major repairs, such as work on the hydrogen storage system, the fuel cell system, the propulsion system, and repairs that require *defueling* of the hydrogen fuel cell vehicle, and maintenance or repairs that require open-flame cutting or welding.	2016 NFPA 2
METAL HYDRIDE. A generic name for compounds composed of metallic element(s) and hydrogen.	2011 & 2016 NFPA 2 2015 IFC
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.	2015 IFC
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.	2011 & 2016 NFPA 2
NATURAL VENTILATION. The flow of air or gases created by the difference in the pressures or gas densities between the outside and inside of a vent, room, or space.	2016 NFPA 2
NON-BULK FLAMMABLE GAS SYSTEM. A system consisting of *cylinders* or other storage systems, with each individual set of connected *cylinders* having less than 5000 scf (141.6 Nm^3).	2016 NFPA 2
NORMAL CUBIC METER (Nm^3) OF GAS. A cubic meter of gas at an absolute pressure of 14.7 psi (101.3 kPa) and a temperature of 70°F (21°C).	2016 NFPA 2
OUTDOOR CONTROL AREA. An outdoor area that contains hazardous materials in amounts not exceeding the maximum allowable quantities of Table 5003.1.1(3) or Table 5003.1.1(4).	2015 IFC

Definition	Source Document
PHYSICAL HAZARD MATERIAL. A chemical or substance classified as a combustible liquid, explosive, flammable cryogen, *flammable gas*, *flammable liquid*, flammable solid, organic peroxide, oxidizer, oxidizing cryogen, pyrophoric, unstable (reactive), or water-reactive material.	2011 & 2016 NFPA 2
PHYSICAL HAZARD. A chemical for which there is evidence that it is a *combustible liquid*, *cryogenic fluid*, *explosive*, flammable (solid, liquid or gas), organic peroxide (solid or liquid), oxidizer (solid or liquid), oxidizing gas, pyrophoric (solid, liquid or gas), unstable (reactive) material (solid, liquid or gas) or water-reactive material (solid or liquid).	2015 IFC
PIPING. Where used in this code, *piping* refers to either pipe or tubing, or both. **Pipe.** A rigid conduit of iron, steel, copper, brass or plastic. **Tubing.** Semi rigid conduit of copper, aluminum, plastic or steel.	2015 IFGC
PIPING SYSTEM. All fuel *piping*, valves and fittings from the outlet of the *point of delivery* to the outlets of the *appliance* shutoff valves.	2015 IFGC
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.	2016 NFPA 2
PORTABLE FUEL CELL APPLIANCE. A fuel cell generator of electricity, which is not fixed in place. A *portable fuel cell appliance* utilizes a cord and plug connection to a grid-isolated load and has an integral fuel supply.	2015 IMC
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.	2011 & 2016 NFPA 2
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.	2011 & 2016 NFPA 2
PRESSURE REGULATOR. A device, either adjustable or nonadjustable, for controlling and maintaining, within acceptable limits, a uniform outlet pressure.	2011 & 2016 NFPA 2

Definition	Source Document
PRESSURE RELIEF DEVICE. A device designed to open to prevent a rise of internal pressure in excess of a specified value.	2011 & 2016 NFPA 2
PRESSURE VESSEL. A *container* or other component designed in accordance with the ASME *Boiler and Pressure Vessel Code* or CSA B51, *Boiler, Pressure Vessel and Pressure Piping Code.*	2011 & 2016 NFPA 2
PRESSURE VESSEL. A closed vessel designed to operate at pressures above 15 psig (103 kPa).	2015 IFC
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.	2016 NFPA 2
QUALIFIED CERTIFYING ORGANIZATION. A laboratory designated by the U.S. Department of Labor's OSHA as an NRTL or other organization *approved* by the *authority having jurisdiction*.	This guide
QUALIFIED INDIVIDUAL. An individual knowledgeable in the hazards of *compressed gases* and *cryogenic fluids* through training and work experience.	2011 & 2016 NFPA 2
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.	2011 & 2016 NFPA 2
REGISTERED DESIGN PROFESSIONAL. An architect or engineer, registered or licensed to practice professional architecture or engineering, as defined by the statutory requirements of the professional registration laws of the state in which the project is to be constructed.	2015 IFC
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.	2011 & 2016 NFPA 2
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.	2016 NFPA 2
REPAIR GARAGE. A building, structure or portion thereof used for servicing or repairing motor vehicles.	2015 IBC, IFC

Definition	Source Document
REPAIR GARAGES. Buildings and structures used for service and repair operations in connection with self-propelled GH_2 and LH_2 fueled vehicles (including, but not limited to, passenger automobiles, buses, trucks and tractors).	2011 NFPA 2
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.	2011 & 2016 NFPA 2
SELF-SERVICE MOTOR FUEL DISPENSING FACILITY. That portion of *motor fuel-dispensing facility* where liquid motor fuels are dispensed from fixed *approved* dispensing equipment into the fuel tanks of motor vehicles by persons other than a motor fuel-dispensing facility attendant.	2015 IFC
STATIONARY FUEL CELL POWER PLANT. A self-contained package or factory-matched packages which constitute an automatically operated assembly of integrated systems for generating useful electrical energy and recoverable thermal energy that is permanently connected and fixed in place.	2015 IMC 2015 IRC
STATIONARY TANK. 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. It does not include *cylinders* having less than a 1,000-pound (454 kg) water capacity.	2015 IFC
TANK, PORTABLE. 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.	2011 & 2016 NFPA 2
THIRD-PARTY REVIEWER. A *third-party reviewer* is a person or group of persons chosen by the *AHJ* to review proposed performance-based designs. Qualifications of the *third-party reviewer* should include experience, education, and credentials that demonstrate knowledgeable and responsible use of applicable models and methods. *For performance-design options See Annex Note A.5.1.5*	2011 & 2016 NFPA 2
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.	2011 & 2016 NFPA 2
USE, AREA. A location inside or outside of a building or structure where the material placed into use is situated.	2016 NFPA 2

Definition	**Source Document**
VENTILATION. The natural or mechanical process of supplying conditioned or unconditioned air to, or removing such air from, any space.	2015 IBC 2015 IMC

Chapter 4. Guidance and Explanation

Chapter 4. Guidance and Explanation

4.1 Introduction to Chapter 4

Explanation, interpretation, and guidance is provided to the reader to aid and assist the user in gaining further insight into the requirements of the codes applicable to a given design. Applicable requirements of the model codes have been limited to the codes published by the ICC and NFPA at this time. The codes published by IAPMO have not been included in this DRAFT. The provisions of Chapter 4 within the scope of this guide have been limited to the requirements of the designated code where the code incorporates the use of the terms *approved*, *certified*, *listed* or *labeled.* Narrative in discussion and recommendations are based on opinions expressed by the HSP. They are included to aid the users of this guide with the proper interpretation and application of the code. The requirements are organized on a code-by-code basis for those individual codes that establish requirements.

Portions of the applicable documents included within Chapters 3 and 4 of this publication are based on requirements published by others. The requirements included have been reproduced with permission from the following publishers.

NFPA 2

Chapter 4 General Fire Safety Requirements

Section	Requirement 2011	Requirement 2016	Narrative	Required References
4.10 Release of GH_2 or LH_2				
4.10.4	**Notification of Unauthorized Discharges**. The fire department shall be notified immediately or in accordance with *approved* emergency procedures when an unauthorized discharge becomes reportable under state, federal, or local regulations. [1:60.1.8.4]	**Notification of Unauthorized Discharges**. 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]	Emergency procedures are normally developed in accordance with requirements of the *authority having jurisdiction (AHJ)*. An unauthorized discharge is a discharge other than those required for normal operation of the system. For example, a rupture disk that releases the contents of a liquid storage system to protect against a major failure of the storage vessel is not considered part of normal system operation. Conversely, the release of gaseous hydrogen from a tank of liquid hydrogen due to the normal warming of the liquid is part of the normal operation of a liquid system. In some communities there are requirements for reporting even small releases if they have consequences of an environmental nature or to personnel, or an impact on the public. Most small outdoor hydrogen releases do not satisfy the criteria of having negative impacts and therefore are likely not required to be reported.	
4.12 Ignition Source Controls				
4.12.3	**Energy-Consuming Equipment**. Energy-consuming equipment shall be *listed* or *approved* for use with [GH_2] or [LH_2].	**Energy-Consuming Equipment**. Energy-consuming equipment with the potential to serve as a source of ignition shall be *listed* or *approved* for use with [GH_2] or [LH_2]. [400.6.1.5.3]	The requirements for ignition source control are general or fundamental requirements identified in Section 4.12. There are three primary sources of ignition, including: 4.12.1 Smoking 4.12.2 Open Flames and High-Temperature Devices, and 4.12.3 Energy-Consuming Equipment. Energy-consuming equipment has not been defined by the code and can include an array of powered and non-powered equipment. The	

Section	Requirement 2011	Requirement 2016	Narrative	Required References
			most common equipment will likely be powered equipment of some sort where active ignition sources are more obvious than those found on non-powered equipment. In either case the ignition of hydrogen is the primary concern and those sources can be active or passive. As a condition of *approval*, the *AHJ* may require that mechanical and process equipment operated in areas where *flammable gases* are present be evaluated to determine whether they can act as potential source for ignition. In terms of power, a joule is a unit of energy equal to the work done when a current of 1 ampere is passed through a resistance of 1 ohm for 1 second. The minimum ignition energy for hydrogen is 0.019 millijoules. In addition to the requirements of Section 4.12, there are specific requirements for ignition source control found within the use-specific sections of the code. An example would be the requirements for ignition source control around hydrogen-cooled generators found in 15.3.2.1.3. As stated in each of the use-specific chapters of NFPA 2, when there is a conflict between a fundamental requirement and a use-specific requirement, the use-specific requirement applies. In cases where the general requirements apply or when *listed* equipment is not available, the use of un*listed* equipment may be *approved* by the *AHJ* under the requirements of Section 1.5 if equivalency can be demonstrated. For the use of un*listed* equipment to be *approved*, the owner's designee, i.e., the equipment manufacturer's representative, must at a minimum provide technical documentation that demonstrates 1) that the surface temperatures of parts likely to be exposed to hydrogen are limited to a temperatures less than the autoignition temperature of hydrogen, which conservatively is a	

Section	Requirement 2011	Requirement 2016	Narrative	Required References
			temperature of 500 °C, [1] and 2) that electrically powered devices are in accordance with the requirements for use in a hazardous (classified) location as defined by the NEC, except that unclassified electrical equipment may be permitted providing the owner's designee can demonstrate that the equipment and the location in which it is operated meet the requirements for an unclassified use to include the area of operation as allowed by the NEC.	
4.14 Protection from Vehicular Damage				
4.14.1	When required, guard posts or other *approved* means shall be provided to protect against physical damage in accordance with Section 4.1.5.	When required, guard posts in accordance with 4.14.1.2 or other *approved* means shall be provided to protect against physical damage.	The reference to Section 4.1.5 as it appeared in the 2011 Edition was an editorial error, as Section 4.14 contains the provisions for protection against vehicular damage. No special consideration is necessary when the design is coordinated with the requirements described in the referenced provision. Following the prescriptive requirements as published should result in *approval* of the proposed design.	
4.14.1.1	Guard posts or other *approved* means shall be provided to protect the following where subject to vehicular damage: [1:60.1.15.1] (1)* Storage *tanks* and connected *piping*, valves, and fittings [1:60.1.15.1(1)] (2) Dispensing areas [1:60.1.15(2)] (3) Use areas [1:60.1.15.1(3)]	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 [GH_2 or LH_2] (3) Use areas [400.6.1.9.1]	There are times when the use of guard posts to protect against vehicular damage would be inappropriate. An example is an indoor area where vehicular traffic may be limited to vehicles operated by hand, electric carts, or powered equipment limited to forklifts. In such cases, the use of guardrail systems, curbs, or other safeguards may be suitable. In instances where other *approved* means are to be applied, the designer or the *AHJ* may consider the provisions of the 2015 IFC, Section 312.3, which allows for the use of means commensurate with an anticipated impact. Although not referenced by NFPA 2, the IFC could be acceptable as the basis to determine equivalent means under the requirements of NFPA 2 Section 1.5, depending on the risk contemplated and the types of	*2015 International Fire Code*

Section	Requirement 2011	Requirement 2016	Narrative	Required References
			vehicles that may be involved.	

Chapter 5 Performance-Based Option

Section	Requirement 2011	Requirement 2016	Narrative	Required References
5.1 General				
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]	**Approved Qualifications.** The performance-based design shall be prepared by a person with qualifications acceptable to the *AHJ*. [1:5.1.3]	The requirement is asking that the qualifications of the party preparing the design be *approved* by the *AHJ*. Definitions are found in NFPA 2 for both *qualified individuals* and *qualified persons.* Both definitions use the terms, among others, training, knowledge, and experience. The informational annex note to Section 5.1.3 contained in NFPA 2 suggests that qualifications should include experience, education, and credentials that demonstrate knowledgeable and responsible use of applicable models and methods.[2]	
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]	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]	Detailed information relative to the preparation of a performance-based design is in the form of an annex note to Section 5.1.4 to NFPA 1. The explanatory material is based on the use of *SFPE Engineering Guide to Performance-Based Fire Protection Analysis and Design of Buildings.* Following the steps outlined in the Annex note to Section 5.1.4 and use of the reference documents should result in the development of a format that will be able to be *approved*. The use of other formats can be *approved*, but the elements of consideration—to include performance objectives and design scenarios identified by the code—must be identified and reconciled to provide the *AHJ* with an approach that recognizes the concerns raised by the code. Reference to NFPA 1, *Fire Prevention Code*, will provide those that prepare and review performance-based design with additional information and content.	*SFPE Engineering Guide to Performance-Based Fire Protection Analysis and Design of Buildings*, Society of Fire Protection Engineers NFPA 1, *Fire Code*
5.1.5* The 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 *AHJ* shall be permitted to require an *approved*, independent *third party* to review the proposed design and provide an evaluation of	The term *third-party reviewer* is not defined in Chapter 3 of NFPA 2, but there is what could be considered a definition found in the annex note to Section 5.1.5 in Annex A. Refer to Section 3 of this guide for definitions. The *approval* of the independent third-party rests with the *AHJ*. It is not	

Section	Requirement 2011	Requirement 2016	Narrative	Required References
	the design to the *AHJ* at the expense of the owner. [1:5.1.5]	the design to the *AHJ* at the expense of the owner. [1:5.1.5]	unusual for owners or designers to want to employ the *third-party reviewer* given the fact that the cost must be borne by the permittee, the applicant, or the owner. Experience shows that the *third-party reviewer* should report to the *AHJ* rather than the applicant, owner, or designer to avoid putting the third-party in a position where the payment of fees may exercise undue influence on the evaluation. It can be appropriate for the evaluator to produce a DRAFT copy of an evaluation report in order to receive comments from both the *AHJ* and the applicant prior to issuance. In the final analysis, the third-party, as the author of the report, has the sole responsibility for its content. See the narrative in 5.1.11.	
5.1.8* Operations and Maintenance Manual	An *approved* Operations and Maintenance (O&M) Manual shall be provided by the owner to the *AHJ* and the fire department [for review] and shall be maintained at the facility in an *approved* location. [1:5.1.8]	An *approved* Operations and Maintenance (O&M) Manual shall be provided by the owner to the *AHJ* and the fire department [for review] and shall be maintained at the facility in an *approved* location. [1:5.1.8]	The O&M manual may be prepared in concert with the instructions provided by the *SFPE Engineering Guide to Performance-Based Fire Protection Analysis and Design of Buildings*, Society of Fire Protection Engineers, Bethesda, MD 2000, as recommended in the Annex notes to NFPA 2, Section 5.1.4 (Item 12). Experience shows that a failure in performance-based design may be caused by changes that occur either in the operating procedures or facility design without evaluating the impact of the change on the control strategy employed. As demonstrated by the requirements of Section 5.1.3, performance-based designs are highly specialized and unique designs that are likely to be based on the use of modeling and risk assessment techniques employed by persons with expertise related to the specific application. As a result, the control strategy is based on careful application of administrative controls, engineering controls, and construction features provided by the design documents. The application of operation procedures is an administrative control designed to recognize the engineering controls and construction features of the design. A performance-based design is dependent on carefully maintaining the	

Section	Requirement 2011	Requirement 2016	Narrative	Required References
			control strategy that was used in the creation of the design, as such a design is tied to the specific application of controls that must be maintained in perpetuity over the life of the project. Storing the O&M manual maintained at the facility can be effective when the manual and related documentation have been identified and designed to work in conjunction with other required documentation. One way in which this can be done is by having the document become part of and referenced by the Hazardous Materials Management Plan (HMMP) required by Section 4.9. See the comments in 5.1.9 below regarding the unique character of performance-based design. This same requirement can be an effective way in which to document the use of alternate materials and methods, which can be incorporated into the HMMP for reference and file purposes. In this way, the plan of record and the required documentation will be maintained by those responsible for facilities management, and the HMMP will be available to the *AHJ* through the inspection process.	

Section	Requirement 2011	Requirement 2016	Narrative	Required References
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]	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]	As indicated by the comments to 5.1.8 above pertinent to the O&M manual, the incorporation of operating procedures into the HMMP will provide a means to assist both the owner and the jurisdiction with the ongoing inspections and evaluation of the facility over time. The unique character of a facility constructed with a performance-based design requires special attention to ensure that the design basis is maintained. Maintaining the design concepts and application intact over the life of the facility or system requires a disciplined approach in order to ensure that the unique aspects of control function as intended and that the limitations of the design are understood by the owners and operators of the facility as well as by the *AHJ*. All designs must be maintained whether they are performance- or prescription-based. Performance-based designs are one of a kind, and there is no published list of requirements similar to those in a prescriptive design that may be obvious to those inspecting the premises or involved with repairs to the facility on a periodic basis. Maintaining the design documents and design concept over the life of the facility should be an expectation of the owner/operator and the *AHJ* alike. If the performance-based design is abandoned or has not been maintained intact, the *AHJ* may view the facility as non-conforming. In such cases, the *AHJ* can revoke the owner's permit to operate. The *AHJ* could, depending on the circumstances, determine that the facility has not been maintained in accordance with the code and that as a result an imminent hazard to life safety exists. In such cases, the code official could determine that the facility should be modified by the application of engineering controls and construction features that will bring the facility into compliance with the current prescriptive code. The *approval* of the design by the *AHJ* could stipulate the inclusion of the following additions to the HMMP including, but not limited to:	

Section	Requirement 2011	Requirement 2016	Narrative	Required References
			• Operating procedures • O&M manual • Details of any special conditions, *approval*s, modifications, or any use of alternate materials and methods applicable to the facility as permitted	
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]	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]	The requirement is intended to create a management of change procedure; however, changes in the administration of either the jurisdiction or the ownership of the facility can occur with the need for documentation and *approval* subject to being overlooked. The challenge for both the owner and the jurisdiction is to recognize the special nature of performance-based design for the facility that is designed to implement a studied and documented control strategy. Notations as to the special nature of the facility can be made on any Certificate of Occupancy issued by the jurisdiction, and if an annual permit process is established, the permits can reflect the presence of special conditions. See the narrative for 5.1.11.	
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]	Any *approved* changes to the original design shall be maintained in the same manner as the original design. [1:5.1.10.2.2]	See the narratives for 5.1.10.2.1 and 5.1.11.	
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	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	The responsibility for an *annual certification* is a joint responsibility of both the owner and the *AHJ*. Experience shows that changing the *certification* creates the risk of *certification* becoming less and less meaningful. The *AHJ* may ask the owner to verify that the *certification* is based on a thorough review to *certify* that the design features and systems continue to be maintained in accordance with the *approved* design and that any modifications are in keeping with the intent of the design.	

Section	Requirement 2011	Requirement 2016	Narrative	Required References
	and assumptions and any subsequent *approved* changes or modifications to the original performance-based design. [1:5.1.11]	and assumptions and any subsequent *approved* changes or modifications to the original performance-based design. [1:5.1.11]	The key elements for review in the validation phase could be identified and summarized by the original third-party as a portion of the third-party report prior to permit issuance.	
5.6 Safety Factors				
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]	*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]	See the discussion on Safety Factors and Sensitivity Analysis in the Annex note A.5.6 of NFPA 2. The determination of *safety factors* by those who model the various design scenarios are a key element of any performance-based design. Those who perform such modeling and those who review the use of the models should question the practical aspects of the model used. *Approval* of safety factors should consider statements made by the designer. It should be noted that the *AHJ* may impose requirements for the use of a greater safety factor than assumed by the designer, but when such is done, reasons for imposing greater safety factors should be documented. In any case, the safety factors should be explicitly quantified and documented in the submittal to the *AHJ*.	
5.7 Documentation Requirements				
5.7.14 Use of Performance-Based Design Option	Design proposals shall include documentation that provides anyone involved in ownership or management of the facility with all of the following notification: [1:5.7.14] (1) The facility was *approved* as a performance-based design with certain specified	Design 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	There are no new *approval*s required by the requirements of 5.7.14; rather, the requirement is designed to put the responsibility on the owner or management of any facility that has been permitted under the performance-based design option to have the documentation in the permit application noting the restrictions on the occupancy as a result of using the performance-based option. The impacts from the transfer of ownership can inadvertently be overlooked, and the jurisdiction and the owner should determine the most appropriate way in which to document the stipulations on the	

Section	Requirement 2011	Requirement 2016	Narrative	Required References
	design criteria and assumptions. [1:5.7.14(1)] (2) Any remodeling, modification, renovation, change in use, or change in the established assumptions requires a re-evaluation and re-*approval*. [1:5.7.14(2)]	assumptions. (2) Any remodeling, modification, renovation, change in use, or change in the established assumptions requires a re-evaluation and re-*approval*. [1:5.7.14]	facility. As mentioned in the comments to 5.1.10.2.1, the special conditions may be made a matter of record on any Certificate of Occupancy issued by the building official as well as in any operational or construction-related permits issued by those in the jurisdiction who have the responsibility for permit issuance. In some cases, the owner may lease a facility to an operator who may or may not be familiar with the restrictions that were issued as a condition of the permit. Any transfer of management responsibility, whether it is for sale or for lease, should provide those responsible for operation and maintenance of the facility with the information necessary to operate the facility within the bounds established by the *approval* process. It may be advisable for the owner and the jurisdiction to establish an agreement that calls for instructions and recommendations to be issued by a *third-party reviewer* upon transfer of ownership, change in management or operation of the facility including lease and sale of the facility, or other business arrangements where a portion of the facility may be leased or sold to a party not otherwise bound into the original *approval* process.	

Chapter 6 General Hydrogen Requirements

Section	Requirement 2011	Requirement 2016	Narrative	Required References
6.12 GH_2 Detection Systems				
6.12.1	Gas detection equipment shall be *listed* or *approved*.	Gas detection equipment shall be *listed* or *approved*.	The regulatory scheme promulgated by NFPA is different from that included in the codes promulgated by the ICC as found within the IFC. The current requirement found in NFPA 2 allows the use of either *listed* or *approved gas detection systems*. No reference is provided to applicable *listing* standards that may be used. NFPA 853 (referenced by NFPA 2 in Chapter 13) does not mandate	

Section	Requirement 2011	Requirement 2016	Narrative	Required References
			either *listing* or *approval* for *gas detection systems*, but the detection system is required to be specific for hydrogen, raising a question as to whether the general *combustible gas detector* can be used if it is non-specific without specific calibration for the detection of hydrogen. The IFC requires that *gas detection systems* be *listed* or *approved*, except that when such systems are installed in repair facilities, the *gas detection system* is required to be *listed* as suitable for those specific gases or vapors to be detected in accordance with the requirements of the UL *listing* Standard 2075 (IFC 2311.7.2.1.1). By contrast, NFPA 2 requirements for *gas detection systems* in *repair garages*, Section 18,3.3, require the use of an *approved gas detection system*. The UL online *flammable gas detection systems listed* for use with various flammable (combustible) gases may be found in the UL Online Certifications Directory.[3] A *listing* standard (ANSI/ISA 60079-29-1-2013) that may be applicable for industrial and commercial (non-residential) installations can be found at the following website: https://www.isa.org/templates/one-column.aspx?pageid=111294&productId=116779 A marketer of the above referenced standard provides a short discussion on the content and application of the AHSI/ISA document. The following statements (in pertinent part) have been extracted from the explanatory text found at the following website: http://standards.globalspec.com/std/1645623/isa-60079-29-1 • This standard is applicable to *flammable gas* detection apparatus intended to provide an indication, alarm or other output function; the purpose of which is to give a warning of a potential explosion hazard and in some cases, to initiate automatic or manual protective action(s).	

Section	Requirement 2011	Requirement 2016	Narrative	Required References
			• This standard is applicable to apparatus, including the integral sampling systems of aspirated apparatus, intended to be used for commercial, industrial and non-residential safety applications. • This standard does not apply to external sampling systems, or to apparatus of laboratory or scientific type, or to apparatus used only for process control purposes. It also does not apply to open path (line of sight) area monitors. For apparatus used for sensing the presence of multiple gases, this standard applies only to the detection of *flammable gas* or vapour [sic]. o NOTE 1 ANSI/ISA-60079-29-1 is intended to provide for the supply of apparatus giving a level of safety and performance suitable for general purpose applications. However, for specific applications, a prospective purchaser (or an appropriate authority) may additionally require the apparatus to be submitted to particular tests or *approval*. For example, Group I apparatus (i.e. apparatus to be used in mines susceptible to firedamp) may not be permitted to be used without the additional, prior *approval* of the relevant authority in mines under its jurisdiction. Such particular tests/*approval* are to be regarded as additional to and separate from the provisions of the standards referred to above and do not preclude *certification* to or compliance with these standards. o NOTE 2 All apparatus calibrated on specific gases or vapours can not [sic] be expected to correctly indicate on other gases or vapours. In addition to the *listing* standards referenced above, Factory Mutual Global published an *approval* standard for *combustible gas detectors*, Class 6320, in November of 2014.[4] It can be found at the following	

Section	Requirement 2011	Requirement 2016	Narrative	Required References
			website: http://www.fmglobal.com/page.aspx?id=50000000 by accessing the site and searching for FM 6320. As for generic *combustible gas detectors*, some manufacturers may calibrate them specifically for hydrogen. It is important that any detector used be evaluated by the manufacturer and a third party even if it's not *listed* and that documentation be provided to the *AHJ* that substantiates performance and reliability. See Appendix A.2 of the guide for informational references. Users should refer to Annex L of NFPA 2 for detailed recommendations and discussion on the selection and installation of hydrogen *gas detection systems*.	
6.13 Lighting				
6.13* Lighting	*Approved* lighting by natural or artificial means shall be provided [for the storage areas]. [55:6.10]	**Lighting**. *Approved* lighting by natural or artificial means shall be provided for areas of storage or use. [55:6.11]	The building codes provide the minimum requirements for natural and artificial lighting. Section 6.2 establishes the requirements for buildings to conform to the adopted building code for the location in which they are constructed. The 2015 IBC establishes requirements for natural and artificial lighting in Section 1205 and the parameters for minimum lighting are specified. There may be other requirements depending on the applicable building code. In the control strategy used by NFPA 2, the requirements of Chapter 6 for lighting are triggered when the quantity of hydrogen in a control area exceeds the maximum allowable quantity (MAQ) threshold. See NFPA 2, Section 6.1.1.5, for application. For existing buildings the addition of hydrogen may trigger a change in occupancy classification that may have an impact on building design. The requirements of a change in occupancy can affect other elements of the building, and designers should investigate the impact of such a change to the building as previously permitted.	*2015 International Building Code*, International Code Council

Section	Requirement 2011	Requirement 2016	Narrative	Required References
6.17 Ventilation				
6.17.2.1.1 Continuous Operation	6.17.1.2 Continuous Operation [Ventilation Systems]. Systems shall operate continuously unless an alternate design is *approved* by the *AHJ*. [55:6.15.4]	When operation of *ventilation* systems is required, systems shall operate continuously unless an alternate design is *approved* by the *AHJ*. [55:6.16.3.1]	No special consideration is necessary when the design is coordinated with the requirements described in the referenced provision. Following the instruction provided in the requirement as published should result in *approval* of the proposed design. The changes made to the 2016 Edition of NFPA 2 are to clarify that the requirements apply only to *ventilation* systems otherwise required by the code. *Ventilation* systems that operate on a non-continuous basis must be *approved*. It is not unusual to have a mechanical *ventilation* system activated by hydrogen gas detection. In such cases, airflow is verified by a flow-sensing device. Additional information including methods to determine the extent and location of the flammable region with site-specific *ventilation* design and specified gas release rates can be found in IEC 60079-10-1.[5] The prescriptive requirements of the 2011 Edition of NFPA 2 in Section 6.17.1 are clear. Section 6.17 allows the use of either mechanical or *natural ventilation*. The requirements of Chapter 6 are “fundamental” or general requirements, which are applicable in buildings where hydrogen is located. Chapters 7 through 20 are material or use-specific chapters. Refer to Sections 10.1.1 through 10.1.1.2 as an example of the directions given to code users to remind users that use-specific requirements take precedent over general requirements. In addition to the use-specific requirements of NFPA 2, the International Codes, including the Fuel Gas and Mechanical Codes, published by the ICC contain prescriptive requirements for the use of *natural ventilation* in various occupancies and garages where fueling occurs.	*2015 International Mechanical Code*, International Code Council, Sections 304.5.1 and 304.5.2, p. 24 *2015 International Fuel Gas Code*, International Code Council, Section 703.1.1, p. 133

Section	Requirement 2011	Requirement 2016	Narrative	Required References
6.17.2.1.2 Shutoff Controls	6.17.1.3 Shutoff Controls. Where powered *ventilation* is provided, a manual shutoff switch shall be provided outside of the room in a position adjacent to the principal access door to the room or in an *approved* location. [55:6.15.5]	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. [55:6.16.5]	*Ventilation* is a key control for indoor locations in the event of a hydrogen leak. The purpose of the switch is to provide a control for use by emergency response personnel and to maintain the operation of the *ventilation* system until it is intentionally shut down. An example of what might be considered to be an *approved* location for the shutoff control would be to locate the required switch at a *constantly attended location* for use by emergency response personnel. Although the term is not included in NFPA 2, it is defined in the IFC*,* published by the ICC.[6] In facilities that don't maintain a *constantly attended location,* other locations near the area where hydrogen is located may be used at the option of the *AHJ* with consideration given to the facility emergency plan. See defined terms in Section 3 of this guide.	

Chapter 7 Gaseous Hydrogen

Section	Requirement 2011	Requirement 2016	Narrative	Required References
7.1.3 Listed and Approved Hydrogen Equipment				
7.1.3	**Listed and Approved Hydrogen Equipment.** *Listed* and *approved* hydrogen generating and consuming equipment shall be in accordance with the *listing* requirements and manufacturers' instructions. [55:7.1.3.1]	**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. [55:10.2.8.1]	*Listed* equipment must meet the conditions of the *listing* standard and the requirements imposed upon the equipment by the *listing* agency. Otherwise, the *listing* is void and does not impart the benefits implied with the *listing*. The equipment must also be installed in accordance with the manufacturer's instructions and any additional requirements imposed by the *AHJ*. It could be argued that the 2011 Edition of the code linked the term *approved* to *listed* equipment. The clarification provided in 2016 requires that the equipment be either *listed* or *approved.* Section 10.2.8.2 provides exemption from the requirements of Chapter 7 when *listed* or *approved* equipment is used.	
7.1.4 Metal Hydride Storage Systems				
7.1.4.1.4*	**Listed or Approved Systems**. *Metal hydride storage systems* shall be *listed* or *approved* for the application and designed in a manner that prevents the addition or removal of the *metal hydride* by other than the original equipment manufacturer. [55:7.1.4.1.4]	**Listed or Approved Systems**. *Metal hydride storage systems* shall be *listed* or *approved* for the application and designed in a manner that prevents the addition or removal of the *metal hydride* by other than the original equipment manufacturer. [55:10.2.9.1.4]	*Metal hydride storage systems* are *pressure vessels* and have unique features to safely contain the *metal hydride* materials. It is insufficient to put *metal hydride* material into a *pressure vessel* without proper design considerations. Special hazards and mitigation features associated with *metal hydrides* are described and accounted for in the requirements of ISO Standard 16111.[7] Additional information can be found in Container Specifications for Metal Hydride Based Storage, available at: http://www.rita.dot.gov/sites/default/files/publications/hydrogen_infrastructure_safety_analysis/html/section_25_02.html.	

Section	Requirement 2011	Requirement 2016	Narrative	Required References
7.1.4.1.7.4	**Pressure Vessel Markings**. *Cylinders*, *containers*, and *tanks* used in *metal hydride storage systems* shall be marked with the following: [55:7.1.4.1.7.4] (3) Authorized body *approving* the design and initial inspection and test of the vessel [55:7.1.4.1.7.4(3)]	**Pressure Vessel Markings**. *Cylinders*, *containers*, and *tanks* used in *metal hydride storage systems* shall be marked with the following: (3) Authorized body *approving* the design and initial inspection and test of the vessel [55:7.1.4.1.7.4]	*Cylinders* and *pressure vessels* are required to be built to specific codes. Stationary equipment generally needs to meet ASME requirements and portable equipment needs to meet DOT requirements. Most states have *pressure vessel* regulations adopted into state law. For those that don't, there are references to acceptable *pressure vessel* codes within the adopted *fire code*. It is important for every vessel containing pressure to be marked with the appropriate code to which it was built and tested.	
7.1.4.1.10	**Refilling of Containers**. The refilling of *listed* or *approved metal hydride storage systems* shall be in accordance with the *listing* requirements and manufacturers' instructions. [55:7.1.4.1.11]	**Refilling of Containers**. The refilling of *listed* or *approved metal hydride storage systems* shall be in accordance with the *listing* requirements and manufacturers' instructions. [55:10.2.9.1.11]	The *approval* should include a description of the basis for safe refilling of the *containers*. *Metal hydride storage system*s are *pressure vessels* and have unique features to safely contain the *metal hydride* materials. It is insufficient to put *metal hydride* material into a *pressure vessel* without proper design considerations.	
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. [55:7.1.4.1.11.2]	**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. [55:10.2.9.1.11.2]	There are several standard grades of purity for hydrogen, both in gaseous or liquid form, that are used for commercial sale. There are also numerous processes that may use, produce, or process hydrogen of varying purity that is acceptable for that particular process piece of equipment, even if not one of the standard purity grades. The purity of hydrogen can significantly affect a process or its associated equipment. A specific commercial grade of hydrogen purity is not necessary to be maintained, but the purity of hydrogen should remain within the process conditions for which a piece of equipment was designed. Certain off-specification impurities can have a harmful effect on equipment that could lead to unsafe conditions.	

Section	Requirement 2011	Requirement 2016	Narrative	Required References
7.1.6 Labeling Requirements				
7.1.6.4.2	*Piping* within gas manufacturing plants, gas processing plants, refineries, and similar occupancies shall be marked in an *approved* manner. [55:7.1.7.4.2]	*Piping* within gas manufacturing plants, gas processing plants, refineries, and similar occupancies shall be marked in an *approved* manner. [55:7.1.7.4.2]	The purpose of pipe *labeling* is to properly identify materials within the system. *Labeling* is important for maintenance and operation of the system. It's also important for first responders to understand the materials that might be involved in an incident. Documents such as ASME A13.1[8] provide guidance for proper *labeling* and can be used by an *AHJ* as a guideline. For additional guidance, the code user may refer to IFC Section 5303.4.3.	
7.1.9.1.1.1		Valve protection of individual valves shall not be required to be installed on individual *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 4.11and 7.1.8.3 or other *approved* means. Protective systems required by DOT for over the road transport shall provide an acceptable means of protection. [55:7.1.9.1.1.1]	This section applies solely to *compressed gas systems*. Section 4.11 establishes requirements for *containers* or systems subject to vehicular damage. Section 7.1.8.3 requires that *cylinders*, *containers*, or tanks subject to exposure where physical damage can occur to be protected. Stationary gas systems located in areas subject to vehicular traffic are normally protected by barriers of some sort. On the other hand, mobile systems should be protected by devices that must travel with the unit and that shield the manifold and valves from impact from falling objects or similar exposures. Other *approved* means could include installation within a protective enclosure such as a gas cabinet or a ventilated enclosure to shield the system from *physical hazards* that can damage valves and manifolds should unexpected incidents occur. Other *physical hazards* can include objects that are able to fall onto or that may dislodge the gas system, including those that have components such as unsecured *piping* or energy sources that can come into physical contact with the gas system if premature failure occurs.	

Section	Requirement 2011	Requirement 2016	Narrative	Required References
7.1.13 Leaks, Damage, or Corrosion				
7.1.13.3*	**Handling of Containers, Cylinders, and Tanks Removed from Service**. [GH_2] *containers*, *cylinders*, and *tanks* that have been removed from service shall be handled in an *approved* manner. [55:7.1.14.3]	**Handling of Containers, Cylinders, and Tanks Removed from Service**. [GH_2] *cylinders*, *containers*, and *tanks* that have been removed from service shall be handled in an *approved* manner. [55:7.1.14.3]	Proper relocation and/or disposal of vessels and their contents are necessary to prevent hazardous situations. One course of action is to have the gas supplier, if applicable, handle the storage vessels. There is no standard that is directly applicable for guidance to remove *pressure vessels* from service. CFR Title 49 provides limited guidance for DOT vessels and equipment. Title 29 OSHA regulations address the need for appropriate *labeling* and marking of *containers* that contain any hazardous materials. See 29 CFR Section 1910.1200(f) for additional information. When equipment used in hydrogen service is no longer needed, it is a practice of the equipment suppliers to remove the hydrogen and to inert the equipment with a non-flammable atmosphere. Once the hydrogen has been removed, the placards and/or markings on the *container* are also revised to comply with the requirements of OSHA to reflect the actual contents of the *container*.	
7.1.15 Piping				
7.1.15.1	**Piping Systems [GH_2]**. *Piping*, tubing, fittings, and related components shall be designed, fabricated, and tested in accordance with the requirements of ASME B31.3, *Process Piping*, or other *approved* standards. [55:7.3.1.3]	**Piping Systems**. *Piping*, tubing, fittings, and related components shall be designed, fabricated, and installed in accordance with applicable parts of ASME B31.3, *Code for Process 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-iron	While ASME B31.3[9] is widely recognized, other standards may also be used if acceptable to the *AHJ*. For example, ISO 15649,[10] *piping system*s built to the European Pressure Equipment Directive or other codes such as ASME B31.12, *Hydrogen Piping and Pipelines,*[11] as well as other recognized standards can be acceptable. The IFGC Section 704.1.2.3 requires the use of 300 series stainless steel *piping* or tubing in addition to *piping* or tubing that has been *listed* in B31.3. ASME B31.3 defines the term *listed* to describe a material or component that conforms to a specification referenced within the	*2015 International Fuel Gas Code*, International Code Council

Section	Requirement 2011	Requirement 2016	Narrative	Required References
		pipe, valves, and fittings shall not be used. [55:10.2.2.1]	ASME code, and it is not equivalent to the term *listing* as defined by the IFGC. For example, the ASTM A403 Standard specification is one of the *listed* standards used for wrought austenitic stainless steel fittings for pressure *piping* applications. Although the term *listed* is not defined in ASME B31.12, it is used in the same manner as in B31.3. In addition to allowing the use of components that are *listed*, the ASME B31 codes allow the use of components that are not *listed*, as long as they are qualified.	
7.1.15.3.2.1	Gas *piping* in contact with earth or other material that could corrode the *piping* shall be protected against corrosion in an *approved* manner. [55:7.1.17.2]	Gas *piping* in contact with earth or other material that could corrode the *piping* shall be protected against corrosion in an *approved* manner. [55:7.1.17.2]	There are numerous combinations of *piping* materials and soil conditions where *piping* in contact with the earth may corrode if improperly installed. Corrosion can be mitigated by proper choice of materials, coatings, and *cathodic protection*. The *AHJ* should review documentation provided by the designer that would indicate that the mitigation selected is suitable. Another approach is to avoid contact with the earth by using appropriate sleeves or other isolation barriers.	
7.1.18 Cathodic Protection				
7.1.18.4	**Corrosion Expert**. Repairs, maintenance, or replacement of a *cathodic protection* system shall be under the supervision of a *corrosion expert certified* by NACE. [55:7.1.6.4]	**Corrosion Expert**. Repairs, maintenance, or replacement of a *cathodic protection* system shall be under the supervision of a *corrosion expert certified* by NACE. [55:7.1.6.4]	The National Association of Corrosion Engineers (NACE) provides *certification* for professionals knowledgeable about corrosion. *Cathodic protection* systems require detailed knowledge for proper function and a NACE *certified* professional can provide the oversight needed.	
7.1.18.4.1	The *corrosion expert* shall be *certified* by NACE as a senior corrosion technologist, a *cathodic protection* specialist, or a corrosion specialist or shall be a registered engineer	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	NACE provides *certification* for professionals knowledgeable about corrosion. *Cathodic protection* systems require detailed knowledge for proper function and a NACE *certified* professional can provide the oversight needed.	

Section	Requirement 2011	Requirement 2016	Narrative	Required References
	with registration in a field that includes education and experience in corrosion control. [55:7.1.6.4.1]	with registration in a field that includes education and experience in corrosion control. [55:7.1.6.4.1]		
7.1.23 Hydrogen Equipment Enclosures				
7.1.23.8		A *HEE* shall be secured to a structure or foundation in a manner *approved* by the *AHJ*.	The definition of a *hydrogen equipment enclosure* (*HEE*) in Chapter 3 of this guide as applied by the code can be confusing as the definition refers to the enclosure as an "area" with at least three walls rather than as a prefabricated item of equipment of limited area. To help the user understand the typical enclosure, the annex note for the definition provides explanatory text that describes the object and clarifies that it is an item of equipment. The "walls" described in the definition may better be described as "sides," and it is anticipated that such enclosures may also have a top that serves as a roof, although not built to roofing standards as would be the roof of a building under the requirements for buildings. *HEEs* are typically portable modules similar to a shipping *container* found in intermodal shipping, which can be relocated from one location to another by a forklift or crane. A foundation is required to prevent dislodgement and to resist movement from physical forces such as wind, seismic events, flooding, and similar perils. The anchors used to secure the equipment to the foundation or supporting structure should be designed in accordance with the structural requirements of the building code used for items of equipment, or miscellaneous structures.	
7.1.25.1		Where [GH_2] [-] is carried in pressurized *piping* above a gauge pressure of 15 psi (103 kPa), an *approved*	Section 7.1.25.2 provides a list of items that can be used to gain *approval*.	

Section	Requirement 2011	Requirement 2016	Narrative	Required References
		means of emergency isolation shall be provided [-]. [55:7.3.1.12.1]		
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 [55:7.3.1.12.2]	The provisions introduce several new and undefined terms for the code user, including the term "emergency isolation." The following explanation is provided to help users apply the requirements. • The automatic shutoff valve described in item 1 should meet the requirements for an *automatic emergency shutoff valve.* See the definition in Chapter 3. The operation of the shutoff valve should be interlocked to the leak detection system so that activation or failure of the leak detection system will activate the shutoff valve. It should be noted that there are no requirements for "leak detection systems" in occupancies or uses other than those specifically identified in the code. For *approval* to be granted for the use of item 1, a "*gas detection system*" should be provided. • The term "attended control station" in item 2 is undefined. As necessary, the location of the control station can be remote from the facility where the source is located. The intended emergency responses that are described are not identified further. The use of an attended control station should be equipped with controls that can be activated to shut the system down from the control station. The term *remotely located, manually activated shutdown control* is included in Chapter 3 of this guide. • The term "excess flow valve" is not defined. The defined term *excess flow control* is a method rather than a device. An excess flow valve is a valve that has a predetermined maximum rate of flow that when exceeded causes the valve to close. Section 7.1 applies to both bulk and non-bulk sources or systems.	

Section	Requirement 2011	Requirement 2016	Narrative	Required References
			The methods used to provide shutdown as described in items 1 and 4 are limited to bulk *gaseous hydrogen systems*, defined as systems with a contained gas volume of 5,000 cubic feet or more. The methods described in items 2 and 3 can be applied to either bulk or non-bulk sources. Where gas is piped from a central source to multiple points of use in one or more buildings, major problems can be created by shutting down the source as the result of a leak or loss in an individual building. Where multiple buildings are served by a single source, it is reasonable to have the ability to isolate or shut down an individual building in the event of leakage in the building without having to isolate the central supply from multiple buildings, which may be remote from one another.	
7.2.4 Nonbulk GH_2 Handling				
7.2.4.2.1	*Containers, cylinders,* and *tanks* shall be moved using an *approved* method. [55:7.3.3.2.1]	*Cylinders, containers,* and *tanks* shall be moved using an *approved* method. [55:7.3.3.2.1]	Suppliers provide literature on appropriate ways of moving *pressure vessels*. This can be for DOT vessels that are intended to be moved in a pressurized condition, or for ASME vessels that are not. Pressurized *cylinders* can be hazardous if not moved properly. For example, portable DOT *cylinders* should always be moved with the valve closed and a *cylinder* cap installed.	
7.3.2 Bulk GH_2 Systems Storage				
7.3.2.3.1.1	**Minimum Distance for Aboveground Locations** (A) (d) Separation distances determined based on the use of Table 7.3.2.3.1.2(c) shall be subject to review and *approval* by the *AHJ*. [55:10.3.2.2.1.1(D)]	**Minimum Distance for Aboveground Locations.** (1) (b) Separation distances determined based on the use of Table 7.3.2.3.1.1(b) or Table 7.3.2.3.1.1(c) shall be subject to review and *approval* by the *AHJ*. [55:10.4.2.2.2.2]	The separation distances provided in NFPA 2 are based on numerous criteria. The *AHJ* should ensure that the proper line size and pressure were used to calculate the separation distance. In addition, the *AHJ* may use judgement as to the distances as they are applied and interpreted. Additional guidance is provided in the Annex material related to distance as found in Chapter 7.	

Section	Requirement 2011	Requirement 2016	Narrative	Required References
7.3.2.3.1.2		**Reduction of Distance by Mitigation Means (B) Active Means.** Active control systems that mitigate the rise of system leaks and failures shall be permitted to be used as a means to reduce separation distances where *approved* by the *AHJ* under the authority as granted by Section 1.5. [55:10.4.2.2.4.2]	Section 1.5 requires that alternate means of compliance with the prescriptive requirements of the code must be equivalent to the requirements in terms of quality, strength, fire resistance, effectiveness, durability, and safety. The term "failures" should be viewed as being all inclusive, and the focus of the requirements should not be centered solely on leaks. Proximity to all exposures identified in the tables prescribing separation distance must be considered and discussed in the documentation required by Section 1.5.2.	
7.3.2.4.4.1	Joints in the *piping system* shall be butt welded and 100 percent inspected using nondestructive testing (NDT) methods in accordance with the requirements of ANSI/ASME B31.3, *Process Piping*, or other *approved* standards. [55:10.4.2.4.1]	Joints in the *piping system* shall be installed and inspected in accordance with the requirements of ASME B31.12, *Hydrogen Piping and Pipelines,* , or other *approved* standards. [55:10.44.3.1.5.2]	While ASME B31.3[9] is widely recognized, other standards may also be used if acceptable to the *AHJ*. For example, ISO 15649,[10] *piping system*s built to the European Pressure Equipment Directive or other ASME codes such as ASME B31.12, *Hydrogen Piping and Pipelines*,[11] as well as other recognized standards can be acceptable. Even though the code now recognizes B31.12 as ASME's hydrogen *piping* and pipeline code, *piping* systems designed and installed in accordance with other applicable B31 codes can be used. The types of joints that can be used are specified by the designer of the system in accordance with the applicable code or standard used. The types of joints used are dependent on the expected service and test conditions of pressure, temperature, and external loading. Code users and *AHJs* should verify that the codes or standards used in the design are applicable to the systems regulated by the code.	

Chapter 8 Liquefied Hydrogen

Section	Requirement 2011	Requirement 2016	Narrative	Required References
8.1 Liquefied Hydrogen Containers - Design, Construction, and Maintenance				
8.1.3.1	**Piping Systems [LH2]**. *Piping*, tubing, fittings, and related components shall be designed, fabricated, and tested in accordance with the requirements of ANSI/ASME B31.3, *Process Piping*, or other *approved* standards and shall be in accordance with 8.1.3.1.1. [55:8.14.1.4.2]	**Piping Systems**. *Piping*, tubing, fittings, and related components shall be designed, fabricated, and tested in accordance with the requirements of ASME B31.*12, Hydrogen Piping and Pipelines,* , or other *approved* standards and shall be in accordance with 8.1.3.1.1.	While ASME B31.3[9] is widely recognized, other standards may also be used if acceptable to the *AHJ*. For example, ISO 15649,[10] *piping systems* built to the European Pressure Equipment Directive or other ASME codes such as ASME B31.12, *Hydrogen Piping and Pipelines*,[11] as well as other recognized standards can be acceptable. Even though the code now recognizes B31.12 as ASME's hydrogen *piping* and pipeline code, *piping systems* designed and installed in accordance with other applicable B31 codes can be used.	
8.1.3.1.8.2	**Inspection** (B) The *cathodic protection tester* shall be *certified* as being qualified by the National Association of Corrosion Engineers, International (NACE). [55:8.14.9.2.2]	**Inspection** (B) The *cathodic protection tester* shall be *certified* as being qualified by the National Association of Corrosion Engineers, International (NACE). [55:8.14.9.2.2]	NACE provides *certification* for professionals knowledgeable about corrosion. *Cathodic protection* systems require detailed knowledge for proper function and a NACE *certified* professional can provide the oversight needed.	
8.1.3.1.8.4	**Corrosion Expert** (A) Repairs, maintenance, or replacement of a *cathodic protection* system shall be under the supervision of a *corrosion*	**Corrosion Expert** (A) Repairs, maintenance, or replacement of a *cathodic protection* system shall be under the supervision of a *corrosion*	NACE provides *certification* for professionals knowledgeable about corrosion. *Cathodic protection* systems require detailed knowledge for proper function and a NACE *certified* professional can provide the oversight needed.	

Section	Requirement 2011	Requirement 2016	Narrative	Required References
	expert certified by NACE. [55:8.14.9.4]	*expert certified* by NACE. [55:8.14.9.4]		
8.1.4 Pressure Relief Devices				
8.1.4.2.1	*Containers* shall be equipped with *approved* controls to prevent the condensation of air within the *container*.	*Containers* shall be equipped with *approved* controls to prevent the condensation of air within the *container*.	The mixture of liquid or solid air with liquid hydrogen is extremely hazardous because the danger of fire or explosion is substantially increased. Open-topped *containers* are generally designed and intended for atmospheric cryogenic products such as oxygen, nitrogen, or argon, and are not intended for liquid hydrogen. Such use is a highly specialized application and requires unique engineering methods to prevent the introduction of air into the system. The system designer may be required to provide the *AHJ* with documentation that demonstrates that air cannot condense or freeze within the *container*. The *AHJ* may require third-party evaluation of such systems when such use is proposed.	
8.1.10.1	**Containers**. *Containers* that have been removed from service shall be handled in an *approved* manner. [55:8.9.1]	**Containers**. *Containers* that have been removed from service shall be handled in an *approved* manner. [55:8.9.1]	Proper relocation and/or disposal of vessels and their contents are necessary to prevent hazardous situations. One course of action is to have the gas supplier, if applicable, handle the storage vessels. ANSI/CGA H-5, *Standard for Bulk Hydrogen Supply Systems,* provides guidance for removing liquid tanks and systems used for supplying LH_2. DOT and ASME *pressure vessels* may be encountered depending on size and service requirements. Systems with a capacity exceeding 39.7 gal (150 liters) of LH_2 are classified as *bulk liquefied hydrogen systems*. CFR Title 49 provides limited guidance for DOT vessels and equipment. Title 29 OSHA regulations address the need for appropriate *labeling* and marking of *containers* that contain any hazardous materials. See 29 CFR Section 1910.1200(f) for additional information. When the equipment used in hydrogen service is no longer needed, it is the practice of the equipment suppliers to remove the hydrogen and to inert the equipment with a non-flammable atmosphere. Once	ANSI/CGA H-5 *Standard for Bulk Hydrogen Supply Systems - 2014 Edition.*

Section	Requirement 2011	Requirement 2016	Narrative	Required References
			the hydrogen has been removed, the placards and/or markings on the *container* are also revised to comply with the requirements of OSHA to reflect the actual contents of the *container*.	
8.1.15	**Dispensing Areas**. Dispensing of [LH_2] associated with *physical* or *health hazards* shall be conducted in *approved* locations. [55:8.14.11.3.2]	**Dispensing Areas**. Dispensing of [LH_2] associated with *physical* or *health hazards* shall be conducted in *approved* locations. [55:8.14.11.3.2]	Locations of LH_2 transfer should be sited to meet the minimum requirements of LH_2 storage systems. Additional hazards involved with transferring LH_2 include parking of a delivery vehicle, release of hydrogen during delivery, increased potential for accidental releases, and increased hazards to members of the public who might be in the area. These hazards should be considered in addition to the required LH_2 separation distances prescribed by tabular distances found in NFPA 2.	
8.2.3.1.1.4	**Design** (B) *Piping Systems* [LH_2]. *Piping*, tubing, fittings and related components shall be designed, fabricated, and tested in accordance with the requirements of ANSI/ASME B31.3, *Process Piping*, or other *approved* standards and shall be in accordance with 8.2.3.1.2. [55:8.14.1.4.2]	**Design.** (B) *Piping Systems*. *Piping*, tubing, fittings and related components shall be designed, fabricated, and tested in accordance with the requirements of ANSI/ASME B31.3, *Process Piping*, or other *approved* standards and shall be in accordance with 8.2.3.1.2. [55:8.14.1.5.2]	While ASME B31.3[9] is widely recognized, other standards may also be used if acceptable to the *AHJ*. For example, ISO 15649,[10] *piping systems* built to the European Pressure Equipment Directive or other ASME codes such as ASME B31.12, *Hydrogen Piping and Pipelines*,[11] as well as other recognized standards can be acceptable.	
8.2.3.1.3		**Joints.** Joints in *piping* and tubing shall be in accordance with the requirements of ANSI/ASME B31.3, *Process Piping,* or other *approved* standards. [55:8.14.3]	The use of ASME B31.3 is specified. The "other *approved* standards" provision can include B31.12, ASME's hydrogen *piping* and pipeline code, or other relevant ASME standards. There are several apparent inconsistencies in NFPA 2 where the use of B31.3 and/or B31.12 is required. For example, for *non*-bulk systems, the use of ASME B31.3 is required (see 8.2.3.1.1.4), while for *bulk* systems, the use of ASME B31.12 is required (see 8.3.1.2.3). When bulk supplies are connected to dispensers, the dispensers may be required to comply with ASME B31.3 (see 10.3.1.7.3). These inconsistencies are likely due to the introduction of ASME B31.12 as it was coordinated with NFPA 2 and	

Section	Requirement 2011	Requirement 2016	Narrative	Required References
			NFPA 55 subsequent to the release of the first edition of NFPA 2. Although there is a strong parallel between these two ASME documents, when used as the basis for design there are differences between B31.3 and B31.12 with respect to design factor as it may affect ultimate tensile strength or burst pressure of the *piping system*. The practical application of the code would be to design and install *piping systems* in accordance with one document or the other using the provision for "other *approved* standards" to achieve a system that complies with one ASME code, and not to vary the use of the document based on the literal reading of the requirements as they now appear in NFPA 2. Uniformity in approach is also an important consideration for the repair of systems that may have been constructed under the requirements of one document, and repairs or supplemental portions of the system should remain consistent with the codes under which the system was constructed.	
8.2.3.1.9.2	**Inspection** (B) The *cathodic protection tester* shall be *certified* as being qualified by the National Association of Corrosion Engineers, International (NACE). [55:8.14.9.2.2]	**Inspection** (B) The *cathodic protection tester* shall be *certified* as being qualified by the National Association of Corrosion Engineers, International (NACE). [55:8.14.9.2.2]	NACE provides *certification* for professionals knowledgeable about corrosion. *Cathodic protection* systems require detailed knowledge for proper function and a NACE *certified* professional can provide the oversight needed.	
8.2.3.1.9.5	Repairs, maintenance, or replacement of a *cathodic protection* system shall be under the supervision of a *corrosion expert certified* by NACE. [55:8.14.9.4]	Repairs, maintenance, or replacement of a *cathodic protection* system shall be under the supervision of a *corrosion expert certified* by NACE. [55:8.14.9.4]	NACE provides *certification* for professionals knowledgeable about corrosion. *Cathodic protection* systems require detailed knowledge for proper function and a NACE *certified* professional can provide the oversight needed.	

Section	Requirement 2011	Requirement 2016	Narrative	Required References
8.2.4.2 Carts and Trucks				
8.2.4.2.1	[LH_2] *containers* shall be moved using an *approved* method. [55:8.14.11.4.2.1]	[LH_2] *containers* shall be moved using an *approved* method. [55:8.14.11.4.2.1]	Suppliers provide literature on appropriate ways of moving *pressure vessels*. This can be for DOT vessels that are intended to be moved in a pressurized condition, or for ASME vessels that are not. Pressurized *cylinders* can be hazardous if not moved properly. For example, portable DOT *cylinders*, including liquid *cylinders*, should always be moved with the valve closed and a *cylinder* cap or valve protection installed.	
8.3.2 Bulk LH_2 Systems Storage				
8.3.2.1.4.3	**Nonstandard Containers** (A) *Containers*, equipment, and devices that are not in compliance with recognized standards for design and construction shall be permitted if *approved* by the *authority having jurisdiction* upon presentation of evidence that they are designed and constructed for safe operation. [55:8.2.2.1]	**Nonstandard Containers** (A) *Containers*, equipment, and devices that are not in compliance with recognized standards for design and construction shall be permitted if *approved* by the *authority having jurisdiction* upon presentation of evidence that they are designed and constructed for safe operation. [55:8.2.2.1]	ASME and DOT are widely recognized in the United States for design and construction. Federal law requires compliance with DOT requirements for hazardous material transportation. Most states require the use of the *ASME Boiler and Pressure Vessel Code*. Equipment sourced overseas may meet the applicable regulations and codes of the source country and may be acceptable. The local *AHJ* does not have jurisdiction over hazardous material transportation and generally cannot supersede federal law. The *AHJ*, as allowed by state law, may be permitted to consider other *pressure vessel* codes for acceptance after review.	
8.3.2.3.1.7	**Overfill Protection and Prevention Systems**. An *approved* means or method shall be provided to prevent the overfilling of storage *tanks*. [55:11.4.3.7]	**(G) Overfill Protection and Prevention Systems**. An *approved* means or method shall be provided to prevent the overfilling of storage *tanks*. [55:11.4.3.7]	Liquid level is typically indicated by a differential pressure gauge and the “full” level is typically marked on or beside the gauge. In addition, an overflow valve system is often used to indicate when the tank has reached a predetermined maximum liquid level.	
8.3.2.3.1.7	**Vacuum Level Monitoring**. An *approved* monitoring method shall be provided	**(H) Vacuum Level Monitoring**. An *approved* monitoring method shall be	A vacuum in the annular space of double-walled vessels is important for operation of liquid hydrogen systems. The vacuum acts as an insulator, enabling the temperature in the inner tank to remain low	

Section	Requirement 2011	Requirement 2016	Narrative	Required References
	to indicate vacuum degradation within the vacuum jacket(s). [55:11.4.3.8]	provided to indicate vacuum degradation within the vacuum jacket(s). [55:11.4.3.8]	over extended periods. The best indication of a poor vacuum is condensation or frost on the surface of the outer vessel. Continuous monitoring of vacuum is not recommended since the monitoring equipment itself can potentially lead to vacuum degradation via leakage. Vacuum insulation systems are typically equipped with a means to measure the vacuum pressure as needed. Checking the vacuum pressure, or level of vacuum, as part of a maintenance program, is an acceptable means of monitoring insulation integrity.	
8.3.4.2.1	[LH_2] *containers* shall be moved using an *approved* method. [55:8.14.11.4.2.1]	[LH_2] *containers* shall be moved using an *approved* method. [55:8.14.11.4.2.1]	Suppliers provide literature on appropriate ways of moving *pressure vessels*. Such literature can be provided for DOT vessels that are intended to be moved in a pressurized condition, or for ASME vessels that are not. Pressurized *cylinders* can be hazardous if not moved properly. For example, portable DOT *cylinders* should always be moved with the valve closed and a *cylinder* cap installed. Valve protection for liquid *cylinders* is typically provided by unremovable collars or other means that shield the controls for cryogenic service from impact during movement. Dollies that are designed to handle liquid *containers* are typically fitted with specialized brackets or cradles to facilitate movement of portable *cryogenic containers*.	

Chapter 10 GH_2 Vehicle Fueling Facilities

Section	Requirement 2011	Requirement 2016	Narrative	Required References
10.2.1.1	Dispensing and storage facilities shall be *certified* as meeting the requirements of this code by qualified engineer(s) with expertise and competence in the design, fabrication, and construction of hydrogen *containers*, *piping systems*, site fire protection, gaseous detection, emergency shutdown provisions, isolation, drainage, site spacing, fire protection equipment, operating procedures, worker protection, and other components of the facility. [52:9.2.2]	Dispensing and storage facilities shall be *certified* as meeting the requirements of this code by qualified engineer(s) with expertise and competence in the design, fabrication, and construction of hydrogen *containers*, *piping systems*, site fire protection, gaseous detection, emergency shutdown provisions, isolation, drainage, site spacing, fire protection equipment, operating procedures, worker protection, and other components of the facility.	Proof of *certification* can be in the form of a signed drawing or signed letter describing the design and operation of the system and demonstrating its compliance to this code. Although not defined by the code, a qualified engineer is one who is knowledgeable and experienced in the subject matter and comparability can be established with the term *qualified individual*. A *qualified individual* is one knowledgeable in the hazards of *compressed gases* and *cryogenic fluids* through training and work experience.[12] Also see *qualified person* as defined in Chapter 3 of this guide.	
System Component Qualifications				
10.3.1.1*	**System Component Qualifications**. The following systems and system components shall be *listed* or *approved*: [52:5.2.1] (1) *Pressure relief devices*, including pressure relief valves [52:5.2.1(1)] (2) Pressure gauges [52:5.2.1(2)]	**System Component Qualifications**. The following systems and system components shall be *listed* or *approved*: (1) *Pressure relief devices*, including pressure relief valves (2) Pressure gauges (3) *Pressure regulators*	There are no *listed* components available in a number of the categories included from which a system designer may choose. In lieu of *listing*, the use of un*listed* components may be *approved* when good engineering judgement by the system designer is used, and the requirements of industrial codes, such as the ASME B31 *piping* codes or the *ASME Boiler and Pressure Vessel Code*, should be followed. Components that are not *listed* will require *approval* by the *AHJ*. The lack of pursuit to acquire a *listing* for hydrogen fueling station equipment and fuel cell industrial trucks may be due to one or more	

<table>
<tr><th>Section</th><th>Requirement 2011</th><th>Requirement 2016</th><th>Narrative</th><th>Required References</th></tr>
<tr><td></td><td>(3) Pressure regulators [52:5.2.1(3)]
(4) Valves [52:5.2.1(4)]
(5) Hose and hose connections [52:5.2.1(5)]
(6) Vehicle fueling connections (nozzle) [52:5.2.1(6)]
(7) Metal hydride storage [52:5.2.1(7)]
(8) Electrical equipment used with GH_2 systems [52:5.2.1(8)]
(9) Gas detection equipment and alarms [52:5.2.1(9)]
(10) Hydrogen generators [52:5.2.1(10)]
(11) Hydrogen dispensers [52:5.2.1(11)]
(12) Pressure switches [52:5.2.1(12)]
(13) Flow meters [52:5.2.1(13)]
(14) Composite storage (reserved)</td><td>(4) Valves
(5) Hose and hose connections
(6) Vehicle fueling connections (nozzle)
(7) Electrical equipment used with GH_2 systems
(8) Gas detection equipment and alarms
(9) Hydrogen dispensers
(10) Pressure switches
(11) Flow meters
(12) Breakaway devices
(13) Dispenser enclosure</td><td>factors: (1) reservations on the part of the equipment manufacturers about the listing standards, (2) business decisions based on the size of the potential user market, and (3) the cost of authorizing the listing organization, in an early market, to conduct a full listing evaluation requiring many types of tests. As the hydrogen equipment markets continue to grow and mature, one can envision evolving listing standards and practices and the successful pursuit of more listing by equipment manufacturers.

The table below gives a representative sample of the codes and standards that may be considered in the approval process:

<table>
<tr><th>Item</th><th>Documents that May Be Considered in the Approval Process</th></tr>
<tr><td>(1) Pressure relief devices, including pressure relief valves (PRVs)</td><td>• ASME pressure vessels: ASME Boiler and Pressure Vessel Code.
• DOT containers: CFR Title 49, DOT regulations. Relief devices for piping systems: applicable ASME B31 codes</td></tr>
<tr><td>(2) Pressure gauges</td><td>Applicable ASME B31 codes</td></tr>
<tr><td>(3) Pressure regulators</td><td>Applicable ASME B31 codes</td></tr>
<tr><td>(4) Valves</td><td>Applicable ASME B31 codes, CSA HGV 4.6,[13] CSA 4.7[14]</td></tr>
<tr><td>(5) Hose and hose connections</td><td>Applicable ASME B31 codes, CSA HGV 4.2[15]</td></tr>
</table>
</td><td></td></tr>
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Section	Requirement 2011	Requirement 2016	Narrative	Required References
			(6) Vehicle fueling connections (nozzle): SAE J2600 (7) Electrical equipment used with GH_2 systems: NFPA 70, NFPA 79 (8) *Gas detection* equipment and alarms: See NFPA 2, Section 6.12 (9) Hydrogen dispensers: CSA HGV 4.1,[16] CSA 4.3[17] (10) Pressure switches: ASME B31, NFPA 70, NFPA 79 (11) Flow meters: ASME B31, NFPA 70, NFPA 79	
10.3.1.3 Design and Construction of Containers, Cylinders and Tanks				
	Containers, *cylinders*, and *tanks* manufactured prior to the effective date of this code shall be permitted to be used in GH_2 service if designated for GH_2 service by the *container* manufacturer or if *approved* by the *AHJ*. [52:5.3.1.4]		This requirement has been deleted from the 2016 Edition of NFPA 2. The hydrogen industry has successfully built, installed, and used *containers*, *cylinders*, and *tanks* in hydrogen service prior to the issuance of this code. These vessels are often used to supply numerous applications and are not dedicated for use at hydrogen fueling stations. If these storage vessels met industry standards for hydrogen service at their time of manufacture, they should be acceptable for use. Existing installations can continue to be used unless it is determined under the requirements of Section 1.4.2 that the existing system presents an unacceptable degree of risk.	
10.3.1.8 Hose and Hose Connections				
10.3.1.8.5.3	The hose shall be *approved* or *listed* for hydrogen service. [52:9.9.4]		Incidents in the field have shown that hoses present a significant vulnerability in the fuel dispensing system. Special attention needs to be given to the appropriateness of the hose material of construction and the testing with hydrogen under the pressure and temperature conditions anticipated in use.	

Section	Requirement 2011	Requirement 2016	Narrative	Required References
			No hoses have yet been manufactured or tested to a *listing* standard. Hoses have been used in industry applications and at hydrogen fueling stations for many years. It is anticipated that ISO 19880-5[18] and CSA 4.2[15] will be revised in the near future. These documents may be considered in the *approval* process Detailed requirements for hoses are now provided in Section 10.3.1.8 of the 2016 Edition of NFPA 2.	
10.3.1.9 Valves				
10.3.1.9.1		All system components shall be *listed* or *approved* for the hydrogen service pressures, internal and external temperatures, and operating environment of the hydrogen dispensing system.	The use of the term "all" implies that the requirement is a general requirement applicable to any component in a system; however, it is a subsection of 10.3.1.9, which is pertinent to valves. The term "all system components" could be interpreted as "all system valves" as valves are the explicit components regulated by this section of the code. The application of this section of the code to elements other than valves would not be appropriate. Valves that are components of a hydrogen *piping system* are regulated by the codes and standards used to design the *piping system*.	
10.3.1.14 Vehicle Fueling Dispenser System Operation				
10.3.1.14.5	Where an overpressure incident that results in operation of the overpressure protection system occurs, the dispenser pressure control system shall be examined and *certified* by a qualified technician prior to	**10.3.1.13.4** Where an overpressure incident that results in operation of the overpressure protection system occurs, the dispenser pressure control system shall be examined and *certified* by a qualified technician prior to	The dispenser pressure control system should prevent the actuation of the overpressure protection system. If the protection system was actuated, it may also indicate a fault within the dispenser pressure control system. An inspection is required by a qualified and experienced technician to validate that the system is undamaged and functional prior to further use. The examination and *certification* by the technician is subject to review by the *AHJ* upon request. See the definition of *qualified individual* and *qualified person* in Chapter 3 of this guide.	

Section	Requirement 2011	Requirement 2016	Narrative	Required References
	being returned to service. [52:9.14.4]	being returned to service.		
10.3.1.14 Vehicle Fueling Connection				
10.3.1.15.1	*Fueling nozzles* for GH_2 service shall be *listed* or *approved* in accordance with SAE J2600, *Compressed Hydrogen Surface Refueling Connection Devices*. [52:5.11.1]	**10.3.1.14.1** *Fueling nozzles* for GH_2 service shall be *listed* or *approved* in accordance with SAE J2600, *Compressed Hydrogen Surface Refueling Connection Devices*.	SAE J2600[19] provides performance requirements for *fueling nozzle*s and receptacles. It also specifies the geometry required for the proper mating of the fuel station nozzle with the vehicle receptacle. Improper dimensions of these devices could lead to hydrogen leakage and/or serious safety consequences. It is also critical that: 1) the receptacle on a vehicle match the pressure classification of the onboard vehicle tank, and 2) the nozzle on the station match the pressure classification of dispensing pressure. Nozzles and receptacles are designed such that a higher pressure nozzle cannot be attached to a lower pressure receptacle. Proper selection and installation of the nozzles and receptacles is required to ensure that vehicle tanks are not filled to pressures that exceed their design.	
10.3.1.15 Installation of Electrical Equipment				
10.3.1.15.2.1	New requirement	Modifications shall be *approved* by a qualified engineer with expertise in fire safety and gaseous fuels.	As stated in Section 10.2.1.1 of NFPA 2, proof of *certification* can be in the form of a signed drawing or signed letter describing the design and operation of the system and demonstrating its compliance to this code. A *qualified* engineer is one who is knowledgeable and experienced in the subject matter. A *qualified individual* is one knowledgeable in the hazards of *compressed gases* and *cryogenic fluids* through training and work experience.	
10.3.1.15.4.1	New requirement	*Listed* dispensers shall be permitted to be installed using classified areas in accordance with the terms of the *listing*.	The requirements of the *listing* should be referred to in determining whether a dispenser may be used in an electrically classified area.	

Section	Requirement 2011	Requirement 2016	Narrative	Required References
10.3.2.3.1 General.				
10.3.2.3.1.3*	[Fueling Pads] The vehicle fueling pad shall be of concrete or a material having a resistivity not exceeding 1 megohm as determined by an *approved* method [unless the vehicle is grounded by other means such as a grounding cable]. [52:9.13.3.2]	The vehicle fueling pad shall be of concrete or a material having a resistivity not exceeding 1 megohm as determined by an *approved* method unless the vehicle is grounded by other means, such as a grounding cable.	The 2011 Edition of NFPA 2, Section 10.3.1.17.3, requires that vehicles be fueled on a fueling pad, which is provided to eliminate potential sources of ignition caused by static spark or similar initiating forces. Although there are basic requirements to have a fueling pad when LH_2 is being fueled, there is no basic requirement for a fueling pad for GH_2 fueling in the 2016 Edition of the code. When a fueling pad is provided, the resistivity of the vehicle fueling pad should be below 1 megohm to ensure that the vehicle is properly grounded prior to fueling activity. An example of an *approved* method to measure the resistivity is an electrician using a megger to verify that the resistivity is less than 1 megohm under normal fueling conditions. Humid air and surface moisture will reduce the fuel pad resistivity compared to what would be expected on cool dry days. Therefore, tests conducted during relatively cool and dry ambient conditions would be most useful for verifying that the pad resistivity is less than 1 megohm over a wide range of local ambient conditions.	
10.3.1.18*	**Fire Protection**. A portable fire extinguisher having a rating of not less than 20-B:C shall be provided at the dispensing area in *approved* locations not more than 50 ft (15.2 m) away from the dispensing area. [52:9.15] Fire extinguishers shall be inspected and maintained according to NFPA 10, *Standard for Portable Fire Extinguishers* [52:9.15.1]	**Fire Protection**. A portable fire extinguisher having a rating of not less than 20-B:C shall be provided at the dispensing area in *approved* locations not more than 50 ft (15.2 m) away from the dispensing area. Fire extinguishers shall be inspected and maintained according to NFPA 10.	Fire extinguishers should be installed in an area that is visible and accessible within the 50 ft radius described by the requirement.	

Section	Requirement 2011	Requirement 2016	Narrative	Required References
10.3.2.2 Indoor Nonpublic Fueling.				
10.3.3.2.2.10	[Gas Detection] (A) The *gas detection system* shall be *certified* by a qualified engineer with expertise in fire safety and gaseous detection. [52:9.3.3.6.1]	(A) The *gas detection system* shall be *certified* by a qualified engineer with expertise in fire safety and gaseous detection.	Proof of *certification* can be in the form of a signed drawing or signed letter describing the design and operation of the system and demonstrating its compliance to this code. A *qualified* engineer is one who is knowledgeable and experienced in the subject matter. A *qualified individual* is one knowledgeable in the hazards of *compressed gases* and *cryogenic fluids* through training and work experience. See also *qualified person* as defined by Chapter 3 of this guide.	
10.3.3.2.3 Indoor Nonpublic Fast Fill Fueling				
10.3.3.2.3.2(B)	[Ventilation] (I) The dispensing area shall be inspected annually and *certified* in accordance with 10.2.1.1.1. [52:9.4.3.2.8]	(8) The dispensing area shall be inspected annually and *certified* in accordance with 10.21.1.	There is an editorial error in the code in the section referenced. The correct reference is 10.2.1.1. Inspections by a qualified engineer are required because dispensing areas are subject to change. For example, storage of unsuitable materials or the installation of unclassified electrical equipment may occur after the original installation without understanding their impact. The annual inspection of the dispensing area is conducted to ensure that changes to the facility do not violate the original installation requirements and that any modifications to the facility comply the requirements of the adopted code.	
10.3.3.2.3.7	**Dispensing Equipment**. Gas dispensing equipment shall be *listed* or *approved* for indoor use. [52:9.4.7]	**Dispensing Equipment**. Gas dispensing equipment shall be *listed* or *approved* for indoor use.	To be *approved*, indoor dispensers should be in accordance with Sections 10.3.3.2.2.7(A) through (J). Section (F) leads the user to Table 10.3.1.15.1 for requirements for electrical classification. In turn, the table refers the user to Section 10.3.3.2.2.3 for requirements regarding the point of transfer. The section referenced contains an editorial error. The correct reference is 10.3.3.2.3.3.	

Section	Requirement 2011	Requirement 2016	Narrative	Required References
10.3.3.3.5 Outdoor Nonpublic Refueling from Transport Vehicles				
10.3.3.3.5.2	(J) The dispensing hose shall be properly placed on an *approved* reel or in an *approved* compartment before moving the transport vehicle. [52:9.19.11]	(J) The dispensing hose shall be properly placed on an *approved* reel or in an *approved* compartment before moving the transport vehicle.	The dispenser hose can be subject to damage if not properly stored. To be *approved*, reels or hose compartments should be evaluated to ensure that use of the reel and storage of the hose will not subject the hose to damage due to cuts or abrasion as a result of operation.	

Chapter 11 LH_2 Fueling Facilities

Section	Requirement 2011	Requirement 2016	Narrative	Required References
11.2.12 Electrical Equipment				
11.2.12.5	A primary seal shall be provided between the flammable fluid system and the electrical conduit wiring system. If the failure of the primary seal would allow the passage of flammable fluids to another portion of the conduit or wiring system, an additional *approved* seal, barrier, or other means shall be provided to prevent the passage of the flammable fluid beyond the additional device or means in the event that the primary seal fails.	A primary seal shall be provided between the flammable fluid system and the electrical conduit wiring system. If the failure of the primary seal would allow the passage of flammable fluids to another portion of the conduit or wiring system, an additional *approved* seal, barrier, or other means shall be provided to prevent the passage of the flammable fluid beyond the additional device or means in the event that the primary seal fails.	When secondary seals are provided, they should meet the pressure and temperature requirements of the conditions to which they may be exposed in the event of failure of the primary seal. See Section 11.2.14.7. The reasoning for the *approval* of the secondary seal is not clear. A redundant conduit seal is required as a backup to the primary conduit seal where liquid or gas can migrate to the conduit system.	

Section	Requirement 2011	Requirement 2016	Narrative	Required References
	[52:14.14.7]			
11.2.12.7	Each additional seal or barrier and interconnecting enclosure shall meet the pressure and temperature requirements of the condition to which it could be exposed in the event of failure of the primary seal, unless other *approved* means are provided to accomplish this purpose. [52:14.14.7.2]	Each additional seal or barrier and interconnecting enclosure shall meet the pressure and temperature requirements of the condition to which it could be exposed in the event of failure of the primary seal, unless other *approved* means are provided to accomplish this purpose.	Additional seals or barriers should be designed to prevent the passage of flammable fluids or gases through the conduit, stranded conductors, or cables. See Section 11.2.14.4. The reasoning for the *approval* of the secondary seal is not clear. A redundant conduit seal is required as a backup to the primary conduit seal where liquid or gas can migrate to the conduit system.	
11.2.12.8	Unless specifically designed and *approved* for the purpose, the seals specified in 11.2.14.5 through 11.2.14.9 are not intended to replace the conduit seals required by 501.15(A) through 501.15(D) of NFPA 70, National Electrical Code. [52:14.14.8]	Unless specifically designed and *approved* for the purpose, the seals specified in 11.2.12.5 through 11.2.12.9 are not intended to replace the conduit seals required by 501.15(A) through 501.15(D) of NFPA 70.	The reasoning for the *approval* of the secondary seal is not clear. A redundant conduit seal is required as a backup to the primary conduit seal where liquid or gas can migrate to the conduit system.	
11.3 Dispensing				
11.3.1.1	**System Component Qualifications**. The following systems and system components shall be *listed* or *approved*: [52:5.2.1] (1) *Pressure relief devices*, including pressure relief valves [52:5.2.1(1)] (2) Pressure gauges	**System Component Qualifications**. The following systems and system components shall be *listed* or *approved*: (1) *Pressure relief devices*, including pressure relief valves (2) Pressure gauges	There are no *listed* components available in a number of the categories included from which a system designer may choose. In lieu of *listing*, good engineering judgement by the system designer must be considered, and industrial codes and standards, such as the ASME B31 codes, can be used to guide the design. Components that are not *listed* will require *approval* by the *AHJ*. The lack of pursuit to acquire a *listing* for hydrogen fueling station equipment and fuel cell industrial trucks may be due to one or more	

<table>
<tr><th>Section</th><th>Requirement 2011</th><th>Requirement 2016</th><th>Narrative</th><th>Required References</th></tr>
<tr><td></td><td>[52:5.2.1(2)]
(3) Pressure regulators [52:5.2.1(3)]
(4) Valves [52:5.2.1(4)]
(5) Hose and hose connections [52:5.2.1(5)]
(6) Vehicle fueling connections (nozzle) [52:5.2.1(6)]
(7) Electrical equipment used with [LH_2] systems [52:5.2.1(8)]
(8) Gas detection equipment and alarms [52:5.2.1(9)]
(9) Hydrogen dispensers [52:5.2.1(10)]
(10) Pressure switches [52:5.2.1(12)]
(11) Flow meters [52:5.2.1(13)]</td><td>(3) Pressure regulators
(4) Valves
(5) Hose and hose connections
(6) Vehicle fueling connections (nozzle)
(7) Electrical equipment used with [LH_2] systems
(8) Gas detection equipment and alarms
(9) Hydrogen dispensers
(10) Pressure switches
(11) Flow meters</td><td>factors: (1) reservations on the part of the equipment manufacturers about the listing standards, (2) business decisions based on the size of the potential and emerging user market, and (3) the cost of authorizing the listing organization, in an early market, to conduct a full listing evaluation requiring many types of tests. As the hydrogen equipment markets continue to grow and mature, one can envision evolving listing standards and practices and the successful pursuit of more listings by equipment manufacturers.

The table below gives a representative sample of the codes and standards that may be applied in the approval process:
<table>
<tr><th>Item</th><th>Documents that May Be Considered in the Approval Process</th></tr>
<tr><td>(1) Pressure relief devices, including PRVs</td><td>• ASME pressure vessels: ASME Boiler and Pressure Vessel Code
• DOT containers: CFR Title 49 DOT regulations.
• Relief devices for piping systems: ASME B31.</td></tr>
<tr><td>(2) Pressure gauges</td><td>ASME B31</td></tr>
<tr><td>(3) Pressure regulators</td><td>ASME B31</td></tr>
<tr><td>(4) Valves</td><td>ASME B31, CSA HGV 4.6,[13] CSA HGV 4.7[14]</td></tr>
<tr><td>(5) Hose and hose connections</td><td>ASME B31, CSA HGV 4.2[20]</td></tr>
<tr><td>(6) Vehicle fueling connections (nozzle)</td><td>SAE J2600</td></tr>
<tr><td>(7) Electrical equipment used with GH_2 systems</td><td>NFPA 70, NFPA 79</td></tr>
<tr><td>(8) Gas detection equipment and alarms</td><td>See Section 6.12</td></tr>
</table></td><td></td></tr>
</table>

Section	Requirement 2011	Requirement 2016	Narrative	Required References
			(9) Hydrogen dispensers: CSA HGV 4.1,[16] CSA 4.3[17] (10) Pressure switches: ASME B31, NFPA 70, NFPA 79 (11) Flow meters: ASME B31, NFPA 70, NFPA 79	
11.3.1.3.3*	*Containers, cylinders*, and *tanks* manufactured prior to the effective date of this code shall be permitted to be used in [LH_2] service if designated for [LH_2] service by the *container* manufacturer or if *approved* by the *AHJ*. [52:5.3.1.4]	*Containers, cylinders*, and *tanks* manufactured prior to the effective date of this code shall be permitted to be used in LH_2 service if designated for LH_2 service by the *container* manufacturer or if *approved* by the *AHJ*.	The hydrogen industry has successfully built, installed, and used *containers*, *cylinders*, and *tanks* in hydrogen service prior to the issuance of this code. These vessels are often used to supply numerous applications and are not dedicated solely for use at hydrogen fueling stations. Storage vessels that met industry standards for hydrogen service at the time of manufacture should be acceptable for use. For additional information, see CGA H-5,[21] referenced by NFPA 2 Section M.1.2.6. The current standards of design are found in CGA H-3[22] as referenced by CGA H-5.	ANSI/CGA H-5, *Standard for Bulk Hydrogen Supply Systems - 2014 Edition.*
11.3.1.6 Hose and Hose Connections				
11.3.1.6.5.3	The hose shall be *approved* or *listed* for hydrogen service. [52:9.9.4]	The hose shall be *approved* or *listed* for hydrogen service.	See the discussion in Section 11.3.1.1 (item 5).	
11.3.3.4 Outdoor Public Unattended Self Service Fueling				
11.3.3.4.1	Unattended self-service facilities shall be permitted, where *approved* by the *authority having jurisdiction*. [30A:9.5.1]	Unattended self-service facilities shall be permitted, where *approved* by the *authority having jurisdiction*. [30A:9.5.1]	An *unattended self-service motor fuel dispensing facility* for the dispensing of liquid hydrogen is highly specialized and should be designed by a qualified design professional or professional engineer. The design should demonstrate that sufficient safeguards are built into the system to protect the public. Additional safety features should be provided in accordance with NFPA 30A-9.5.[23]	
11.3.3.4.5	A telephone or other *approved*, clearly identified means to notify the fire department shall be provided on the site in a location *approved* by the *authority*	A telephone or other *approved*, clearly identified means to notify the fire department shall be provided on the site in a location *approved* by the *authority*	Another *approved* means could include an emergency notification system in accordance with NFPA 72.[24] The location of the communication device is intended to be at or near the fueling station but away from the dispenser.	

Section	Requirement 2011	Requirement 2016	Narrative	Required References
	having jurisdiction. [30A:9.5.5]	*having jurisdiction*. [30A:9.5.5]		
11.3.3.4.7*	Emergency controls as specified in [NFPA 70, *National Electrical Code*,] shall be installed at a location acceptable to the *authority having jurisdiction*, but the control shall be more than 20 ft (6 m) but less than 100 ft (30 m) from the dispensers. Additional emergency controls shall be installed on each group of dispensers or the outdoor equipment used to control the dispensers. Emergency controls shall shut off all power to all dispensing equipment at the station. Controls shall be manually reset only in a manner *approved* by the *authority having jurisdiction*. [70:514.11(C)]	Emergency controls as specified in [NFPA 70] shall be installed at a location acceptable to the *authority having jurisdiction*, but the control shall be more than 20 ft (6 m) but less than 100 ft (30 m) from the dispensers. Additional emergency controls shall be installed on each group of dispensers or the outdoor equipment used to control the dispensers. Emergency controls shall shut off all power to all dispensing equipment at the station. Controls shall be manually reset only in a manner *approved* by the *authority having jurisdiction*. [70:514.11 (C)]	See NFPA 70, Article 514, Motor Fuel Dispensing Facilities, for additional details on the requirements for circuit disconnects under Article 514.11(A). The system should have features to prevent the automatic restart of the system after an emergency control is actuated. In order to *approve* the operation used to reset the controls, the *AHJ* may require as a minimum that 1) the operator determine the cause of the initial emergency actuation, and 2) that a procedure is in place to validate that the system is undamaged and functional.	
11.3.4 Outdoor Nonpublic Fueling				
11.3.4.6.8	The transport vehicles shall be positioned with respect to vehicles being fueled to prevent traffic from driving over the delivery hose and between the transport	The transport vehicles shall be positioned with respect to vehicles being fueled to prevent traffic from driving over the delivery hose and between the transport	The dispenser hose can be subject to damage if not properly stored. To be *approved*, reels or hose compartments should be evaluated to ensure that use of the reel and storage of the hose will not subject the hose to damage due to cuts or abrasion as a result of operation.	

Section	Requirement 2011	Requirement 2016	Narrative	Required References
	vehicle and the motor vehicle being fueled. The dispensing hose shall be properly placed on an *approved* reel or in an *approved* compartment before the transport vehicle is moved. [52:14.17.8]	vehicle and the motor vehicle being fueled. The dispensing hose shall be properly placed on an *approved* reel or in an *approved* compartment before the transport vehicle is moved.		

Chapter 12 Hydrogen Fuel Cell Power Systems

Section	Requirement 2011	Requirement 2016	Narrative	Required References
12.2.1 Listed and Approved Equipment				
12.2.1.1		*Listed* and *approved* hydrogen fuel cell equipment shall be installed in accordance with the *listing* requirements and manufacturers' instructions.	No special consideration is necessary when the design is coordinated with the requirements described in the referenced provision. Following the prescriptive requirements as published should result in *approval* of the proposed design.	
12.3.1.1.1 Prepackaged self-contained Fuel Cell Power Systems [853:4.2]				
12.3.1.1.1.1	Prepackaged, self-contained [stationary] *fuel cell power systems* shall be designed, tested, and *listed* in accordance with ANSI CSA FC.1, *American National Standard for Fuel Cell Power Systems.* [853:4.2.1]	Prepackaged, self-contained [stationary] *fuel cell power systems* shall be designed, tested, and *listed* in accordance with ANSI CSA FC.1, *American National Standard for Fuel Cell Power Systems.* [853:4.2.1]	ANSI/CSA FC-1 :2014, *Fuel cell technologies - Part 3-100: Stationary fuel cell power systems – Safety*, is a product standard for stationary *fuel cell power systems* intended for indoor and outdoor commercial, industrial, and residential use in electrically non-hazardous (unclassified) areas. This is the first edition where U.S. requirements have been harmonized with the identically titled IEC Standard 62282-3-100 (First Edition, 2012-02).[25] This standard provides for the design, testing, and *listing* of pre-	ANSI/CSA America FC1-2014 (IEC 62282-3-100:2012, MOD) (formerly ANSI Z21.83), *American National Standard For Fuel Cell Power Systems*

Section	Requirement 2011	Requirement 2016	Narrative	Required References
			packaged, self-contained fuel cells [stationary] *fuel cell power systems* by a *qualified certifying organization*. When this approach is taken, the *fuel cell power system* can be treated as a single unit for *certification* purposes. When this approach is not followed, further evaluation of individual components is necessary as described in the next few sections. In lieu of a *listing*, field *approval* or *certification* by a *qualified certifying organization* or qualified engineer to ANSI/CSA FC-1 may be considered as being equivalent to the specific *listing* for the purpose of *approval* by the *AHJ*. It can be useful to determine the limits of the system in terms of physical boundary and equipment covered by the system. When considering fuels, materials, designs, or construction not specifically addressed in this standard, the alternatives should be evaluated by the *listing* organization as to their ability to yield levels of safety and performance equivalent to those prescribed by this standard; see NFPA 2, Section 1.5. The scope of CSA FC-1 excludes fuel storage to facilitate equipment siting. Where a fuel cell power plant includes hydrogen storage, Section 12.4 and Chapter 7 of NFPA 2 will apply unless the *listing* for the equipment includes storage. A third-party report explaining the basis for the *listing* relative to the fuel storage may be helpful in expediting the *approval* process by the *AHJ*. The product standard requires the inclusion of installation manuals and documents. *Approval* should also consider compliance to manufacturer's instructions. Maintenance manuals and documents should also be provided. The *AHJ* may wish to confirm that appropriate processes are in place to ensure that the required maintenance is	

Section	Requirement 2011	Requirement 2016	Narrative	Required References
			performed and documented. There are *fuel cell power systems listed* to this standard or its predecessors. Doing so demonstrates compliance with safety and performance requirements, which otherwise need to be evaluated, as described in subsequent sections. http://fuelcellsworks.com/news/2013/10/22/fuel-cell-company-altergy-receives-ansicsa-fc1-12-certificationlisting/	
12.3.1.2 Indoor Installation of Fuel Cell Power Systems				
12.3.1.2.1.1	All *fuel cell power systems* shall be provided with a source of *ventilation*, exhaust, and makeup air in accordance with 12.3.1.2, with the exception of the following: [853:7.1.1] (1) *Listed* prepackaged or *pre-engineered and matched modular fuel cell power systems* that have a sealed, direct *ventilation* and exhaust system that is installed in accordance with the terms of the *listing* and manufacturer's installation instructions. [853:7.1.1]		No special consideration is necessary when the design is coordinated with the requirements described in the referenced provision. Following the prescriptive requirements as published should result in *approval* of the proposed design.	

Section	Requirement 2011	Requirement 2016	Narrative	Required References
12.3.2 Portable Fuel Cells				
12.3.2.1.1*	Prepackaged, self-contained portable *fuel cell power systems* shall be designed, tested, and *listed* in accordance with ANSI/CSA FC 3, *American National Standard / CSA American Standard for Portable Fuel Cell Power Systems*, or IEC 6228-1, *Portable Fuel Cell Power Systems, Safety*.	Prepackaged, self-contained portable *fuel cell power systems* shall be designed, tested, and *listed* in accordance with ANSI/CSA FC 3, *American National Standard / CSA American Standard for Portable Fuel Cell Power Systems*, or IEC 6228-1, *Portable Fuel Cell Power Systems, Safety*.	There is a typographical error in the reference to IEC 6228-1. There is no IEC 6228-1. IEC 62282-5-1 is the correct reference. The Second Edition of IEC 62282-5-1 was published on June 17, 2015,[26] but the U.S. effort to update references and re-publish ANSI/CSA FC-3 is currently on hold.[27] The CSA FC-3 TAG has not met recently, but it is still active. Either of these standards allow for pre-packaged, self-contained portable *fuel cell power systems* to be designed, tested, and *listed* by a *qualified certifying organization*. When this approach is taken, the *fuel cell power system* can be treated as a single unit for *certification* purposes. In lieu of a *listing*, field evaluation may be used to achieve a field evaluation mark or *certification* by a *qualified certifying organization* or qualified engineer to either of the above standards. The evaluation and application of a field evaluation mark may be considered as being equivalent to the specific *listing* for the purpose of *approval* by the *AHJ*. This standard applies to all AC and DC type *portable fuel cell appliances*, not exceeding 600V, for commercial, industrial, and residential indoor and outdoor use in non-*hazardous locations*. It includes moveable and hand-held equipment but does not address systems that are permanently connected, export to the grid, or for propulsion or auxiliary power for transportation. Portable *fuel cell power systems* should only be used as intended by the manufacturer, and if *approval* for installation and/or use is deemed necessary, the *approval* may also consider compliance to the manufacturer's instructions.	IEC 62282-5-1:2012, *Fuel cell technologies – Part 5-1: Portable fuel cell power systems – Safety*, International Electrotechnical Commission

Section	Requirement 2011	Requirement 2016	Narrative	Required References
12.3.3 Micro Fuel Cell Power Systems				
12.3.3.1.1	**Listed or Approved Systems**. Prepackaged, self-contained micro *fuel cell power systems* shall be *listed* or *approved* for the application.	**Listed or Approved Systems**. Prepackaged, self-contained micro *fuel cell power systems* shall be *listed* or *approved* for the application.	These systems are typically worn or hand-held. IEC 62282-6-100 (2012-10) Ed.1.1 is the current safety standard for these devices. This standard is adopted by reference in UN Model Regulations and International Civil Aviation Organization (ICAO) shipping regulations and may serve as a basis for *listing* by a *qualified certifying organization*. In lieu of a *listing*, field *approval* or *certification* by a *qualified certifying organization* or qualified engineer to IEC 62282-6-100 may be considered as being equivalent to the specific *listing* for the purpose of *approval* by the *AHJ*. These DC units power or recharge consumer electric devices and should only be used as intended by the manufacturer. If *approval* for use is deemed necessary, the *approval* may also consider compliance to manufacturer's instructions.	IEC 62282-6-100 (2012-10) Ed.1.1, *Micro Fuel Cell Power Systems – Safety,* International Electrotechnical Commission
12.4.2 Requirements for Hydrogen Storage Systems Serving Portable Fuel Cell Power Systems				
12.4.2.1.1 Fuel Cell Cartridges				
12.4.2.1.1.1	**Listed or Approved Devices**. *Fuel cell cartridges* shall be *listed* or *approved* for the application.	**Listed or Approved Devices**. *Fuel cell cartridges* shall be *listed* or *approved* for the application.	IEC 62282-5-1:2012(E) covers construction, marking, and test requirements for portable *fuel cell power systems*, including the *fuel cell cartridges*. *Fuel cell cartridges* do not literally house the electrochemical fuel cell devices that generate power, but rather store the fuel used by the fuel cell systems.	IEC 62282-5-1:2012(E), *Fuel cell technologies - Part 5-1: Portable fuel cell power systems - Safety*

Section	Requirement 2011	Requirement 2016	Narrative	Required References
			Portable *fuel cell cartridges* may be *listed* to IEC 62282-5-1. In lieu of a *listing*, field *approval* or *certification* by a *qualified certifying organization* or qualified engineer to this standard may be considered as being equivalent to the specific *listing* for the purpose of *approval* by the *AHJ*. *Fuel cell cartridges* should only be used in accordance with manufacturer's instructions. If *approval* for use is deemed necessary, the *approval* may also consider compliance to manufacturer's instructions.	IEC 62282-5-1:2012, *Fuel cell technologies – Part 5-1: Portable fuel cell power systems – Safety*, International Electrotechnical Commission
12.4.2.1.1.2	*Fuel cell cartridge* refilling equipment shall be *listed* or *approved* for the application, and refill shall be in accordance with the manufacturer's published instructions and the *listing*.	*Fuel cell cartridge* refilling equipment shall be *listed* or *approved* for the application, and refill shall be in accordance with the manufacturer's published instructions and the *listing*.	IEC 62282-5-1:2012(E) for portable fuel cell power plants including *fuel cell cartridges* does not address the design and construction of equipment used for refilling the *fuel cell cartridges*, and no other standard specifically addresses these systems from a safety standpoint. Without a specific product standard, *listing* by a *qualified certifying organization* or *approval* by the *AHJ* of refilling equipment may be based on applicable sections of general hydrogen system requirements in Chapters 6 through 8 of NFPA 2. In lieu of a *listing*, field *approval* or *certification* by *a qualified certifying organization* or qualified engineer may be considered as being equivalent to the specific *listing* for the purpose of *approval* by the *AHJ*. Portable *fuel cell cartridges* should only be refilled using equipment and methods in accordance with manufacturer's instructions. If *approval* for this process is deemed necessary, the *approval* may also consider compliance to manufacturer's instructions.	IEC 62282-5-1:2012(E) covers construction, marking and test requirements for portable *fuel cell power systems* intended to produce electrical power. Applies to AC and DC type portable *fuel cell power systems*, with a rated output voltage not exceeding 600 V AC, or 850 V DC for indoor and outdoor use. IEC 62282-5-1:2012, *Fuel cell technologies – Part 5-1: Portable fuel cell power systems – Safety*, International Electrotechnical Commission

Section	Requirement 2011	Requirement 2016	Narrative	Required References
12.4.3 Requirements for Hydrogen Storage Systems Serving Micro Fuel Cell Power Systems				
12.4.3.1.1.1	**Listed or Approved Devices**. *Fuel cell cartridges* shall be *listed* or *approved* for the application.	**Listed or Approved Devices**. *Fuel cell cartridges* shall be *listed* or *approved* for the application.	IEC 62282-6-100:2012 is the current safety standard for these devices. This standard is adopted by reference in UN Model Regulations and ICAO shipping regulations. *Fuel cell cartridges* do not literally house the electrochemical fuel cell devices that generate power, but rather store the fuel used by the fuel cell systems. *Fuel cell cartridges* should be *listed* to IEC 62282-6-100. In lieu of a *listing*, field *approval* or *certification* by a *qualified certifying organization* or qualified engineer to this standard may be considered as being equivalent to the specific *listing* for the purpose of *approval* by the *AHJ*. *Fuel cell cartridges* should only be used in accordance with manufacturer's instructions. If *approval* for use is deemed necessary, the *approval* may also consider compliance to manufacturer's instructions.	IEC 62282-6-100:2010, *Fuel cell technologies – Part 6-100: Micro fuel cell power systems - Safety*, International Electrotechnical Commission
12.4.3.1.1.2	*Fuel cell cartridge* refilling equipment shall be *listed* or *approved* for the application, and refill shall be in accordance with the manufacturer's published instructions and the *listing*.	*Fuel cell cartridge* refilling equipment shall be *listed* or *approved* for the application, and refill shall be in accordance with the manufacturer's published instructions and the *listing*.	IEC 62282-6-100:2012 for micro *fuel cell power system* addresses the *fuel cell cartridges* but not the design and construction of equipment used for refilling the *fuel cell cartridges*, and no other standard specifically addresses these systems. Without a specific product standard, *listing* or *approval* by the *AHJ* of refilling equipment should be based on applicable sections of general hydrogen system requirements in Chapters 6 through 8 of NFPA 2. In lieu of a *listing*, field *approval* or *certification* by *a qualified certifying organization* or qualified engineer may be considered as being	IEC 62282-6-100:2010, *Fuel cell technologies – Part 6-100: Micro fuel cell power systems - Safety*, International Electrotechnical Commission

Section	Requirement 2011	Requirement 2016	Narrative	Required References
			equivalent to the specific *listing* for the purpose of *approval* by the *AHJ*. *Fuel cell cartridge* refilling equipment should only be refilled using equipment and methods in accordance with manufacturer's instructions. If *approval* for this process is deemed necessary, the *approval* may consider compliance to manufacturer's instructions.	

Chapter 13 Hydrogen Generation Systems

Section	Requirement 2011	Requirement 2016	Narrative	Required References
13.2 General				
13.2.1* Listed or Approved Equipment				
13.2.1.1*	*Listed* and *approved* hydrogen-generating equipment shall be [installed] in accordance with the *listing* requirements and manufacturers' instructions. [55:12.3.1.1]	*Listed* or *approved* hydrogen-generating equipment shall be installed in accordance with the *listing* or *approval* requirements and manufacturers' instructions.	A consensus standard for hydrogen generators using fuel processing technologies is ISO 16110-1, *Hydrogen generators using fuel processing technologies- Part 1: Safety*. It may be used by a *listing* organization in the creating of a *listing* standard. For generators using water electrolysis see the comments on Section 13.3.1.1.1 below. In lieu of a *listing*, field *approval* or *certification* by a *qualified certifying organization* or qualified engineer may be considered as being equivalent to the specific *listing* for the purpose of *approval* by the *AHJ*. Hydrogen generators should only be used in accordance with manufacturer's instructions. If *approval* for use is deemed necessary, the *approval* may also consider compliance to manufacturer's instructions.	ISO 16110-1:2007, *Hydrogen generators using fuel processing technologies – Part 1: Safety,* International Organization for Standardization
13.2.3	Fuel processing equipment integral to *listed* fuel cell [power system] *appliances* installed in accordance with NFPA 853, *Standard for the Installation of Stationary Fuel*	**Integral Fuel Processing Equipment.** Fuel processing equipment integral to *listed fuel cell power system appliances* installed in accordance with NFPA 853,	The text extracted from the 2013 Edition of NFPA 55 served as the basis for requirements and *approval* was achieved as part of the overall stationary *fuel cell power system approval* for a *listed* system. The requirements for the 2016 Edition of NFPA 2 are no longer extracted as NFPA 55 was revised to eliminate requirements for gas generation systems, reserving a section for *flammable gases* yet to be	

Section	Requirement 2011	Requirement 2016	Narrative	Required References
	Cell Power Systems, shall not be required to meet [the requirements of this chapter]. [55:12.3.2.3]	*Standard for the Installation of Stationary Fuel Cell Power Systems*, shall not be required to meet the requirements of this chapter.	developed. Equipment installed integral to *listed* equipment should be addressed by the *listing*. If not, the requirements of Chapter 7 will apply.	
13.3.1 Electrolyzers				
13.3.1.1.2*	Electrolyzers shall be tested and *approved* in accordance with ISO/DIS 22734-1, *Hydrogen generators using water electrolysis process — Part 1: Industrial and commercial applications*. [55:12.3.2.7.1]	**Product Standards.** Water electrolyzers shall be *listed* or *approved* for their use.	ISO/DIS 22734-1 was a Draft International Standard (DIS) when it was adopted into the 2011 Edition of NFPA 2. The first edition of the completed standard was published in 2008 as ISO 22734-1. The *AHJ* may accept the use of a more current document if requested by the permittee. The *AHJ* may ask the permittee to relate or explain any differences between the published version of the standard and the draft. ISO 22734-2:2012 has been published to extend coverage to *appliances* in residential applications.[28] Either of these standards may be used by a *listing* organization in the creating of a *listing* standard (depending on the target application). In lieu of a *listing*, field *approval* or *certification* by a *qualified certifying organization* or qualified engineer may be considered as being equivalent to the specific *listing* for the purpose of *approval* by the *AHJ*. Hydrogen generators (electrolyzers) should only be operated or used in accordance with the manufacturer's instructions. If *approval* for use is deemed necessary, the *approval* may also consider compliance to manufacturer's instructions.	ISO 22734-1:2008*, Hydrogen generators using water electrolysis process - Part 1: Industrial and commercial applications*, International Organization for Standardization

Section	Requirement 2011	Requirement 2016	Narrative	Required References
13.3.2 Catalytic Reforming-Based Hydrogen Generation Systems				
13.3.2.1.2 Fire Protection for Catalytic Reforming Based Hydrogen Generation Systems				
13.3.2.1.2(2)	Where installed in a room containing a catalytic *reformer* system, the location of the detector shall be *approved*. [55:12.3.2.8.6(2)]	Where installed in a room containing a catalytic *reformer* system, the location of the detector shall be *approved*.	See also 13.3.2.1.2(1). The detector referenced is a carbon monoxide detector. In addition to meeting requirements of NFPA 853, when the hydrogen-generating equipment is installed in a room containing a catalytic *reformer* system, the location of the carbon monoxide detector should be *approved* based on a determination that the detector will perform adequately in the selected location based on manufacturer's instruction.	NFPA 72, *National Fire Alarm and Signaling Code,* 2013 Edition
13.3.2.2.1.2	Electrical and *piping* penetrations and joints associated with the room shall be sealed with *approved* materials that have a 1-hour fire resistance rating. [55:12.3.2.8.3.4]	Electrical and *piping* penetrations and joints associated with the room shall be sealed with *approved* materials that have a 1-hour fire resistance rating.	Refer to the building code for specific requirements relative to fire stopping. For this type of product, there are many *listed* products that are appropriate for the application. A *listed* product should be used. See also NFPA 2, Section 4.1.1.	

Chapter 15 Special Atmosphere Applications

Section	Requirement 2011	Requirement 2016	Narrative	Required References
15.3.1.1.2	Before new equipment is installed or existing equipment is remodeled, complete plans, sequence of operations and specifications shall be submitted for *approval* to the *authority having jurisdiction*. [86:4.1.1]	Before new equipment is installed or existing equipment is remodeled, complete plans, sequence of operations and specifications shall be submitted for *approval* to the *authority having jurisdiction*. [86:4.1.1]	*AHJ approval.* Sections 15.3.1.1.2.1 and 15.3.1.1.2.2 provide the basis for *approval.* Documentation should be provided showing how the equipment, *piping*, and electrical systems comply with the requirements in the pertinent paragraphs in Section 15.3.1 for hydrogen atmosphere furnaces, as well as the NFPA 86 requirements cited in those paragraphs. In the case of a submittal for remodeled furnace equipment, the *approval* submittal should also include a Management of Change section documenting the changes from the original installation and the expected safety impact of each change.	
15.3.1.1.2.3	Any deviation from this code shall require special permission from the *authority having jurisdiction*. [86:4.1.2]	Any deviation from this code shall require *approval* from the *authority having jurisdiction*. [**86:**4.1.2]	Users are advised that deviations should be in writing so that the record and reason for the deviation is clear. Without such documentation, the basis for deviation is likely to be lost over time, raising the possibility of a future inspection requiring a correction for compliance for an item previously believed to have been resolved. *Approval* of a permit in and of itself with or without documentation in support of the design does not grant authority for non-compliance. Deviations and rationale can be made a matter of record in facilities files by including them in the plans required by Section 15.3.1.1.2.	
15.3.1.1.11.1	**Furnace Safety Components**. All *safety devices* shall meet one of the following criteria: [86:8.2.1] (1) Be *listed* for the service intended [86:8.2.1(1)] (2) Be *approved* if *listed* devices are not available [86:8.2.1(2)] (3) Be programmable [logic] controllers applied in		A ***Safety Device*** *[Furnaces]* is defined in NFPA 2 and 86 as 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. Examples include furnace combustion flame sensors and interlocks, *pressure relief devices*, and excess temperature sensors and shutdown control circuits. The *listing* option (1) requires the *safety device* to be *listed* by one of the *listing* organizations acceptable to the *AHJ*. The *approved* option (2) involves the *AHJ* determining that the *safety device* is acceptable for use in the subject oven. The programmable logic controller (PLC) *safety*	NFPA 86, *Standard for Ovens and Furnaces*, 2011 Edition, National Fire Protection Association

Section	Requirement 2011	Requirement 2016	Narrative	Required References
	accordance with 8.3.3 of NFPA 86 [86:8.2.1(3)]		*device* option (3) requires, among other things, that the PLC be able to detect input and output communication failures and to initiate safe shutdown within 3 seconds of such failures. The 2015 Edition of NFPA 86 covers PLC requirements in Section 8.4. The requirements for this section have been deleted from the 2016 Edition of NFPA 2. However, Section 15.3.1.1.1.2 of NFPA 2 requires compliance with NFPA 86, and the requirements remain in NFPA 86 in a similar form in Sections 8.2.1, 8.2.2, and 8.2.4.	
15.3.1.1.6.7	The effluents from relief valves used to protect control unit components containing flammable or toxic fluids shall be piped to an *approved* disposal location. [86:13.5.8.9]	The effluents from relief valves used to protect control unit components containing flammable or toxic fluids shall be piped to an *approved* disposal location. [86:13.5.8.9]	This requirement refers to the PRVs for the furnace atmosphere gas and for inert gas *piping* used for *purging* the furnace. The *AHJ* should verify that the PRV does not discharge into occupied areas or, in the case of hydrogen and other *flammable gas* PRVs, into locations with ignition sources in the path of the discharged gas. Although not required by the provisions of Chapter 15, the use of CGA G-5.5, *Hydrogen Vent Systems,* provides additional guidance on hydrogen PRV discharge design; also see NFPA 2, Section 6.16.	CGA G-5.5, *Hydrogen Vent Systems*, 3rd Edition, Compressed Gas Association, 2014.
15.3.1.1.6.8	Alternative valves meeting the following criteria shall be provided for manually shutting off the flow of flammable fluids into a furnace: [86:13.5.8.10] (1) They shall be separate from the atmosphere control unit. [**86:**13.5.8.10(1)] (2) They shall be accessible to operators. [**86:**13.5.8.10(2)] (3) They shall be located remotely from the furnace and control unit. [**86:**13.5.8.10(3)]	Alternative valves meeting the following criteria shall be provided for manually shutting off the flow of flammable fluids into a furnace: [86:13.5.8.10] (1) They shall be separate from the atmosphere control unit. [**86:**13.5.8.10(1)] (2) They shall be accessible to operators. [**86:**13.5.8.10(2)] (3) They shall be located remotely from the furnace and control unit. [**86:**13.5.8.10(3)]	The *approval* option for these valves involves the *AHJ* determining that the valves have some acceptable level of reliability and effectiveness in achieving complete shutoff of the hydrogen flow, including their suitability for service at the hydrogen gas supply pressure to the furnace. For additional information on reliability see the ISA references in Appendix A.2	

Section	Requirement 2011	Requirement 2016	Narrative	Required References
	(4) They shall be *listed* or *approved* for the service.	(4) They shall be *listed* or *approved* for the service.		
Protective Equipment for Type I Furnaces				
15.3.1.2.3	(6) Pilots at outer doors meeting the following criteria: (a) One pilot at each outer door shall be supervised with an *approved* combustion safeguard interlocked to prevent automatic opening of the vestibule door, shut off fuel gas to the curtain burners (if provided), and alert the operator. (b) Pilots shall be of the type that remain lit when subjected to an inert or indeterminate atmosphere.		The combustion safeguard is intended to verify the existence of the pilot flame and take the designated actions upon loss of pilot flame. The *AHJ approval* could be based on a *listing* of the pilot flame sensor, or upon some other consideration of sensor reliability and effectiveness for this application, i.e., for this particular pilot flame. For additional information on reliability and effectiveness, see the informational references from ISA 84 in Appendix A.2 regarding reliability.[29] The provisions have been deleted from the 2016 Edition of NFPA 2. Section 15.3.1.1.1.2 of NFPA 2 requires compliance with NFPA 86. Refer to NFPA 86, 2015 Edition, Chapter 13, for detailed requirements.	

Chapter 16 Laboratory Operations

Section	Requirement 2011	Requirement 2016	Narrative	Required References
Standpipe and Hose Systems				
16.2.3.3.3	Hose lines shall be of an *approved* type and shall be tested and maintained in accordance with NFPA 1962, *Standard for the Inspection, Care, and Use of Fire Hose, Couplings, and Nozzles and*		The hose lines should be compatible with equipment used by the jurisdiction. Hose lines, when provided, are used by emergency responders. Consistency in equipment familiar to the emergency responders is an important aspect of the overall scheme of protection. The provisions have been deleted from the 2016 Edition of NFPA 2. The provisions of the building code and fire prevention code adopted by the jurisdiction relative to requirements for standpipes will establish	

Section	Requirement 2011	Requirement 2016	Narrative	Required References
	the Service Testing of Fire Hose. [45:6.3.3]		requirements, if any.	
16.3 Use				
Exhausters (Fans), Controls, Velocities, and Discharge				
16.3.2.1.6.5	Motors and their controls shall be located outside the location where [GH_2] is generated or conveyed, unless specifically *approved* for that location and use. [45:8.7.5]	Motors and their controls shall be located outside the location where [GH_2] is generated or conveyed, unless specifically *approved* for that location and use. [45:7.7.5]	Electrical equipment serving an exhaust system where hydrogen is generated or conveyed should meet the requirements of NFPA 70, *National Electrical Code,* provisions for hazardous (classified) locations.	
Analytical Instruments				
16.3.2.2.2.4	(B) Analytical instruments shall be operated in accordance with manufacturers' instructions or *approved* recommended operating procedures. [45:12.2.6.2]	(B) Analytical instruments shall be operated in accordance with manufacturers' instructions or *approved* recommended operating procedures. [45:11.3.6.2]	If manufacturer's instructions are not available or are not applicable to the laboratory operations, operating procedures should provide for safe operation of the unit through all expected activities and conditions.	
16.3.2.3.2	**Identification Systems**. Graphic systems used to identify hazards shall comply with ANSI Z535.1, *Safety Color Code*; ANSI Z535.2, *Environmental and Facility Safety Signs*; ANSI Z535.3, *Criteria for Safety Symbols*; and ANSI Z535.4, *Product Safety Signs and Labels*; or	**Identification Systems**. Graphic systems used to identify hazards shall comply with ANSI Z535.1, *Safety Color Code*; ANSI Z535.2, *Environmental and Facility Safety Signs*; ANSI Z535.3, *Criteria for Safety Symbols*; and ANSI Z535.4, *Product Safety Signs and Labels*; or	Graphic systems should provide hazard information consistent with what is typically deemed necessary and appropriate for the jurisdiction.	

Section	Requirement 2011	Requirement 2016	Narrative	Required References
	other *approved* graphic systems. [45:13.4]	other *approved* graphic systems. [45:13.5]		

Chapter 17 Parking Garages

Section	Requirement 2011	Requirement 2016	Narrative	Required References
17.1.2		Storage or use of GH_2 or LH_2 other than within the fuel and propulsion systems of vehicles being stored shall not be allowed unless specifically *approved* by the *AHJ*.	Section 17.1 of NFPA 2 applies to garages in one and two family dwellings, which are also regulated by the IRC, which is used by the majority of jurisdictions throughout the U.S.. Section 17.2 prohibits the storage or use of hydrogen in other than hydrogen propelled vehicles stored in residential garages unless *approved* by the *AHJ*. The result is that the prohibition conflicts with the IRC and associated codes likely used for construction of residential occupancies where the use of *listed appliances* that can generate hydrogen for residential fueling purposes are anticipated to be used. Hydrogen generating and refueling *appliances* are regulated by the IRC, 2015 Edition,[30] Section 1307.4, and the *appliances* are further regulated by IRC Section 1904 and referenced to additional applicable requirements found in the IFGC, the IFC, and the IBC. The conflict presented by these two codes can be resolved by the application of the governing document. See Appendix B of this guide, Section B1.1, for an example of conflict resolution. In cases where the occupancy is regulated by the IRC or other building codes that establish the requirements for construction, the building codes are the dominant code and NFPA 2 becomes the referenced document. Hydrogen in residential uses is well regulated under the requirements of the I-Codes, and the *approval* sought can be granted by the *AHJ* if the design complies with the requirements of the IRC and related codes associated with the construction of the residence. A permit would be required to be issued, and designs and installation must conform to the requirements for the equipment to be used as well as for the *piping* and control system, *ventilation*, and other building-related controls.	

Chapter 18 Repair Garages

Section	Requirement 2011	Requirement 2016	Narrative	Required References
18.3.3		**Gas Detection System.** *Major repair garages* shall be provided with an *approved* hydrogen *gas detection system* such that gas can be detected where vehicle hydrogen fuel storage systems are serviced or indoor *defueling* occurs.	See the discussion on gas detection provided in explanation to the requirements of NFPA 2, Section 6.12.	
18.7.2		***Defueling* Equipment Required at Vehicle Maintenance and Repair Facilities.** *Major repair garages* shall have equipment to defuel vehicle *fuel supply containers*. Equipment used for *defueling* shall be *listed* and *labeled* for the intended use.	Following the prescriptive requirements as published should result in *approval* of the proposed design.	

International Building Code

Section	Requirement	Narrative	Required References
406 Motor Vehicle Related Occupancies			
406.8 Repair Garages			
	406.8.5 Gas detection system. *Repair garage*s used for the repair of vehicles fueled by nonodorized gases such as hydrogen and nonodorized LNG, shall be provided with a *flammable gas detection system*. **406.8.5.1 System design.** The *flammable gas detection system* shall be *listed* or *approved* and shall be calibrated to the types of fuels or gases used by vehicles to be repaired. The *gas detection system* shall be designed to activate when the level of *flammable gas* exceeds 25 percent of the *lower flammable limit* (*LFL*). Gas detection shall be provided in lubrication or chassis service pits of *repair garages* used for repairing nonodorized LNG-fueled vehicles.	The principal use of hydrogen in automotive applications is as an energy source to power fuel cells through a battery system. Such use requires hydrogen that is not odorized, as the typical odorants in use today would render the fuel cells inoperable. The regulatory scheme promulgated by NFPA is different from that included in the codes promulgated by the ICC as found within the IFC. The current general requirement found in NFPA 2 allows the use of either *listed* or *approved gas detection systems*. No reference is provided to applicable *listing* standards that may be used. NFPA 853 (referenced by NFPA 2 in Chapter 13) does not mandate either *listing* or *approval* for *gas detection systems*, but the detection system is required to be specific for hydrogen, raising a question of whether the general *combustible gas detector* can be used if it is non-specific without specific calibration for the detection of hydrogen. The IFC requires that *gas detection systems* be *listed* or *approved,* except that when such systems are installed in repair facilities, the *gas detection system* is required to be *listed* is to be suitable for those specific gases or vapors to be detected in	

Section	Requirement	Narrative	Required References
		accordance with the requirements of the UL *listing* Standard 2075.[u] By contrast, NFPA 2 requirements for *gas detection systems* in *repair garages*, Section 18,3.3, require the use of an *approved gas detection system*. The UL Online *flammable gas detection systems listed* for use with various flammable (combustible) gases may be found in the UL Online Certifications Directory.[3] A *listing* standard, ANSI/ISA 60079-29-1-2013, that may be applicable for industrial and commercial (non-residential) installations can be found at the following website: https://www.isa.org/templates/one-column.aspx?pageid=111294&productId=116779 A marketer of the above referenced standard provides a short discussion on the content and application of the AHSI/ISA document. The following statements (in pertinent part) have been taken from the explanatory text found at the following website: http://standards.globalspec.com/std/1645623/isa-60079-29-1 • This standard is applicable to *flammable gas* detection apparatus intended to provide an indication, alarm or other output function; the purpose of which is to give a warning of a potential explosion hazard and in some cases, to initiate automatic or manual protective action(s). • This standard is applicable to apparatus, including the integral sampling systems of aspirated apparatus, intended to be used for commercial, industrial and non-residential safety applications.	

[u] IFC Section 2311.7.2.1.1

Section	Requirement	Narrative	Required References
		• This standard does not apply to external sampling systems, or to apparatus of laboratory or scientific type, or to apparatus used only for process control purposes. It also does not apply to open path (line of sight) area monitors. For apparatus used for sensing the presence of multiple gases, this standard applies only to the detection of *flammable gas* or vapour [sic]. ○ NOTE 1 ANSI/ISA-60079-29-1 is intended to provide for the supply of apparatus giving a level of safety and performance suitable for general purpose applications. However, for specific applications, a prospective purchaser (or an appropriate authority) may additionally require the apparatus to be submitted to particular tests or *approval*. For example, Group I apparatus (i.e. apparatus to be used in mines susceptible to firedamp) may not be permitted to be used without the additional, prior *approval* of the relevant authority in mines under its jurisdiction. Such particular tests/*approval* are to be regarded as additional to and separate from the provisions of the standards referred to above and do not preclude *certification* to or compliance with these standards. ○ NOTE 2 All apparatus calibrated on specific gases or vapours can not [sic] be expected to correctly indicate on other gases or vapours. In addition to the *listing* standards referenced above, Factory Mutual Global published an *approval* standard for *combustible gas detectors*, Class 6320, in November 2014.[4] It can be found at the following website: http://www.fmglobal.com/page.aspx?id=50000000 by accessing the site and searching for FM 6320.	

Section	Requirement	Narrative	Required References
		As for generic *combustible gas detectors*, some manufacturers may calibrate them specifically for hydrogen. It is important that any detector used be evaluated by the manufacturer and a third party even if it's not *listed*, and that documentation provided to the *AHJ* that substantiates performance and reliability. See Appendix A.2 of this guide for informational references. Users should refer to Annex L of NFPA 2 for detailed recommendations and discussion on the selection and installation of hydrogen *gas detection systems*.	
	406.8.5.1.1 Gas detection system components. *Gas detection system* control units shall be *listed* and *labeled* in accordance with UL 864 or UL 2017. Gas detectors shall be *listed* and *labeled* in accordance with UL 2075 for use with the gases and vapors being detected.	Relevant guidance from UL describes the equipment covered by UL 864, UL 2017, and UL 2075 available to the user at the UL website: http://database.ul.com/cgi-bin/XYV/template/LISEXT/1FRAME/showpage.html?name=FTAM.GuideInfo&ccnshorttitle=Gas+and+Vapor+Detectors+and+Sensors&objid=1074300071&cfgid=1073741824&version=versionless&parent_id=1073986828&sequence=1[31] Until such time as *listed* detectors are available, gas detectors must be *approved* or alternate *listing* standards may be used when *approved* by the *AHJ* (see the discussion on 406.8.5 above). The authority to *approve* the use of un*listed* equipment can be granted by the *AHJ* under the provisions for equivalency currently found in the code. Alternatively, the code official may want to view the use of un*listed* equipment as a "modification" to the code based on practical difficulties in compliance. In the IBC, the provisions for modification are located in Section 104.10 and those for equivalency are found in Section 104.11.[32] Similar provisions for modification or equivalency can be found in the IFC, Sections 104.8 and 104.9, respectively.[6]	UL 864, *Standard for Control Units and Accessories for Fire Alarm Systems,* 2014, Underwriters Laboratories UL 2017, *Standard for General-Purpose Signaling Devices and Systems,* 2008, Underwriters Laboratories UL 2075, *Standard for Gas and Vapor Detectors and Sensors,* 2013, Underwriters Laboratories

Section	Requirement	Narrative	Required References
	406.8.5.3 Failure of the gas detection system. Failure of the *gas detection system* shall result in the deactivation of the heating system, activation of the mechanical *ventilation* system where the system is interlocked with the *gas detection system* and cause a trouble signal to sound in an *approved* location.	The *approved* location could be a supervising station service such as a central-station, proprietary or remote-station signaling service, or a local signaling service that will cause the sounding of an audible signal at a *constantly attended location*. For details and requirements for supervising station services see NFPA 72, *National Fire Alarm and Signaling Code.*	NFPA 72, *National Fire Alarm and Signaling Code,* 2013 Edition, National Fire Protection Association
421 Hydrogen Fuel Gas Rooms			
	421.6 Gas detection system. *Hydrogen fuel gas rooms* shall be provided with an *approved flammable* gas detection system in accordance with Sections 421.6.1 through 421.6.4.	(See also the comments in 406.8.5.1.) The regulatory scheme promulgated by NFPA is different from that included in the codes promulgated by the ICC as found within the IFC. The current requirement found in NFPA 2 allows the use of either *listed* or *approved gas detection systems*. No reference is provided to applicable *listing* standards that may be used. NFPA 853 (referenced by NFPA 2 in Chapter 13) does not mandate either *listing* or *approval* for *gas detection systems*, but the detection system is required to be specific for hydrogen, raising a question of whether the general *combustible gas detector* can be used if it is non-specific without specific calibration for the detection of hydrogen. The IFC in Section 2311.7.2.1.1 requires that *gas detection systems* be *listed* or *approved,* except that when such systems are installed in repair facilities, the *gas detection system* is	

Section	Requirement	Narrative	Required References
		required to be *listed* as suitable for those specific gases or vapors to be detected in accordance with the requirements of UL 2075.[33] By contrast, NFPA 2 requirements for *gas detection systems* in *repair garages*, Section 18,3.3, require the use of an *approved gas detection system*. The UL Online *flammable gas detection systems listed* for use with various flammable (combustible) gases may be found in the UL Online Certifications Directory.[3] A *listing* standard, ANSI/ISA 60079-29-1-2013, that may be applicable for industrial and commercial (non-residential) installations can be found at the following website: https://www.isa.org/templates/one-column.aspx?pageid=111294&productId=116779 A marketer of the above referenced standard provides a short discussion on the content and application of the AHSI/ISA document. The following statements (in pertinent part) have been taken from the explanatory text found at the following website: http://standards.globalspec.com/std/1645623/isa-60079-29-1 • This standard is applicable to *flammable gas* detection apparatus intended to provide an indication, alarm or other output function; the purpose of which is to give a warning of a potential explosion hazard and in some cases, to initiate automatic or manual protective action(s). • This standard is applicable to apparatus, including the integral sampling systems of aspirated apparatus, intended to be used for commercial, industrial and non-residential safety applications. • This standard does not apply to external sampling systems,	

Section	Requirement	Narrative	Required References
		or to apparatus of laboratory or scientific type, or to apparatus used only for process control purposes. It also does not apply to open path (line of sight) area monitors. For apparatus used for sensing the presence of multiple gases, this standard applies only to the detection of *flammable gas* or vapour [sic]. ○ NOTE 1 ANSI/ISA-60079-29-1 is intended to provide for the supply of apparatus giving a level of safety and performance suitable for general purpose applications. However, for specific applications, a prospective purchaser (or an appropriate authority) may additionally require the apparatus to be submitted to particular tests or *approval*. For example, Group I apparatus (i.e. apparatus to be used in mines susceptible to firedamp) may not be permitted to be used without the additional, prior *approval* of the relevant authority in mines under its jurisdiction. Such particular tests/*approval* are to be regarded as additional to and separate from the provisions of the standards referred to above and do not preclude *certification* to or compliance with these standards. ○ NOTE 2 All apparatus calibrated on specific gases or vapours can not [sic] be expected to correctly indicate on other gases or vapours. In addition to the *listing* standards referenced above, Factory Mutual Global published an *approval* standard for *combustible gas detectors*, Class 6320, in November2014.[4] It can be found at the following website: http://www.fmglobal.com/page.aspx?id=50000000 by accessing the site and searching for FM 6320.	

Section	Requirement	Narrative	Required References
		As for generic *combustible gas detectors*, some manufacturers may calibrate them specifically for hydrogen. It is important that any detector used be evaluated by the manufacturer and a third party even if it's not *listed*, and that documentation be provided to the *AHJ* that substantiates performance and reliability. See Appendix A.2 of this guide for informational references. Users should refer to Annex L of NFPA 2 for detailed recommendations and discussion on the selection and installation of hydrogen *gas detection systems*.	
	421.6.1 System design. The *flammable gas detection system* shall be *listed* for use with hydrogen and any other *flammable gases* used in the *hydrogen fuel gas room*. The *gas detection system* shall be designed to activate when the level of *flammable gas* exceeds 25 percent of the *lower flammability limit* (*LFL*) for the gas or mixtures present at their anticipated temperature and pressure.	Since hydrogen has a *lower flammable limit* of 4 percent, the system should be designed to activate at 1 percent (by volume) hydrogen concentration. Detectors should be located at points where the hydrogen is likely to collect (high points within 12 inches of the ceiling). For additional information in this regard, see the discussion on sensor placement in Annex L of 2016 NFPA 2 and the explanatory text shown in this guide under the narrative for Section 6.12.1 of NFPA 2. A *gas detection system* can be *approved* under the provisions for code modifications or equivalency. Until *listed* detectors are available, gas detectors must be *approved*. The authority to *approve* the use of un*listed* equipment can be granted by the *AHJ* under the provisions for equivalency currently found in the code. Alternatively, the code official may want to view the use of un*listed* equipment as a "modification" to the code based on practical difficulties in compliance. In the IBC, the provisions for modification are located in Section 104.10 and those for equivalency are found in Section 104.11.[32] Similar provisions for modification or equivalency can be found in the IFC, Sections 104.8 and 104.9, respectively.[6]	

Section	Requirement	Narrative	Required References
	421.6.2 Gas detection system components. *Gas detection system* control units shall be *listed* and *labeled* in accordance with UL 864 or UL 2017. Gas detectors shall be *listed* and *labeled* in accordance with UL 2075 for use with the gases and vapors being detected.	See the comments under 406.8.5.1.1 above.	
	421.6.4 Failure of the gas detection system. Failure of the *gas detection system* shall result in activation of the mechanical exhaust *ventilation* system, cessation of hydrogen generation and the sounding of a trouble signal in an *approved* location.	See the comments under 406.8.5.3 above. In *hydrogen fuel gas rooms*, the mechanical exhaust *ventilation* system is required to be activated whether or not the *ventilation* system is interlocked. Hydrogen may or may not be generated in *hydrogen fuel gas rooms*. Although it is not required by the code in rooms where no hydrogen generation occurs, and where hydrogen may be supplied from outside of the room or building, the designer should consider the need to shut off the source of supply to the fuel gas room upon failure of the *gas detection system*.	
908 Emergency Alarm Systems			
	908.5 Repair garages. A *flammable gas detection system* shall be provided in *repair garages* for vehicles fueled by nonodorized gases in accordance with Section 406.8.5.	See the comments on 406.8.5. The criteria established by 406.8.5 and related sub-sections will apply.	

International Fire Code

Chapter 23 - Motor Fuel-Dispensing Facilities and Repair Garages

Section	Requirement	Narrative	Required References
2303 Location of Dispensing Devices			
	2303.2 Emergency disconnect switches An *approved*, clearly identified and readily accessible emergency disconnect switch shall be provided at an *approved* location to stop the transfer of fuel to the fuel dispensers in the event of a fuel spill or other emergency. The emergency disconnect switch for exterior fuel dispensers shall be located within 100 feet (30 480 mm) of, but not less than 20 feet (6096 mm) from, the fuel dispensers. For interior fuel-dispensing operations, the emergency disconnect switch shall be installed at an *approved* location. Such devices shall be distinctly *labeled* as: EMERGENCY FUEL SHUTOFF. Signs shall be provided in *approved* locations.	The *AHJ* can *approve* the type of switch used, for example, a push button or toggle switch. The disconnect switch must be clearly visible and easily accessible without entering the potential release area. The signage for the switch should not be obstructed. For interior locations, the switch should be readily accessible, but outside the immediate area of the dispenser. These distances should be predicated on site-specific situations such as the size of the room where the dispensing occurs and the pressure of the dispensing system.	

Section	Requirement	Narrative	Required References
2304 Dispensing Operations			
	2304.2.1 Special-type dispensers. *Approved* special-dispensing devices and systems such as, but not limited to, card- or coin-operated and remote-preset types, are allowed at motor fuel-dispensing facilities provided there is not less than one qualified attendant on duty while the facility is open to the public. Remote preset-type devices shall be set in the "off" position while not in use so that the dispenser cannot be activated without the knowledge of the attendant.	No special consideration is necessary when the design is coordinated with the requirements described in the referenced provision. Following the prescriptive requirements as published should result in *approval* of the proposed design.	
	2304.2.2 Emergency controls. *Approved* emergency controls shall be provided in accordance with Section 2303.2.	See section 2303.2.	
	2304.2.3 Operating instructions. Dispenser operating instructions shall be conspicuously posted in *approved* locations on every dispenser.	No special consideration is necessary when the design is coordinated with the requirements described in the referenced provision. Following the prescriptive requirements as published should result in *approval* of the proposed design.	
	2304.2.5 Communications. The attendant shall be able to communicate with persons in the dispensing area at all times. An *approved* method of	An intercom is an example of an acceptable method of communication between attendants and persons in the dispensing area. A telephone could be one *approved* method of communicating with the fire department	

Section	Requirement	Narrative	Required References
	communicating with the fire department shall be provided for the attendant.		
	2304.3.1 General. Where *approved*, *unattended self-service motor fuel-dispensing facilities* are allowed. As a condition of *approval*, the owner or operator shall provide, and be accountable for, daily site visits, regular equipment inspection and maintenance.	No special consideration is necessary when the design is coordinated with the requirements described in the referenced provision. Following the prescriptive requirements as published should result in *approval* of the proposed design.	
	2304.3.2 Dispensers. Dispensing devices shall comply with Section 2306.7. Dispensing devices operated by the insertion of coins or currency shall not be used unless *approved*.	While coins or currency are not normally used in dispensing, the *AHJ* must *approve* the use of these devices. Other than limiting the maximum amount of fuel to be dispensed, no special consideration is necessary when the design is coordinated with the requirements described in the referenced provision.	
	2304.3.3 Emergency controls. *Approved* emergency controls shall be provided in accordance with Section 2303.2. Emergency controls shall be of a type that is only manually resettable.	No special consideration is necessary when the design is coordinated with the requirements described in the referenced provision. Following the requirements in 2303.2 as published should result in *approval* of the proposed design. Manually resettable controls are used to ensure the issue has been resolved fully and the controls have not been damaged.	

Section	Requirement	Narrative	Required References
	2304.3.4 Operating instructions. Dispenser operating instructions shall be conspicuously posted in *approved* locations on every dispenser and shall indicate the location of the emergency controls required by Section 2304.3.3.	The instructions should be posted at a location deemed appropriate by the *AHJ*, which is clearly visible to the equipment operator.	
	2304.3.5 Emergency procedures. An *approved* emergency procedures sign, in addition to the signs required by Section 2305.6, shall be posted in a conspicuous location and shall read: IN CASE OF FIRE, SPILL OR RELEASE 1. USE EMERGENCY PUMP SHUTOFF 2. REPORT THE ACCIDENT! FIRE DEPARTMENT TELEPHONE NO._____ FACILITY ADDRESS _____	No special consideration is necessary when the design is coordinated with the requirements described in the referenced provision. Following the prescriptive requirements as published should result in *approval* of the proposed design.	
	2304.3.6 Communications. A telephone not requiring a coin to operate or other *approved*, clearly identified means to notify the fire department shall be provided on the site in a location *approved* by the *fire code* official.	Another *approved* means could include an emergency notification system in accordance with NFPA 72. The location of the communication device is intended to be at or near the fueling station but away from the dispenser.	NFPA 72, *National Fire Alarm and Signaling Code, 2013 Edition,* National Fire Protection Association

Section	Requirement	Narrative	Required References
	2304.3.7 Quantity limits. Dispensing equipment used at unsupervised locations shall comply with one of the following: 1. Dispensing devices shall be programmed or set to limit uninterrupted fuel delivery to 25 gallons (95 L) and require a manual action to resume delivery. 2. The amount of fuel being dispensed shall be limited in quantity by a preprogrammed card as *approved*.	The fuel limit decreases the chance of a major release in the event of equipment failure.	
	2305.2.2 Repairs and service. The *fire code* official is authorized to require damaged or unsafe containment and dispensing equipment to be repaired or serviced in an *approved* manner.	This requirement ensures that equipment is repaired by a *qualified individual* familiar with its use, and using appropriate procedures.	
	2305.5 Fire extinguishers. *Approved* portable fire extinguishers complying with Section 906 with a minimum rating of 2-A:20-B:C shall be provided and located such that an extinguisher is not more than 75 feet (22 860 mm) from pumps, dispensers or storage tank fill-pipe openings.	This *approval* ensures that the correct type of fire extinguisher is in the area of the dispenser. A hydrogen fire should not be extinguished until the source of the hydrogen has been shut off. Refer to NFPA 10 for guidance.	NFPA 10, *Standard for Portable Fire Extinguishers,* 2013 Edition, National Fire Protection Association

<table>
<tr><th>Section</th><th>Requirement</th><th>Narrative</th><th>Required References</th></tr>
<tr><td></td><td>2309.2.1 Approved equipment. Cylinders, containers and tanks; pressure relief devices, including pressure valves; hydrogen vaporizers; pressure regulators; and piping used for gaseous hydrogen systems shall be designed and constructed in accordance with Chapters 53, 55 and 58.</td><td>There are no listed components available in a number of the categories included from which a system designer may choose. In lieu of listing, the use of unlisted components may be approved when good engineering judgement by the system designer is used, and the requirements of industrial codes, such as the ASME B31 piping codes or the ASME Boiler and Pressure Vessel Code should be followed.

Components that are not listed will require approval by the AHJ. The lack of pursuit to acquire a listing for hydrogen fueling station equipment and fuel cell industrial trucks may be due to one or more factors: (1) reservations on the part of the equipment manufacturers about the listing standards, (2) business decisions based on the size of the potential user market, and (3) the cost of authorizing the listing organization, in an early market, to conduct a full listing evaluation requiring many types of tests. As the hydrogen equipment markets continue to grow and mature, one can envision evolving listing standards and practices and the successful pursuit of more listings by equipment manufacturers.

The table below gives a representative sample of the codes and standards that may be applied in the approval process:

<table><tr><th>Item</th><th>Documents that May Be Considered in the Approval Process</th></tr><tr><td>(1) Pressure relief devices, including PRVs</td><td>• ASME pressure vessels: ASME Boiler and Pressure Vessel Code;
• DOT containers CFR Title 49, DOT regulations</td></tr></table></td><td></td></tr>
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<tr><td></td><td>• Relief devices for piping systems : ASME B31 codes</td></tr>
<tr><td>(2) Pressure gauges</td><td>ASME B31 codes</td></tr>
<tr><td>(3) Pressure regulators</td><td>ASME B31 codes</td></tr>
<tr><td>(4) Valves</td><td>ASME B31 codes, CSA HGV 4.6,[13] CSA HGV 4.7[14]</td></tr>
<tr><td>(5) Hose and hose connections</td><td>ASME B31 codes, CSA HGV 4.2[20]</td></tr>
<tr><td>(6) Vehicle fueling connections (nozzle)</td><td>SAE J2600</td></tr>
<tr><td>(7) Electrical equipment used with GH_2 systems</td><td>NFPA 70, NFPA 79</td></tr>
<tr><td>(8) Gas detection equipment and alarms</td><td>See NFPA 2, Section 6.12</td></tr>
<tr><td>(9) Hydrogen dispensers</td><td>CSA HGV 4.1,[16] CSA HGV 4.3[17]</td></tr>
<tr><td>(10) Pressure switches</td><td>ASME B31, NFPA 70, NFPA 79</td></tr>
<tr><td>(11) Flow meters</td><td>ASME B31, NFPA 70, NFPA 79</td></tr>
</table>
</td><td></td></tr>
<tr><td></td><td>2309.2.2 Listed or approved equipment. Hoses, hose connections, compressors, hydrogen generators, dispensers, detection systems and electrical equipment used for hydrogen shall be listed or approved for use with hydrogen. Hydrogen motor-fueling connections shall be listed and labeled or approved for use with hydrogen.</td><td>A hose or nozzle failure could injure the individual performing the fueling operation. Standards that may be used for listing or approving hoses are CSA America HGV 4.2-2013[20] and CSA America HGV 4.4-20013.[34]

Components that are not listed will require approval by the AHJ. The lack of pursuit to acquire a listing for hydrogen fueling station equipment and fuel cell industrial trucks may be due to one or more factors: (1) reservations on the part of the equipment manufacturers about the listing standards, (2) business decisions based on the size of the potential user market, and (3) the cost of authorizing the listing organization, in an early market, to conduct a full listing evaluation requiring many types of tests. As the hydrogen equipment markets continue to grow and mature, one can envision evolving listing</td><td></td></tr>
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<tr><td></td><td>2309.3.1.5.2 Fire-extinguishing systems. Fuel-dispensing areas under canopies shall be</td><td>Sprinkler systems should be designed and installed in accordance with Section 903.3.1.1 of the IFC and NFPA 13.</td><td>NFPA 13, Standard for the Installation of Sprinkler Systems, 2013</td></tr>
</table>

Section	Requirement	Narrative	Required References
	equipped throughout with an *approved* automatic sprinkler system in accordance with Section 903.3.1.1. The design of the sprinkler system shall be not less than that required for Extra Hazard Group 2 occupancies. Operation of the sprinkler system shall activate the emergency functions of Sections 2309.3.1.5.3 and 2309.3.1.5.4.	The use of alternate fire protection systems may be allowed when in accordance with the requirements of IFC Section 903.1.1.	Edition, National Fire Protection Association
	2309.3.1.5.5 Signage. *Approved* signage having 2-inch (51 mm) block letters shall be affixed at *approved* locations on the exterior of the *canopy* structure stating: CANOPY TOP HYDROGEN STORAGE.	Signage should be provided with contrasting colors to the background material and should be visible to emergency response personnel. Additional guidance can be found in ANSI Z535.3, *Criteria for Safety Symbols*,[35] and ANSI Z535.4, *Product Safety Signs and Labels*.[36]	
	2309.5.1 Protection from vehicles. Guard posts or other *approved* means shall be provided to protect hydrogen storage systems and use areas subject to vehicular damage in accordance with Section 312.	In order to protect the systems, any alternative to guard posts should be robust enough to prevent damage to the system in the event of a vehicular or other anticipated impact.	
	2309.5.1.1 Vehicle fueling pad. The vehicle shall be fueled on noncoated concrete or other *approved* paving material having a resistance not exceeding 1 megohm as determined by the methodology specified in EN 1081.	The resistivity of the vehicle fueling pad should be below 1 megohm to ensure that the vehicle is properly grounded prior to fueling activity. An example of an *approved* method to measure the resistivity is an electrician using a megger to verify that the resistivity is less than 1 megohm under normal fueling conditions. Humid air and surface moisture will reduce the fuel pad	

Section	Requirement	Narrative	Required References
		resistivity compared to what would be expected on cool dry days. Therefore, tests conducted during relatively cool and dry ambient conditions would be most useful for verifying that the pad resistivity is less than 1 megohm over a wide range of local ambient conditions.	
	2309.6.1 Methods of discharge. The discharge of hydrogen from fuel storage *tanks* shall be accomplished through a closed transfer system in accordance with Section 2309.6.1.1 or an *approved* method of atmospheric venting in accordance with Section 2309.6.1.2.	*Defueling* of fuel storage equipment should be through portions of the system that are located such that people, property, or the environment is not impacted. The vent should be arranged to prevent the intrusion of oxygen or air and should be constructed of material that is compatible with hydrogen and is secured to withstand any forces as a result of the *defueling*. CGA G-5.5, *Hydrogen Vent Systems,* provides additional guidance on hydrogen PRV discharge design; also see NFPA 2, Section 6.16, and the comments included in the discussion on IFGC, Section 703.4, relative to the discharge from venting systems.	CGA G-5.5, *Hydrogen Vent Systems*, 3rd Edition, Compressed Gas Association, 2014
	2309.6.1.2.1 Defueling equipment. Equipment used for *defueling* shall be *listed* and *labeled* or *approved* for the intended use.	There is no known *listed* and *labeled defueling* equipment. All equipment used in *defueling* operations must be *approved*. The *AHJ* may require that *defueling* equipment be designed by a qualified engineer. Equipment should be constructed of material that is compatible with hydrogen and should be secured to withstand any forces that may result from the *defueling* operation. *Defueling* of equipment should be through equipment that is located such that people, property, or the environment is not impacted. The vent should be arranged to prevent the intrusion of oxygen or air and should be constructed of material that is compatible with hydrogen and is secured to withstand any forces as a result of the *defueling*. CGA G-5.5, *Hydrogen Vent Systems,* provides additional	CGA G-5.5, *Hydrogen Vent Systems*, 3rd Edition, Compressed Gas Association, 2014

Section	Requirement	Narrative	Required References
		guidance on hydrogen PRV discharge design; also see NFPA 2, Section 6.16. Vent system design and configuration must allow for all expected and potential release conditions.	
	2311.7.1 Ventilation. *Repair garages* used for the repair of natural gas- or hydrogen-fueled vehicles shall be provided with an *approved* mechanical *ventilation* system. The mechanical *ventilation* system shall be in accordance with the International Mechanical Code and Sections 2311.7.1.1 and 2311.7.1.2. Exception: *Repair garages* with *natural ventilation* when *approved*.	No special consideration is necessary when the design is coordinated with the requirements described in the referenced provision. Following the instruction provided in the published requirement should result in *approval* of the proposed design. .	
	2311.7.2.1 System design. The *flammable gas detection system* shall be *listed* or *approved* and shall be calibrated to the types of fuels or gases used by vehicles to be repaired. The *gas detection system* shall be designed to activate when the level of *flammable gas* exceeds 25 percent of the *lower flammable limit* (*LFL*). Gas detection shall be provided in lubrication or chassis service pits of *repair garages* used for	UL 2075, *Gas and Vapor Detectors and Sensors,* is required; however, as of June 2015 there were no *flammable gas detection systems listed* specifically for use with hydrogen found in the UL Online Certifications Directory.[31] See the discussion on gas detection under the narrative to Section 6.12.1 of NFPA 2 in this guide.	

Section	Requirement	Narrative	Required References
	repairing nonodorized LNG-fueled vehicles.		
	2311.7.2.1.1 Gas detection system components. *Gas detection system* control units shall be *listed* and *labeled* in accordance with UL 864 or UL 2017. Gas detectors shall be *listed* and *labeled* in accordance with UL 2075 for use with the gases and vapors being detected.	No consideration is necessary for control units when the design is coordinated with the requirements described in the referenced provision. For detectors, see Section 2311.7.2.1.	
	2311.7.2.3 Failure of the gas detection system. Failure of the *gas detection system* shall result in the deactivation of the heating system, activation of the mechanical *ventilation* system where the system is interlocked with the *gas detection system* and cause a trouble signal to sound in an *approved* location.	Examples of *approved* locations for the alarm to sound are the immediate area where the system is located or an *approved* supervising station or *constantly attended location*.	

Chapter 50 - Hazardous Materials- General Provisions

Section	Requirement	Narrative	Required References
5001 General			
	5001.3 Performance-based design alternative. Where *approved* by the *fire code* official, buildings and facilities where hazardous materials are stored, used or handled shall be permitted to comply with this section as an	In instances where an application is not covered by the code or in instances where a section of the code cannot be met, the code official can allow the project proponent to use a performance-based alternative. If this option is to be used, the code official should ensure that the analysis is performed by someone with sufficient knowledge in the process. For specific details on performance-based alternatives, see narrative on	

Section	Requirement	Narrative	Required References
	alternative to compliance with the other requirements set forth in this chapter and Chapters 51 through 67.	NFPA 2, Chapter 5.	
5003 General Requirements			
	5003.2.1 Design and construction of containers, cylinders and tanks. *Containers*, *cylinders* and *tanks* shall be designed and constructed in accordance with *approved* standards. *Containers*, *cylinders*, *tanks* and other means used for containment of hazardous materials shall be of an *approved* type. *Pressure vessels* not meeting DOTn requirements for transportation shall comply with the ASME *Boiler and Pressure Vessel Code*.	The specific standards for hydrogen systems can be found in the narrative for 2309.2.1.	
	5003.2.2 Piping, tubing, valves and fittings. *Piping*, tubing, valves, and fittings conveying hazardous materials shall be designed and installed in accordance with ASME B31 or other *approved* standards, and shall be in accordance with Sections 5003.2.2.1 and 5003.2.2.2.	The specific standards for hydrogen systems can be found in the narrative for 2309.2.1.	
	5003.2.2.1 Design and construction. *Piping*, tubing, valves, fittings and related components used for hazardous	For leak detectors, refer to Sections 2311.7.2.1 and 2311.7.2.1.1. For emergency shutoff, see 2303.2. For other leak detection systems, such as those using internal flow or pressure monitoring, the project proponent should document	

Section	Requirement	Narrative	Required References
	materials shall be in accordance with the following: 6. Where gases or liquids having a hazard ranking of: Health Class 3 or 4 Flammability Class 4 Instability Class 3 or 4 in accordance with NFPA 704 are carried in pressurized *piping* above 15 pounds per square inch gauge (psig) (103 kPa), an *approved* means of leak detection and emergency shutoff or *excess flow control* shall be provided. Where the *piping* originates from within a hazardous material storage room or area, the *excess flow control* shall be located within the storage room or area. Where the *piping* originates from a bulk source, the *excess flow control* shall be located as close to the bulk source as practical. Exceptions: 1. *Piping* for inlet connections designed to prevent backflow. 2. *Piping* for *pressure relief devices*.	performance and reliability of that system for the *AHJ*. *Excess flow control* should be designed to limit the amount of hydrogen that can be released in the event of a system failure. It should work in conjunction with *ventilation* systems to ensure the accumulation of hydrogen remains below a hazardous level. Reliability of leak detection and emergency shutoff systems should be comparable to that of excess flow valves to ensure that the system performs its safety function. For additional information on reliability, see the informational references under Safety Instrumented System Performance and Reliability in Appendix A.1	

Section	Requirement	Narrative	Required References
	5003.2.3 Equipment, machinery and alarms. Equipment, machinery and required detection and alarm systems associated with the use, storage or handling of hazardous materials shall be *listed* or *approved*.	For equipment and machinery, refer to Section 2309.2.1. For detection systems, refer to Sections 2311.7.2.1 and 2311.7.2.1.1. Alarm systems should be designed to meet NFPA 72.	NFPA 72, *National Fire Alarm and Signaling Code, 2013 Edition,* National Fire Protection Association
	5003.2.6 Maintenance. In addition to the requirements of Section 5003.2.3, equipment, machinery and required detection and alarm systems associated with hazardous materials shall be maintained in an operable condition. Defective *containers*, *cylinders* and *tanks* shall be removed from service, repaired or disposed of in an *approved* manner. Defective equipment or machinery shall be removed from service and repaired or replaced. Required detection and alarm systems shall be replaced or repaired where defective.	Defective equipment should be serviced or repaired by *qualified persons* using appropriate procedures. The National Board Inspection Code (NBBI) NB23-2015, is the most prominent code used for the repair of *pressure vessels* designed to meet the ASME *Boiler and Pressure Vessel Code*. It is published by the NBBI.[37] Title 49 CFR may apply to certain *pressure vessels* used for hydrogen in the transport system. If the defective equipment is repaired, documentation from the manufacturer (or an equivalent source) of the equipment stating that it is safe for use should be obtained. Repair of equipment, detection, and alarm systems should be performed per manufacturer's recommendations. Repair of *piping systems* should meet the requirements in Section 2309.6.2. Before the equipment is returned to service, a field functionality test may be performed on detection systems to verify they are working properly. For disposal, the tank or *container* should be defueled per the requirements in Section 2309.6 prior to disposal. CGA standards establish requirements for the disposal of *pressure vessels*. See Informational References regarding the disposition of *compressed gas cylinders* in Appendix A.2.	

Section	Requirement	Narrative	Required References
	5003.2.6.1 Tanks out of service for 90 days. *Stationary tanks* not used for a period of 90 days shall be properly safeguarded or removed in an *approved* manner. Such *tanks* shall have the fill line, gauge opening and pump connection secured against tampering. Vent lines shall be properly maintained.	It is not unusual for a hydrogen system to be out of service for 90 days or more. Provided normal maintenance is being performed and the integrity of the system is maintained, the system should be able to store the hydrogen indefinitely. Alternatively, *stationary tanks* that are not in use for 90 days could be properly safeguarded by emptying and inerting. *Defueling* of *tanks* should follow the requirements in Section 2309.6. To ensure that the tank is free of hydrogen, an inert gas may be used to displace the combustible gas through a vent stack. For additional requirements involving vent stacks, see IFC Section 2309.6.1.2.	
	5003.2.6.1.1 Return to service. Tanks that are to be placed back in service shall be tested in an *approved* manner.	If continued in gaseous hydrogen service, no further testing is needed. If continued in liquid hydrogen service, the tank should be filled by the supplier using a documented fill procedure. If the tank was inerted, it should be purged back over to hydrogen and refilled, and tested to ensure that oxygen is not present in a concentration greater than 1 percent prior to filling.	
	5003.2.6.2 Defective containers and tanks. Defective *containers* and *tanks* shall be removed from service, repaired in accordance with *approved* standards or disposed of in an *approved* manner.	Defective equipment should be serviced or repaired by *qualified persons* using appropriate procedures. The ASME *Boiler and Pressure Vessel Code* addresses the repair of ASME *pressure vessels*. Title 49 CFR may apply to certain *pressure vessels* used for hydrogen in the transport system.	

Section	Requirement	Narrative	Required References
	5003.2.9 Testing. The equipment, devices and systems *listed* in Section 5003.2.9.1 shall be tested at the time of installation and at one of the intervals *listed* in Section 5003.2.9.2. Records of the tests conducted or maintenance performed shall be maintained in accordance with the provisions of Section 107.2.1. Exceptions: 1. Periodic testing shall not be required where *approved* written documentation is provided stating that testing will damage the equipment, device or system and the equipment, device or system is maintained as specified by the manufacturer. 2. Periodic testing shall not be required for equipment, devices and systems that fail in a *fail-safe* manner. 3. Periodic testing shall not be required for equipment, devices and systems that self-diagnose and report trouble. Records of the self-diagnosis and trouble reporting shall be made available to the *fire code official.* 4. Periodic testing shall not be required if system activation occurs during the required test	No special consideration is necessary when the design is coordinated with the requirements described in the referenced provision. Following the prescriptive requirements as published should result in *approval* of the proposed design.	

Section	Requirement	Narrative	Required References
	cycle for the components activated during the test cycle. 5. *Approved* maintenance in accordance with Section 5003.2.6 that is performed not less than annually or in accordance with an *approved* schedule shall be allowed to meet the testing requirements set forth in Sections 5003.2.9.1 and 5003.2.9.2.		
	5003.2.9.2 Testing frequency. The equipment, systems and devices *listed* in Section 5003.2.9.1 shall be tested at one of the frequencies *listed* below: 2. In accordance with the *approved* manufacturer's requirements. 3. In accordance with *approved* recognized industry standards. 4. In accordance with an *approved* schedule.	In the absence of industry standards, equipment suppliers have the most knowledge on the required testing frequency of their components. Documentation should be provided that details the testing requirements for the components and systems. In the absence of such requirements, an *AHJ* may allow a technical expert to provide documentation that justifies a testing frequency. The *AHJ* should only *approve* a different testing frequency if the proponent's proposed testing can be substantiated and documentation provided. The permittee is responsible for providing documentation in support of the industry standards to be used.	
	5003.5.1 Markings. Individual *containers*, cartons or packages shall be conspicuously marked or *labeled* in an *approved* manner. Rooms or cabinets containing *compressed gases* shall be conspicuously *labeled*: COMPRESSED GAS.	NFPA 704 placards or signs in accordance with Section 5003.6 should convey the contents of the *containers* and other important information. Alternatively, the *AHJ* may accept markings consistent with the United Nations *Globally Harmonized System of Classification and Labelling of Chemicals* (GHS), which is an international system for standardizing and harmonizing the classification and *labeling* of chemicals.	

Section	Requirement	Narrative	Required References
	5003.6 Signs. Signs and markings required by Sections 5003.5 and 5003.5.1 shall not be obscured or removed, shall be in English as a primary language or in symbols allowed by this code, shall be durable, and the size, color and lettering shall be *approved*.	Signage should meet the NFPA 704 standard. Plain language signage should be of sufficient size and color to be legible at a distance for emergency response purposes. Additional guidance can be found in ANSI Z535.3, *Criteria for Safety Symbols*,[35] and ANSI Z535.4, *Product Safety Signs and Labels*.[36]	
	5003.7.2 Open flames. Open flames and high-temperature devices shall not be used in a manner that creates a hazardous condition and shall be *listed* for use with the hazardous materials stored or used.	Open flames and high-temperature devices should not be allowed in the vicinity of hydrogen *tanks* and equipment. "High temperature" is a temperature greater than the hot surface ignition temperature for hydrogen. The actual hot surface ignition temperature depends on the size and orientation of the hot spot, as well as the hydrogen concentration; a conservative estimate is approximately 500°C.	
	5003.7.3 Industrial trucks. Powered industrial trucks used in areas designated as hazardous (classified) locations in accordance with NFPA 70 shall be *listed* and *labeled* for use in the environment intended in accordance with NFPA 505.	No special consideration is necessary when the design is coordinated with the requirements described in the referenced provision. Following the prescriptive requirements as published should result in *approval* of the proposed design.	
	5003.8.5.3 Fire-extinguishing system. Exhausted enclosures where flammable materials are used shall be protected by an *approved* automatic fire-extinguishing system in accordance with Chapter 9.	No special consideration is necessary when the design is coordinated with the requirements described in the referenced provision. Following the prescriptive requirements as published should result in *approval* of the proposed design.	

Section	Requirement	Narrative	Required References
	5003.8.7.1 Construction. The interior of cabinets shall be treated, coated or constructed of materials that are nonreactive with the hazardous material stored. Such treatment, coating or construction shall include the entire interior of the cabinet. Cabinets shall either be *listed* in accordance with UL 1275 as suitable for the intended storage or constructed in accordance with the following: 1. Cabinets shall be of steel having a thickness of not less than 0.0478 inch (1.2 mm) (No. 18 gage). The cabinet, including the door, shall be double walled with a 1 1/2-inch (38 mm) airspace between the walls. Joints shall be riveted or welded and shall be tight fitting. Doors shall be well fitted, self-closing and equipped with a self-latching device. 2. The bottoms of cabinets utilized for the storage of liquids shall be liquid tight to a minimum height of 2 inches (51 mm). Electrical equipment and devices within cabinets used for the storage of hazardous gases or liquids shall be in accordance with NFPA 70.	No special consideration is necessary when the design is coordinated with the requirements described in the referenced provision. Following the prescriptive requirements as published should result in *approval* of the proposed design.	

Section	Requirement	Narrative	Required References
	5003.8.7.2 Warning markings. Cabinets shall be clearly identified in an *approved* manner with red letters on a contrasting background to read: HAZARDOUS—KEEP FIRE AWAY.	Marking should be of a size and contrast that it can be recognized at a distance by emergency response personnel. Additional guidance can be found in ANSI Z535.3, *Criteria for Safety Symbols*,[35] and ANSI Z535.4, *Product Safety Signs and Labels*.[36]	
	5003.9.2 Security. Storage, dispensing, use and handling areas shall be secured against unauthorized entry and safeguarded in a manner *approved* by the *fire code* official.	At fueling stations, the storage *containers* and related equipment should be remotely located from the dispensers and secured from tampering. This could be accomplished through fencing and locking devices, provided there is a way for emergency responders to remove the lock. This can be through the use of a lock box or of a breakaway type lock. An example of a protection against unauthorized access in an industrial setting is a facility-controlled entry point access to the *containers* and systems.	
	5003.9.3 Protection from vehicles. Guard posts or other *approved* means shall be provided to protect storage *tanks* and connected *piping*, valves and fittings; dispensing areas; and use areas subject to vehicular damage in accordance with Section 312.	Guard posts or other types of barriers must be provided to protect the equipment from mechanical impact from vehicles, forklifts, and other equipment. If an alternative to the guard post requirements found in Section 312 is to be used, the barriers should be of sufficient size and strength to prevent any type of vehicle that is to be on the site from impacting the equipment and *tanks*. See also Section 312.3.	
	5003.10.2 Carts and trucks required. Liquids in *containers* exceeding 5 gallons (19 L) in a corridor or enclosure for a stairway or ramp shall be transported on a cart or truck. *Containers* of hazardous materials having a hazard ranking of 3 or 4 in accordance with NFPA 704 and	Hand trucks should be of sufficient size and capacity to carry the desired *containers*. They should have the ability to secure the equipment to the truck.	

Section	Requirement	Narrative	Required References
	transported within corridors or interior exit stairways and ramps, shall be on a cart or truck. Where carts and trucks are required for transporting hazardous materials, they shall be in accordance with Section 5003.10.3. Exceptions: 3. *Containers* and *cylinders* of *compressed gases* that are transported by *approved* hand trucks, and *containers* and *cylinders* not exceeding 25 pounds (11 kg) that are hand carried.		
	5003.11.3.5 Container type. *Containers* shall be *approved* for the intended use and identified as to their content.	See 2309.2.1	
	5003.12 Outdoor control areas. *Outdoor control areas* for hazardous materials in amounts not exceeding the maximum allowable quantity per *outdoor control area* shall be in accordance with the following: 3. Where a property exceeds 10,000 square feet (929 m^2), a group of two *outdoor control area*s is allowed where *approved* and where each control area is separated by a minimum distance of 50 feet (15 240 mm). 4. Where a property exceeds	Each of the *approved* control areas should meet all of the requirements for a single control area (setbacks, safeguards, pile size limitations, etc.). If an area cannot meet these requirements, it should not be allowed. The separation between the control areas can minimize the likelihood of a conflagration due to the proximity of one area to another.	

Section	Requirement	Narrative	Required References
	35,000 square feet (3252 m^2), additional groups of *outdoor control areas* are allowed where *approved* and where each group is separated by a minimum distance of 300 feet (91 440 mm).		
5004 Storage			
	5004.3.1 System requirements. Exhaust *ventilation* systems shall comply with all of the following: 3. Systems shall operate continuously unless alternative designs are *approved*. 4. A manual shutoff control shall be provided outside of the room in a position adjacent to the access door to the room or in an *approved* location. The switch shall be a break-glass or other *approved* type and shall be *labeled*: VENTILATION SYSTEM EMERGENCY SHUTOFF.	Exhaust *ventilation* systems should be designed to ensure that a hazardous atmosphere is not created. In some instances (such as temperature controlled rooms), it is not energy efficient to run the exhaust system continuously. In these situations, alternatives can be proposed, such as interlocking the exhaust system to a *gas detection system*. In other instances, the exhaust may be interlocked with the electrical circuit such that the exhaust is running whenever there is power to the area. A break glass-type switch is designed such that the glass holds down a switch, and when the glass is broken, the system automatically stops. Other shutoff type systems may be acceptable provided they are clearly marked and require no special knowledge to operate. A *constantly attended location* is an example of what might be an *approved* area for the required switch .	
	5004.5 Automatic sprinkler systems. Indoor storage areas and storage buildings shall be equipped throughout with an *approved* automatic sprinkler system in accordance with Section	Sprinkler systems designed and installed to NFPA 13 requirements should be *approved*. The use of alternate fire protection systems may be allowed when in accordance with the requirements of IFC Section 903.1.1.	NFPA 13, *Standard for the Installation of Sprinkler Systems,* 2013 Edition, National Fire Protection Association

Section	Requirement	Narrative	Required References
	903.3.1.1. The design of the sprinkler system shall be not less than that required for Ordinary Hazard Group 2 with a minimum design area of 3,000 square feet (279 m^2). Where the materials or storage arrangement are required by other regulations to be provided with a higher level of sprinkler system protection, the higher level of sprinkler system protection shall be provided.		
	5004.7.2 Fail-safe engineered systems. Standby power for mechanical *ventilation*, treatment systems and temperature control systems shall not be required where an *approved fail-safe* engineered system is installed.	The *AHJ* may require that any proposed *fail-safe* engineered system be evaluated to ensure that the systems storing or using hydrogen will not be negatively impacted by a power outage. If the systems are designed such that all hazardous materials will be safely contained and cannot escape their containment vessels, under a power out condition it may be unnecessary to have standby power since the operation of the required systems will not have a beneficial effect. For example, a *fail-safe* system may be designed to shut off the supply of gas at the source during a power out condition, thereby mitigating the potential release of *flammable gas* that otherwise might be controlled by a mechanical *ventilation* system.	

Section	Requirement	Narrative	Required References
	5004.8.1 Temperature Control. Materials that must be kept at temperatures other than normal ambient temperatures to prevent a hazardous reaction shall be provided with an *approved* means to maintain the temperature within a safe range. Redundant temperature control equipment that will operate on failure of the primary temperature control system shall be provided. Where *approved*, alternative means that prevent a hazardous reaction are allowed.	*Gaseous hydrogen systems* are typically not provided with temperature controls. The code requires that the temperature of gaseous systems be maintained below 125°F. See IFC 5303.7.4. This is typically accomplished by use of shade when systems are located in hot climates. Liquid hydrogen is stored at cryogenic temperatures of less than -130°F . The storage tank is designed as a double-walled tank equipped with an isolation space between the inner and outer walls of the tank to maintain the cold temperature. The interstitial space between the inner and outer *tanks* normally consists of vacuum as well as a layer of insulating material. If a liquid tank is allowed to warm, the tank is designed with controls to automatically vent or release the hydrogen to a safe location to remove heat from the system and to keep the hydrogen at a cryogenic temperature, thereby mitigating a high-pressure condition.	
	5004.8.2 Pressure control. *Stationary tanks* and equipment containing hazardous material liquids that can generate pressures exceeding design limits because of exposure fires or internal reaction shall have some form of construction or other *approved* means that will relieve excessive internal pressure. The means of pressure relief shall vent to an *approved* location or to an exhaust scrubber or treatment system where required by Chapter 60.	Liquefied *compressed gases* are treated as gases within the context of the code. Gases in their cryogenic form are liquefied because of the temperature where they exist. They are not liquids as defined as they boil at temperatures of less than 68°F. Liquid hydrogen storage *tanks* are required to be provided with *pressure relief devices* in accordance with Section 5503.2. The location and design of relief devices should meet the requirements described in Section 2309.6.	

Section	Requirement	Narrative	Required References
	5004.9 Emergency alarm. An *approved* manual emergency alarm system shall be provided in buildings, rooms or areas used for storage of hazardous materials. Emergency alarm initiating devices shall be installed outside of each interior exit or exit access door of storage buildings, rooms or areas. Activation of an emergency alarm-initiating device shall sound a local alarm to alert occupants of an emergency situation involving hazardous materials.	The alarm system should be designed and installed in accordance with NFPA 72.	NFPA 72, *National Fire Alarm and Signaling Code, 2013 Edition,* National Fire Protection Association
	5004.10 Supervision and monitoring. Emergency alarm, detection and automatic fire-extinguishing systems required by Section 5004 shall be electrically supervised and monitored by an *approved* supervising station or, where *approved*, shall initiate an audible and visual signal at a constantly attended on-site location.	The *approved* location could be a supervising station service such as a central-station, proprietary or remote-station signaling service, or a local signaling service that will cause the sounding of an audible signal at a *constantly attended location*. For details and requirements for supervising station services, see NFPA 72, *National Fire Alarm and Signaling Code*.	NFPA 72, *National Fire Alarm and Signaling Code, 2013 Edition,* National Fire Protection Association

Section	Requirement	Narrative	Required References
5005 Use, Dispensing and Handling			
	5005.1.5.1 Exempt applications. Standby power for mechanical *ventilation*, treatment systems and temperature control systems shall not be required where an *approved fail-safe* engineered system is installed.	See Section 5004.7.2	
	5005.1.6 Supervision and monitoring. Manual alarm, detection and automatic fire-extinguishing systems required by other provisions of Section 5005 shall be electrically supervised and monitored by an *approved* supervisory service or, where *approved*, shall initiate an audible and visual signal at a constantly attended on-site location.	See Section 5004.10	
	5005.4.4 Dispensing, use and handling. Where hazardous materials having a hazard ranking of 3 or 4 in accordance with NFPA 704 are transported through corridors, interior exit stairways or ramps or exit passageways, there shall be an emergency telephone system, a local manual alarm station or an *approved* alarm-initiating device at not more than 150-foot (45 720 mm) intervals	The *approved* location could be a supervising station service such as a central-station, proprietary or remote-station signaling service, or a local signaling service that will cause the sounding of an audible signal at a *constantly attended location*. For details and requirements for supervising station services, see NFPA 72, *National Fire Alarm and Signaling Code*.	NFPA 72, *National Fire Alarm and Signaling Code, 2013 Edition,* National Fire Protection Association

Section	Requirement	Narrative	Required References
	and at each exit and exit access doorway throughout the transport route. The signal shall be relayed to an *approved* central, proprietary or remote station service or constantly attended onsite location and shall also initiate a local audible alarm.		

Chapter 53 - Compressed Gases

Section	Requirement	Narrative	Required References
5303 General Requirements			
	5303.5.1 Security of areas. Areas used for the storage, use and handling of *compressed gas containers*, *cylinders*, *tanks* and *systems* shall be secured against unauthorized entry and safeguarded in an *approved* manner.	See Section 5003.9.2	
	5303.5.2 Physical protection. *Compressed gas containers*, *cylinders*, *tanks* and *systems* that could be exposed to physical damage shall be protected. Guard posts or other *approved* means shall be provided to protect *compressed gas containers*, *cylinders*, *tanks* and *systems* indoors and outdoors from vehicular damage and shall comply with Section 312.	Guard posts or other types of barriers must be provided to protect the equipment from mechanical impact from vehicles, forklifts, and other equipment. If an alternative to the guard post requirements found in Section 312 is to be used, the barriers should be of sufficient size and strength to prevent any type of vehicle that is to be on the site from impacting the equipment and *tanks*. See also Section 312.3.	

Section	Requirement	Narrative	Required References
	5303.7.6 Heating. *Compressed gas containers*, *cylinders* and *tanks*, whether full or partially full, shall not be heated by devices that could raise the surface temperature of the *container*, *cylinder* or *tank* to above 125°F (52°C). Heating devices shall comply with the International Mechanical Code and NFPA 70. *Approved* heating methods involving temperatures of less than 125°F (52°C) are allowed to be used by trained personnel. Devices designed to maintain individual *compressed gas containers*, *cylinders* or *tanks* at constant temperature shall be *approved* and shall be designed to be *fail-safe*.	Hydrogen *cylinders* are not normally heated. Where they are, they should be in an electrically classified area. If heat is to be applied, the heat source should be designed by a *qualified person* to ensure that heat on *containers* is maintained below 125°F at the point of contact.	
	5303.11 Exposure to fire. *Compressed gas containers*, *cylinders* and *tanks* that have been exposed to fire shall be removed from service. *Containers*, *cylinders* and *tanks* so removed shall be handled by *approved*, *qualified persons*.	*Containers*, *cylinders*, and *tanks* may still be under pressure after a fire exposure and the integrity of the equipment may be suspect. Prior to removal, the equipment should be evaluated by a person knowledgeable in equipment design to ensure that it is safe to do so.	
	5303.12 Leaks, damage or corrosion. Leaking, damaged or corroded *compressed gas containers*, *cylinders* and *tanks* shall be removed from service.	Similar to Section 5303.11, any equipment whose integrity is in question should be evaluated by a *qualified person* to ensure the equipment is safe to handle. If depressurization of the equipment is required, see 2309.6.1.	

Section	Requirement	Narrative	Required References
	Leaking, damaged or corroded *compressed gas systems* shall be replaced or repaired in accordance with the following: 1. *Compressed gas containers*, *cylinders* and *tanks* that have been removed from service shall be handled in an *approved* manner.		
	5303.15 Lighting. *Approved* lighting by natural or artificial means shall be provided.	The building codes provide the minimum requirements for natural and artificial lighting. NFPA 2 Section 6.2 establishes the requirements for a building to conform to the adopted building code for the location in which it is constructed. The 2015 IBC establishes requirements for natural and artificial lighting in Section 1205, and the parameters for minimum lighting are specified. There may be other requirements depending on the applicable building code. In the control strategy used by NFPA 2, the requirements of Chapter 6 for lighting are triggered when the quantity of hydrogen in a control area exceeds the MAQ threshold. See NFPA 2 Section 6.1.1.5 for application. For existing buildings, the addition of hydrogen may trigger a change in occupancy classification, which may have an impact on building design. The requirements of a change in occupancy can affect other elements of the building, and designers should investigate the impact of such a change to the building as previously permitted.	*2015 International Building Code*, Section 1205, pp. 313-314, International Code Council
	5303.16.1 Listing required. Vaults shall be *listed* by a nationally recognized testing laboratory. Exception: Where *approved* by the *fire code* official, below-grade	UL 2245[38] provides a *listing* for vaults for *flammable liquids*; however, the code official must be aware that there are differences between *flammable liquids* and *gases* (such as the vapor density of a liquid versus the buoyancy of the gas) and should ensure that these differences are addressed. The code	

Section	Requirement	Narrative	Required References
	vaults are allowed to be constructed on site, provided that the design is in accordance with the International Building Code and that special inspections are conducted to verify structural strength and compliance of the installation with the *approved* design in accordance with Section 1707 of the International Building Code. Installation plans for below-grade vaults that are constructed on site shall be prepared by, and the design shall bear the stamp of, a professional engineer. Consideration shall be given to soil and hydrostatic loading on the floors, walls and lid; anticipated seismic forces; uplifting by ground water or flooding; and to loads imposed from above, such as traffic and equipment loading on the vault lid.	official should ensure that any vault provides sufficient access for emergency response, adequate *ventilation*, the appropriate electrical rating, appropriate monitoring, and sufficient depth and cover to protect the vault from vehicular damage. Installation plans should specify depth of burial and minimum cover to address loads imposed by the soil condition and location in which the vault is buried. Proposals to use vaults may require evaluation by a third party to examine the safety features of the design, including but not limited to *explosion control*, confined space entry, and special access and egress requirements. Technical assistance as provided for by IFC Section 104.7.2 is available to the *AHJ* and may be considered in the *approval* process.	
	5303.16.3 Secondary containment. Vaults shall be substantially liquid-tight and there shall not be backfill within the vault. The vault floor shall drain to a sump. For pre-manufactured vaults, liquid tightness shall be *certified* as part of the *listing* provided by a nationally recognized testing laboratory. For	One method of certifying liquid tightness for field-erected vaults could be a hydrostatic test for liquid tightness, performed before commissioning. There should be an acceptable tolerance to the leak rate. As an example, the acceptable variation for underground storage tank sumps in California is 0.002 inches over a 15-minute test. *Certification* may be provided by a qualified third-party *approved* by the *AHJ*. Proposals to use vaults may require evaluation by a third party to examine the safety features of	

Section	Requirement	Narrative	Required References
	field-erected vaults, liquid tightness shall be *certified* in an *approved* manner.	the design, including but not limited to *explosion control*, confined space entry, and special access and egress requirements. Technical assistance as provided for by IFC Section 104.7.2 is available to the *AHJ* and may be considered in the *approval* process.	
	5303.16.7 Arrangement. Equipment in vaults shall be *listed* or *approved* for above-ground use. Where multiple vaults are provided, adjacent vaults shall be allowed to share a common wall. The common wall shall be liquid and vapor tight and shall be designed to withstand the load imposed when the vault on either side of the wall is filled with water.	If the equipment is acceptable for aboveground use, it may be acceptable for use in an underground vault provided there are additional safeguards (*ventilation*, access, emergency venting, etc.). Proposals to use vaults may require evaluation by a third party to examine the safety features of the design, including but not limited to *explosion control*, confined space entry, and special access and egress requirements. Technical assistance as provided for by IFC Section 104.7.2 is available to the *AHJ* and may be considered in the *approval* process.	
	5303.16.10 Monitoring and detection. Vaults shall be provided with *approved* vapor and liquid detection systems and equipped with on-site audible and visual warning devices with battery backup. Vapor detection systems shall sound an alarm when the system detects vapors that reach or exceed 25 percent of the lower explosive limit (LEL) or one-half the immediately dangerous to life and health (IDLH) concentration for the gas in the vault. Vapor detectors shall be located not higher than 12 inches (305 mm)	For leak detection systems, refer to narratives for Sections 2311.7.2.1 and 2311.7.2.1.1. For emergency shutoff, see 2303.2. For supervision and monitoring, see narratives for section 5004.10. Proposals to use vaults may require evaluation by a third party to examine the safety features of the design, including but not limited to *explosion control*, confined space entry, and special access and egress requirements. Technical assistance as provided for by IFC Section 104.7.2 is available to the *AHJ* and may be considered in the *approval* process.	

Section	Requirement	Narrative	Required References
	above the lowest point in the vault for heavier-than-air gases and not lower than 12 inches (305 mm) below the highest point in the vault for lighter-than-air gases. Liquid detection systems shall sound an alarm upon detection of any liquid, including water. Liquid detectors shall be located in accordance with the manufacturers' instructions. Activation of either vapor or liquid detection systems shall cause a signal to be sounded at an *approved*, *constantly attended location* within the facility served by the *tanks* or at an *approved* location. Activation of vapor detection systems shall also shut off gas-handling equipment in the vault and dispensers.		

Section	Requirement	Narrative	Required References
	5303.16.13 Accessway. Vaults shall be provided with an *approved* personnel accessway with a minimum dimension of 30 inches (762 mm) and with a permanently affixed, nonferrous ladder. Accessways shall be designed to be nonsparking. Travel distance from any point inside a vault to an accessway shall not exceed 20 feet (6096 mm). At each entry point, a warning sign indicating the need for procedures for safe entry into confined spaces shall be posted. Entry points shall be secured against unauthorized entry and vandalism.	The type of accessway should be designed not only for maintenance but also for emergency response. While access to the vault should be secured, it should also allow for responders to easily access the vault while wearing any necessary emergency response equipment. Proposals to use vaults may require evaluation by a third party to examine the safety features of the design, including but not limited to *explosion control*, confined space entry, and special access and egress requirements. Technical assistance as provided for by IFC Section 104.7.2 is available to the *AHJ* and may be considered in the *approval* process.	
5305 Use and Handling of Compressed Gases			
	5305.1 Compressed gas systems. *Compressed gas systems* shall be suitable for the use intended and shall be designed by persons competent in such design. *Compressed gas* equipment, machinery and processes shall be *listed* or *approved*.	See narratives for Sections 2309.2.1 and 2309.2.2.	

Section	Requirement	Narrative	Required References
	5305.5 Venting. Venting of gases shall be directed to an *approved* location. Venting shall comply with the International Mechanical Code.	The termination point for relief devices is of concern to ensure that the public, employees, and property are not exposed to the effects of ignition should a release from a *pressure relief device* occur. *Pressure relief devices* are provided to prevent the rupture of the system and fall into two general categories: 1) to relieve over-pressure in a *piping* or storage system due to over-pressurization, or 2) to vent gas from the system as the result of a fire or other thermal event. In either case, the release of hydrogen through the relief device is preferable to an uncontrolled rupture of the system. Standards for design of venting systems, including points of termination for vent stacks serving PRV systems, are found in CGA G-5.5, *Hydrogen Vent Systems*.[39] Reference to CGA G-5.5 is not specified within the I-Codes by direct reference. Its use is required by NFPA 2 for vehicular fueling operations and by NFPA 55 for general use for venting of gaseous and liquid hydrogen systems. The IFC directs the user to these NFPA codes by the provisions found in IFC Section 5301.1. Section 7.3.3 of CGA G-5.5 contains the requirements for arrangement for the discharge of *pressure relief devices* and venting systems. The potential for ignition at the point of discharge from the vent must be considered as hydrogen is released and mixed with air. In general, the discharge of *flammable gases* should be directed upward to open air. The termination point for vent stacks can be through a pipe with a tee configuration, with the branches of the tee angled down to avoid the entrainment of precipitation that may plug the vent. The termination point from the legs of the tee should be designed to discharge the plume in an upward direction. Detailed drawings are provided by CGA-G5.5. The height of the point of termination or discharge from	

Section	Requirement	Narrative	Required References
		storage *containers* is dependent on pipe diameter and the velocity of discharge. Specific requirements for vent pipe discharge were established in the 2006 Edition of the IFC, and later removed from the code through reference to CGA G-5.5, which has been referenced by the IFC. The former IFC requirements related to vent stacks serving vehicular fueling systems illustrate separation distance for points of termination from the vent stack in terms of height and location based on flow rate for small diameter *piping systems* i.e., *piping* < NPS 3 (less than 3 inches in diameter). Additional and detailed information on the construction of vent pipes is included in the 2006 IFC, Section 2209.5.4.[40] The use of this material is consistent with the performance requirements of CGA G-5.5.	
	5305.10.1 Carts and trucks. *Containers*, *cylinders* and *tanks* shall be moved using an *approved* method. Where *containers, cylinders or tanks* are moved by hand cart, hand truck or other mobile device, such carts, trucks or devices shall be designed for the secure movement of *containers, cylinders or tanks*. Carts and trucks utilized for transport of *compressed gas containers*, *cylinders* and *tanks* within buildings shall comply with Section 5003.10. Carts and trucks utilized for transport of *compressed gas containers*, *cylinders* and *tanks* exterior to buildings shall be designed so that	See Section 5003.10.2.	

Section	Requirement	Narrative	Required References
	the *containers*, *cylinders* and *tanks* will be secured against dropping or otherwise striking against each other or other surfaces.		

Chapter 55 - Cryogenic Fluids

Section	Requirement	Narrative	Required References
5503 General Requirements			
	5503.1.1 Nonstandard containers. *Containers*, equipment and devices that are not in compliance with recognized standards for design and construction shall be *approved* upon presentation of satisfactory evidence that they are designed and constructed for safe operation.	Evidence to demonstrate design and construction for safe operation should be provided by an independent qualified engineer or person knowledgeable in equipment design; however, any proposed use of nonstandard equipment could be evaluated for comparability against ASME requirements for standard tank design. There does not seem to be experience using any of these nonstandard designs for liquid hydrogen installations.	
	5503.5.1 Security of areas. *Containers* and systems shall be secured against unauthorized entry and safeguarded in an *approved* manner.	See Section 5003.9.2.	
	5503.7.1 Containers. *Containers* that have been removed from service shall be handled in an *approved* manner.	For *containers* that are to be returned to service, see Section 5003.2.6.1. *Containers* that are permanently removed from service may be managed in accordance with CGA P-30.[41]	

Section	Requirement	Narrative	Required References
5505 Use and Handling			
	5505.1.1 Cryogenic fluid systems. *Cryogenic fluid* systems shall be suitable for the use intended and designed by persons competent in such design. Equipment, machinery and processes shall be *listed* or *approved*.	See Sections 2309.2.1 and 2309.2.2. There is no broadly accepted *listing* standard for the category of equipment, machinery, and processes for liquid hydrogen. *Piping systems* and components of *piping systems* serving liquid hydrogen that are in accordance with the requirements of the ASME B31 codes can be *approved*. See IFC Section 5003.2.2.[42] NFPA 70, *National Electrical Code*, establishes the requirements for electrical equipment and devices suitable for use with liquid hydrogen. The NEC and NFPA 55 refer the user to NFPA 497 for the classification of *hazardous locations* by the use of figures that have been included specifically to address hydrogen in a cryogenic state.[43]	NFPA 70, *National Electrical Code,* 2014 Edition, National Fire Protection Association
	5505.4.1 Dispensing areas. Dispensing of *cryogenic fluids* with *physical* or *health hazards* shall be conducted in *approved* locations. Dispensing indoors shall be conducted in areas constructed in accordance with the International Building Code.	Lacking any specific requirements regarding outdoor dispensing, setback distances as detailed in NFPA 2 Table 8.3.2.4.5.1 may be used. The requirements for fuel dispensing of liquid hydrogen are found in NFPA 2, Chapters 10 and 11, as referenced by IFC Section 5801.1. Indoor dispensing should be performed in accordance with requirements identified in Chapter 50. If amounts exceed the maximum allowable quantity, they should be conducted within an appropriate H-type occupancy and meet all the requirements for that type of occupancy. If small quantities are to be dispensed (below a maximum allowable quantity), elements that should be examined include electrical	

Section	Requirement	Narrative	Required References
		classification, *ventilation*, and emergency controls to determine what safeguards are necessary. Indoor fuel dispensing must also comply with the requirements of NFPA 2, Chapter 10; see IFC Section 5801.1	
	5505.4.2 Vehicle loading and unloading areas. Loading or unloading areas shall be conducted in an *approved* manner in accordance with the standards referenced in Section 5501.1.	Section 5501 references the user to NFPA 55 (see Section 11.5), and Chapters 23, 50, and 58 of the IFC. All necessary elements identified in these codes should be evaluated for compliance.	
	5505.5.1 Carts and trucks. *Cryogenic containers* shall be moved using an *approved* method. Where *cryogenic containers* are moved by hand cart, hand truck or other mobile device, such carts, trucks or devices shall be designed for the secure movement of the *container*. Carts and trucks used to transport *cryogenic containers* shall be designed to provide a stable base for the commodities to be transported and shall have a means of restraining *containers* to prevent accidental dislodgement.	See Section 5003.10.2.	

Chapter 58 - Flammable Gases and Flammable Cryogenic Fluids

Section	Requirement	Narrative	Required References
5803 General Requirements			
	5803.1.3 Emergency shutoff. *Compressed gas systems* conveying *flammable gases* shall be provided with *approved* manual or *automatic emergency shutoff valves* that can be activated at each point of use and at each source.	See Section 5003.2.2.1.	
5806 Flammable Cryogenic Fluids			
	5806.4.6 Underground liquid hydrogen piping. Underground liquid hydrogen *piping* shall be vacuum jacketed or protected by *approved* means and designed in accordance with Chapter 55.	The *piping* should be designed such that a leak in the system will be readily detected. Protection from impact and damage from vehicles or equipment over the buried *piping* should be provided. *Piping* should not be allowed in areas where a leak of liquid could become confined within or near a structure. Vacuum-jacketed *piping* not only adds efficiency to the system, but provides a level of impact protection for the primary *piping* as well.	
	5806.4.7 Overfill protection and prevention systems. An *approved* means or method shall be provided to prevent the overfill of all storage *tanks*.	Liquid hydrogen, a *cryogenic fluid* under pressure, cannot be gauged the same way that other liquids, including Class I Liquids under atmospheric conditions, are measured. Liquid level controls typically consist of a temperature measurement device along with a pressure measurement device and may include a liquid level measurement device that determines the liquid level interior to the tank. The ullage space or vapor space available to accommodate the expansion of gas considering temperature differential between the delivered and the stored liquid is	

Section	Requirement	Narrative	Required References
		determined by the operator before filling begins. Liquid level is typically indicated by the difference in pressure between the top and the bottom of the tank. The "full" level is typically marked on or beside the instrument provided. In addition, an overflow valve system is often used to indicate when the tank has reached a predetermined maximum liquid level, which is normally higher than the "full" level.	
	5806.4.8.1 Material. The vacuum jacket shall be constructed of stainless steel or other *approved* corrosion-resistant material.	There are many corrosion-resistant materials that may be acceptable for use in a vacuum jacket application. Consideration should be given to the material's ability to withstand the cryogenic temperature of the material contained in the primary (inner) tank and any potential impact on the vacuum jacket. A sacrificial material that will corrode to protect the integrity of the tank or isolation of the vacuum jacket from the backfill may be used as a means of *cathodic protection*. For the requirements on the use of *cathodic protection,* refer to IFC Section 5501.1, and by reference to the requirements found in NFPA 55, Section 8.14.9. The requirements for *cathodic protection* in NFPA 2, Section 8.1.3.1.7, are consistent with the requirements of NFPA 55.	
	5806.4.8.2 Corrosion protection. The vacuum jacket shall be protected by *approved* or *listed* corrosion-resistant materials or an engineered *cathodic protection* system. Where *cathodic protection* is utilized, an *approved* maintenance schedule shall be established. Exposed components shall be inspected	See Section 5806.4.8.1.	

Section	Requirement	Narrative	Required References
	not less than twice a year. Records of maintenance and inspection events shall be maintained.		
	5806.4.8.3 Vacuum-level monitoring. An *approved* method shall be provided to indicate loss of vacuum within the vacuum jacket(s).	A vacuum in the annular space of double-walled vessels is important for operation of liquid hydrogen systems. The best indication of a poor vacuum is condensation or frost on the surface of the outer vessel. Continuous monitoring of vacuum is not typically provided since the monitoring equipment itself can potentially lead to vacuum degradation via leakage. Vacuum insulation systems are typically equipped with a means to measure vacuum as needed. Checking the vacuum level as part of a maintenance program is an acceptable means of monitoring insulation integrity.	
5807 Metal Hydride Storage Systems			
	5807.1.2 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.	*Metal hydride storage systems* are *pressure vessels* and should have unique features to safely contain the *metal hydride* materials. It is insufficient to put *metal hydride* material into a *pressure vessel* without proper design considerations. Special hazards and mitigation features associated with *metal hydride*s are described and accounted for in the requirements of ISO Standard 16111.[7] Additional information can be found in Container Specifications for Metal Hydride Based Storage, available at: http://www.rita.dot.gov/sites/default/files/publicatications /hydrogen_infrastructure_safety_analysis/html/section _25_02.html	

Section	Requirement	Narrative	Required References
	5807.1.9 Refilling of containers. The refilling of *listed* or *approved metal hydride storage systems* shall be in accordance with the *listing* requirements and manufacturer's instructions.	The *AHJ* may request that the documentation for the use of un*listed* storage systems provide *approval* the basis for the safe refilling of the *containers* to include any standards referenced. *Metal hydride storage systems* are *pressure vessels* that have unique features to safely contain the *metal hydride* materials. It is insufficient to put *metal hydride* material into a *pressure vessel* without proper design considerations. Refer to the requirements of IFC Sections 5807.1.2 through 5807.1.5. The manufacturer's operating instructions for refilling *containers* are essential elements of safety necessary to maintain the integrity of the *metal hydride storage system*. The *AHJ* may determine *approval* of the storage system based in part on the instructions provided.	
	5807.1.9.2 Hydrogen purity. The purity of hydrogen used for the purpose of refilling *containers* shall be in accordance with the *listing* and the manufacturer's instructions.	There are several standard grades of purity for hydrogen, both in gaseous or liquid form, that are used for commercial sale. In addition, there are numerous processes that may use, produce, or process hydrogen of varying purity that is acceptable for that particular process piece of equipment, even if not one of the standard purity grades. The purity of hydrogen can significantly affect a process or its associated equipment. A specific commercial grade of hydrogen purity is not necessary to be maintained, but the purity of hydrogen should remain within the process conditions for which a piece of equipment was designed. Certain off-specification impurities can have a harmful effect on equipment that could lead to unsafe conditions.	

Section	Requirement	Narrative	Required References
5808 Hydrogen Fuel Gas Rooms			
	5808.5 Gas detection system. *Hydrogen fuel gas rooms* shall be provided with an *approved flammable gas detection system* in accordance with Sections 5808.5.1 through 5808.5.4.	For *gas detection systems*, refer to Sections 2311.7.2.1 and 2311.7.2.1.1.	
	5808.5.1 System design. The *flammable gas detection system* shall be *listed* for use with hydrogen and any other *flammable gases* used in the *hydrogen fuel gas room*. The *gas detection system* shall be designed to activate when the level of *flammable gas* exceeds 25 percent of the *lower flammable limit* (*LFL*) for the gas or mixtures present at their anticipated temperature and pressure.	For *gas detection systems*, refer to Sections 2311.7.2.1 and 2311.7.2.1.1.	
	5808.5.2 Gas detection system components. *Gas detection system* control units shall be *listed* and *labeled* in accordance with UL 864 or UL 2017. Gas detectors shall be *listed* and *labeled* in accordance with UL 2075 for use with the gases and vapors being detected.	See the discussion in Section 2311.7.2.1.1 of the IFC, and in Section 6.12.1 of NFPA 2 in the narrative of this guide.	

International Fuel Gas Code

Requirement	Narrative	Required References
101.2.1 Gaseous hydrogen systems. *Gaseous hydrogen systems* shall be regulated by Chapter 7.	Only *gaseous hydrogen systems* and not liquid hydrogen systems are defined in the IFGC, but there is a definition for *liquefied hydrogen system* found in NFPA 2. See Chapter 3 of this guide for definitions.	
101.2.4 Systems, appliances and equipment outside the scope. This code shall not apply to the following: 1. Portable LP-gas *appliances* and *equipment* of all types that is not connected to a fixed fuel *piping system*. 2. Installation of farm *appliances* and *equipment* such as brooders, dehydrators, dryers and irrigation *equipment*. 3. Raw material (feedstock) applications except for *piping* to special atmosphere generators. 4. Oxygen-fuel gas cutting and welding systems. 5. Industrial gas applications using gases such as acetylene and acetylenic compounds, hydrogen, ammonia, carbon monoxide, oxygen and nitrogen. 6. Petroleum refineries, pipeline *compressor* or pumping stations, loading terminals, compounding plants, refinery tank farms and natural gas processing plants. 7. Integrated chemical plants or portions of such plants where flammable or combustible liquids or gases are produced by, or used in, chemical reactions. 8. LP-gas installations at utility gas plants. 9. Liquefied natural gas (LNG) installations.	Item 5 exempts hydrogen systems, *appliances*, and equipment used for industrial applications from regulation under the requirements of the IFGC. The IFGC appears to be limited to the regulation of these systems in occupancies other than those deemed to be industrial, lacking a formal interpretation and a definition for industrial gas applications. Within the I-Codes, the term “industrial” is found in the term “Factory Industrial Occupancy,” and its two subcategories include Factory Industrial Moderate Hazard Occupancy and Factory Industrial Low Hazard Occupancy uses. One way to interpret the code would be that the requirements of Chapter 7 would apply to uses of hydrogen in businesses, including those engaged in activities associated with mercantile or commercial operations, while those engaged in factory or uses other than mercantile or commercial uses would be exempt from these requirements. System designers should discuss the application of the code with the *AHJ* in the planning phase in order to determine the applicability of the IFGC to the systems to be installed.	

Requirement	Narrative	Required References
10. Fuel gas *piping* in power and atomic energy plants. 11. Proprietary items of *equipment*, apparatus or instruments such as gas-generating sets, *compressors* and calorimeters. 12. LP-gas *equipment* for vaporization, gas mixing and gas manufacturing. 13. Temporary LP-gas *piping* for buildings under construction or renovation that is not to become part of the permanent *piping system*. 14. Installation of LP-gas systems for railroad switch heating. 15. Installation of hydrogen gas, LP-gas and compressed natural gas (CNG) systems on vehicles. 16. Except as provided in Section 401.1.1, gas *piping*, meters, gas *pressure regulators* and other appurtenances used by the serving gas supplier in the distribution of gas, other than undiluted LP-gas. 17. Building design and construction, except as specified herein. 18. *Piping systems* for mixtures of gas and air within the flammable range with an operating pressure greater than 10 psig (69 kPa gauge). 19. *Portable fuel cell appliances* that are neither connected to a fixed *piping system* nor interconnected to a power grid.		

<table>
<tr><th>Requirement</th><th>Narrative</th><th>Required References</th></tr>
<tr><td>633.1 General. Stationary fuel-cell power systems having a power output not exceeding 10 MW shall be tested in accordance with ANSI CSA America FC 1 and shall be installed in accordance with the manufacturer’s instructions, NFPA 853, the International Building Code and the International Fire Code.</td><td>ANSI/CSA America FC-1 limits the testing of fuel cell systems with capacities greater than 10 MW to those that use natural gas or LP-Gas as a source of fuel.[44]

Requirements for elements of construction or fire protection in the Building Code and Fire Code supersede requirements of NFPA 853, Standard for the Installation of Stationary Fuel Cell Power Systems.

The full understanding of where other differences may lie requires a comparative review of the proposed installation as described by NFPA 853 vs. the requirements of the applicable I-Codes. Installation in accordance with the requirements of NFPA 853 related to the siting of fuel cell power systems as found in NFPA 853, Section 5.1.1, can be used as an example where the requirements of the IBC or IFC may supersede those of the NFPA standard.

<table>
<tr><th>NFPA 853</th><th>IBC, IFC, IMC</th></tr>
<tr><td>Equipment to be placed on a firm foundation capable of supporting the equipment. The equipment is required to be anchored, located and protected in a manner that protects it from being adversely affected by the elements, i.e., rain, snow, ice, wind, seismic events, and lightning. In addition, the foundation is to be above the base flood elevation. [NFPA 853: 5.1.1 Items (1) through (3)</td><td>The specific loads to be considered in design depend in part on the purpose of the power supply system. In general the foundation will likely be viewed as a structure and requirements of IBC Chapter 16, Structural Design, will apply. If the power system is intended to serve essential facilities such as those described by IBC Table 1604.5, there are a number of elements to be considered that may have an additional impact on the foundation used to support the equipment,</td></tr>
</table>
</td><td>NFPA 853, Standard for the Installation of Stationary Fuel Cell Power Systems, 2015 Edition, National Fire Protection Association

International Fire Code 2015, International Code Council</td></tr>
</table>

Requirement	Narrative		Required References
		including environmental factors such as wind and snow. *Flood hazard areas* are designated by the jurisdiction in which the equipment is to be installed. Where *flood hazard areas* are not designated, the building official can require the use of a special study to determine the impact of flood events [IBC: 1612.3.1]. If the structure is to be located in a *flood hazard* area, design must be in compliance with American Society of Civil Engineers (ASCE) 7 and applicable engineering standards of the ASCE [IBC: 1612.4]	
	Equipment is to be sited to that the power system and related equipment do not affect required building exits, during normal operation or fire emergencies [NFPA 853: 5.1.1 (6)]	The required exits are determined by Chapter 10 of the building code (IBC). The requirements for *accessible* areas including egress from areas required to be *accessible* are found in IBC Chapter 11. The requirements in areas required to be accessible vary based on the location of the equipment if installed indoors. There are some exemptions for egress in *equipment spaces* that may apply [IBC 1103.2.9]. The	

Requirement	Narrative		Required References
		required building exits must be determined from as built plans for existing buildings or from the proposed plans for new construction, taking into account the occupancies of the space where the equipment is to be located.	
	Vents or exhaust termination points to be separated from doors, windows, outdoor air intakes, and other openings into a building [NFPA 853: 5.1.1 (7)]	IBC Section 2801 requires mechanical *appliances*, equipment, and systems to be constructed, installed, and maintained in accordance with the IMC. The provisions in NFPA 853 are established to avoid the potential release of hydrogen from equipment installed outdoors that may be able to be entrained into an adjacent structure. Whether the equipment is indoors where the collection of vapors is then exhausted and released outdoors, or the installation is outdoors where the release of vapors originates with a *ventilation* or exhaust system, the same concerns exist. IMC Sections 501.3 and 501.3.1 address the termination point	

Requirement	Narrative		Required References
		for exhaust outlets to avoid introduction of vented vapors into the *ventilation* system of buildings and structures. Hydrogen released in gaseous form is a *flammable vapor*: The termination point of exhaust outlets and ducts discharging to the outdoors shall be located with the following minimum distances: 1. For ducts conveying explosive or *flammable vapors*, *fumes*, or dusts: • 30 feet (9144 mm) from property lines; • 10 feet (3048 mm) from operable openings into buildings; • 6 feet (1829 mm) from exterior walls and roofs; • 30 feet (9144 mm) from combustible walls and operable openings into buildings which are in the direction of the exhaust discharge; • 10 feet (3048 mm) above adjoining grade.	
	Fuel cell power systems and associated equipment, components, and controls	Greater distances may apply in recognition that hydrogen or other *flammable gases* or liquids	

Requirement	Narrative		Required References
	must be located 5 feet away from stored combustible materials, hazardous chemicals, high piled combustible stock, and other exposures to fire hazards [NFPA 853: 5.1.1 (9).	may be present within equipment, including associated fuel supplies. The location of the fuel supply may result in greater distances being required if the fuel supply is contained as an integral component of the power system. The required distances can vary depending on the materials and components involved. The term "exposure" as addressed by this section relates to a fire in the *fuel cell power system* and related components that may expose other materials in the proximate area to the effects of a fire. The term "hazardous chemical" has been replaced by *hazardous material* in codes published by NFPA and ICC, including NFPA 400, *Hazardous Materials Code,* and NFPA 1, *Fire Code*. An example is the requirement to separate *flammable gases* from incompatible materials, such as oxygen, by a minimum distance of 20 feet. The use of distance is only one way to achieve the needed separation.	

Requirement	Narrative	Required References
	Fire barriers and certain enclosures can also provide separation, all of which are intended to prevent a conflagration should a fire occur. General requirements for separation can be found in IFC Section 5003.9.8. For general requirements pertaining to *cylinders, containers,* and *tanks* containing *compressed gases* in storage or use, see IFC Section 5303.7.1 There are parallel requirements published in NFPA 400 as well as NFPA 1. The 2015 Fuel Gas Code does not give direction for testing of fuel-cell power systems with a power output exceeding 10 MW; however, the requirements for the installation of stationary power systems of any size can be found in NFPA 853, the IBC, and IFC. There are no fuel cell specific requirements established in the IFC, but the fuels used for operation of a system may be regulated based on individual hazards. For example, if hydrogen is used as a fuel for the system, the applicable requirements specific to the storage and use of hydrogen in IFC Chapters 50, 53, and 58 would apply.	

Requirement	Narrative	Required References
703.1 Hydrogen-generating and refueling operations. Hydrogen-generating and refueling *appliances* shall be installed and located in accordance with their *listing* and the manufacturer and refueling *appliances* shall be installed and located in accordance with 703.1.1, 703.1.2 or 703.1.3 in public garages, private garages, *repair garages*, automotive motor fuel-dispensing facilities and parking garages that contain *hydrogen-generating appliances* or refueling systems. For the purpose of this section, rooms or spaces that are not part of the living space of a *dwelling unit* and that communicate directly with a private garage through openings shall be considered to be part of the private garage.	The potential exists for *listing* standards to require additional *ventilation* or restrictions applicable to *ventilation* other than those found in the code. Conditions can exist where the requirements of the *listing* are more restrictive than the requirements of the code. *Note: Where there are conflicts between the code and the listing for a listed item of equipment or appliance such that the application of the requirements of the code would violate the requirements of the listing, the requirements of the listing would take precedent.* *For additional information, see 2015 IFGC Section 102.8 and its Exception, and 102.8.1 regarding conflicts.*	
703.1.1 Natural ventilation. Indoor locations intended for hydrogen-generating or refueling operations shall be limited to a maximum floor area of 850 square feet (79 m^2) and shall communicate with the outdoors in accordance with Sections 703.1.1.1 and 703.1.1.2. The maximum rated output capacity of *hydrogen generating appliances* shall not exceed 4 standard cubic feet per minute (0.00189 m^3/s) of hydrogen for each 250 square feet (23.2 m^2) of floor area in such spaces. The minimum cross-sectional dimension of air openings shall be 3 inches (76 mm). Where ducts are used, they shall be of the same cross-sectional area as the free area of the openings to	IFGC Section 703.1.1 and its subparts apply to *automotive motor fuel-dispensing facilities* as well as to *public, private, repair,* and *parking garages* when hydrogen generators or *appliances*, or fueling devices, are located within the space. Historically, the codes have established a *ventilation* rate using either natural or mechanical *ventilation* at a rate to dilute the anticipated release of gas-air mixtures to a concentration below 25% of their *lower flammable limit* (*LFL*). The use of 25% as the threshold provides a safety factor of 4 which accounts for variable conditions that may exist in the LFL as reported as well as ambient or environmental conditions in which such mixtures may be found. It is also recognized by the codes that in any release of a *flammable gas* there exists a flammable envelope that forms near the point of release where higher concentrations exist, and dilution is not	*International Code Council, 2002 Final Action Agenda for the Proposed Changes to the 2000 Editions of the International Codes,* October 1-5, 2002, Code Changes M7-02 and FG15-02, pp. 458-465 and 491-494 respectively.

Requirement	Narrative	Required References
which they connect. In such locations, *equipment* and *appliances* having an *ignition source* shall be located such that the source of ignition is not within 12 inches (305 mm) of the ceiling. **703.1.1.1 Two openings.** Two permanent openings shall be provided within the garage. The upper opening shall be located entirely within 12 inches (305 mm) of the ceiling of the garage. The lower opening shall be located entirely within 12 inches (305 mm) of the floor of the garage. Both openings shall be provided in the same exterior wall. The openings shall communicate directly with the outdoors and shall have a minimum free area of 1/2 square foot per 1,000 cubic feet (1 m^2/ 610 m^3) of garage volume. **703.1.1.2 Louvers and grilles.** In calculating the free area required by Section 703.1.1.1, the required size of openings shall be based on the net free area of each opening. If the free area through a design of louver or grille is known, it shall be used in calculating the size opening required to provide the free area specified. If the design and free area are not known, it shall be assumed that wood louvers will have 25-percent free area and metal louvers and grilles will have 75-percent free area. Louvers and grilles shall be fixed in the open position.	instantaneous. The 25% limit assumes a homogeneous mixture. Regardless of the type of *ventilation* provided, e.g., natural or mechanical, the risk of ignition is not eliminated. The requirements of Sections 703.1.1 and 703.1.2 have been established by computational fluid dynamics modeling and analysis performed circa 2000 by Professor Michael Swain and colleagues at the University of Miami in Coral Gables, Florida. The area chosen for modeling was a ventilated garage with a room volume of 2,350 cubic feet (floor area of 256 square feet) and leak rates of 1.0, 4.0 and 13.0 standard cubic feet per minute (SCFM) were evaluated in both naturally ventilated and unventilated garages. Several of the key results leading to the requirements now established in the code include the following:	

Requirement	Narrative	Required References
703.1.2 Mechanical ventilation. Indoor locations intended for hydrogen-generating or refueling operations shall be ventilated in accordance with Section 502.16 of the *International Mechanical Code*. In such locations, *equipment* and *appliances* having an *ignition source* shall be located such that the source of ignition is below the mechanical *ventilation* outlet(s). **703.1.3 Specially engineered installations.** As an alternative to the provisions of Section 703.1.1 and 703.1.2 (provided below for information), the necessary supply of air for *ventilation* and dilution of *flammable gases* shall be provided by an *approved* engineered system.	• Using a leak rate of 4.0 SCFM for a period of 20 minutes in a naturally ventilated garage with upper and lower openings, the ignitable layer of gas (hydrogen concentrations greater than 4%) in the ventilated space was about 11 inches thick accumulating at the ceiling level.[45] • A 13 SCFM hydrogen release for a period of 20 minutes with the same *natural ventilation* produced an ignitable layer at the ceiling that was 22 inches thick. • The same 13 SCFM release into an unventilated garage almost completely filled the entire garage with an ignitable mixture. The requirement to prohibit the installation of *appliances* with ignition sources within 12 inches of the ceiling found in Section 703.1.1 is based on a leak rate of 4.0 SCFM in a naturally ventilated garage. Section 703.1.2 applicable to hydrogen-generating and refueling operations directs the user to requirements of the *IMC* designated for use in *repair garages* whenever the space is used for hydrogen generating or refueling operations. Key features include requirements for the following: • An *approved* mechanical ventilating system is required for areas used as *repair garages* when used for the repair of hydrogen fueled vehicles. • Inlets serving the *ventilation* system are required to be installed proximate to floor level. Outlets are required to be installed at the high point of the room or space either on the exterior walls or on the roof. • When mechanical *ventilation* is provided, the *ventilation* is required to be continuous and set to be activated by a *flammable gas detection system* that detects hydrogen at 25% of the LFL or 1% by volume. In addition, sensing at the LFL requires that	

Requirement	Narrative	Required References
	hydrogen fueling systems be shut down. • The rate of exhaust *ventilation* is required to be not less than 1 cubic foot per minute per 12 cubic feet of room volume. The term "specially engineered" is not defined in the IFGC, but requirements are established for *design professionals* and others when construction documents or ancillary calculations, diagrams, and other data may be required to document the design. The administrative provisions of the IFGC in Section 106.3.1 require the use of a *registered design professional* when construction documents are furnished as an element of the permit request. Within the context of the IFGC, design professionals must be registered. The expectation of the *AHJ* is that any design produced should provide equivalent or superior safety to that established by the code. To be *approved*, the specially engineered system designer should demonstrate that the proposed design is equivalent to or better than what is otherwise required under the prescriptive requirements Sections 703.1.1 and 703.1.2.	
703.4 Venting. Relief device vents shall be terminated in an *approved* location in accordance with Section 2309 of the International Fire Code.	The termination point for relief devices is of concern to ensure that the public, employees, and property are not exposed to the effects of ignition should a release from a *pressure relief device* occur. *Pressure relief devices* fall into two general categories: 1) relieve over-pressure in a *piping* or storage system to prevent the rupture of the system due to over-pressurization, or 2) to vent gas from the system as the result of a fire or other thermal event. In either case, the release of hydrogen through the relief device is preferable to an uncontrolled rupture of the system. Standards for design of venting systems, including points of termination for vent stacks serving PRV systems, are found in CGA G-5.5, *Hydrogen Vent Systems*.[39] Reference to CGA G-5.5 is not specified within the I-Codes by direct reference, but its use is	CGA S-1.1-2011, *Pressure Relief Device Standards—Part 1—Cylinders for Compressed Gases*, Compressed Gas Association CGA S-1.2-2005, *Pressure Relief Device Standards—Part 2—Cargo and Portable Tanks for Compressed Gases*, Compressed Gas Association

Requirement	Narrative	Required References
	required by NFPA 2, which is specifically referenced by IFC Section 5301.1. Section 7.3.3 of CGA G-5.5 contains the requirements for arrangement for the discharge of *pressure relief devices* and venting systems. The potential for ignition at the point of discharge from the vent must be considered as hydrogen is released and mixed with air. Therefore, the point of discharge must take ignition of the release into consideration. In general, the discharge of *flammable gases* is to be directed upward to open air. The termination point for vent stacks is normally through a pipe with a tee configuration, with the branches of the tee angled down to avoid the entrainment of rain or other weather such as freezing snow or water that may plug the vent. The termination point from the legs of the tee should be designed to discharge the plume in an upward direction relative to the branch. The branches of the tee can be arranged at a downward angle in order to minimize the elements from entering the discharge system. Detailed drawings are provided by CGA-G5.5. The height of the point of termination or discharge from storage *containers* is dependent on pipe diameter and the velocity of discharge. Specific requirements for vent pipe discharge were established in the 2006 Edition of the IFC, and later removed from the code through reference to CGA G-5.5, which has been incorporated into NFPA 2. The former IFC requirements related to vent stacks serving vehicular fueling systems illustrate separation distance for points of termination from the vent stack in terms of height and location based on flow rate for small diameter *piping systems* i.e., *piping* < 3 inches in diameter). Additional and detailed information on the construction of vent pipes is included in the 2006 IFC, Section 2209.5.4.[40] The use of this material is consistent with the performance requirements of CGA G-5.5. The requirements as they were included in the 2006 Edition are provided below for illustration:	CGA S-1.3-2008, *Pressure Relief Device Standards—Part 3—Stationary Storage Containers for Compressed Gases*, Compressed Gas Association *International Fire Code,* 2006 Edition, International Code Council, p. 209. CGA G-5.5, 2004 Reaffirmed 2007, *Hydrogen Vent Systems, Second Edition,* Compressed Gas Association, NFPA 55, *Compressed Gases and Cryogenic Fluids Code, 2013 Edition,* National Fire Protection Association

Requirement	Narrative	Required References

2006 IFC, 2209.5.4.3.5 Height of vent and separation. The height (H) and separation distance (D) of the vent pipe shall meet the criteria set forth in Table 2209.5.4.3.4 for the combinations of maximum hydrogen flow rates and vent stack opening diameters *listed*. Alternative venting systems shall be allowed when in accordance with Section 2209.5.4.3.6.

2006 IFC Table 2209.5.4.3.4
VENT PIPE HEIGHT AND SEPARATION DISTANCE
VERSUS HYDROGEN FLOW RATE AND VENT PIPE DIAMETER [a,b,c,d,e,f]

Hydro-gen Flow Rate	</=500 CFM at NTP[g]	>500-</=1000 CFM at NTP[g]	>1,000-</=2,000 CFM at NTP[g]	>2,000-</=5,000 CFM at NTP[h]	>5,000-</=10,000 CFM at NTP[h]	>10,000-</=20,000 CFM at NTP[h]
Height (ft.)	8	8	12	17	25	36
Distance (ft.)	13	17	26	40	53	81

For SI: inch = 25.4 mm, 1 foot = 304.8 mm, 1 Btu/ft^2 = 3.153 W/m^2, 1 foot/second = 304.8 mm/sec.

a. Minimum distance to lot line is 1.25 the separation distance.
b. Designs seeking to achieve greater heights with commensurate reductions in separation distances shall be designed in accordance with accepted engineering practice.
c. With this table personnel on the ground or on the building/equipment are exposed to a maximum of 1,500 BTU/hr-ft^2, and are assumed to be provided with a means to escape to a shielded area within three minutes, including the case of a 30 ft/sec. wind.
d. Designs seeking to achieve greater radiant exposures to noncombustible equipment shall be designed in accordance with accepted engineering practice.
e. The analysis reflected in this table assumes that hydrogen/air mixtures do not exceed one-half of the *lower flammable limit* (*LFL*) for hydrogen (2 percent by volume) at the building, equipment or lot line, including the case of a 30 ft. /sec. wind.
f. See Figure 2209.5.4.3.5.

Requirement	Narrative	Required References
	g. For vent pipe diameters up to and including 2 inches. h. For vent pipe diameters up to and including 3 inches. Requirements in the 2015 Editions of the I-Codes are primarily focused on potential contact with personnel, the *container* or adjacent structures. The IFC, and NFPA 55, *Compressed Gases and Cryogenic Fluids Code,* all establish similar requirements with respect to points of termination for relief valves. The 2015 IFC Chapter 53 provides the general requirements for *compressed gases*. Section 5303.3.4 establishes the following requirement for relief valves on a *gaseous hydrogen system*: **2015 IFC, 5303.3.4** *Pressure relief devices* shall be arranged to discharge upward and unobstructed to the open air in such a manner as to prevent any impingement of escaping gas upon the *container*, adjacent structures or personnel. An exception is added to exempt small *containers* with a water volume of 30 cubic feet or less. Hydrogen in its cryogenic form is regulated by the 2015 IFC in Chapter 55. Section 5503.2.5 establishes the following requirements: **2015 IFC, 5503.2.5** *Pressure relief devices* shall be arranged to discharge unobstructed to the open air in such a manner as to prevent impingement of escaping gas on personnel, *containers*, equipment and adjacent structures or to enter enclosed spaces. An exception is added to exempt small *containers* with a water volume of 2 cubic feet or less. The 2015 IFC Section 5303.16.12 establishes requirements for vents discharging from gas systems or storage inside of buried vaults.	

Requirement	Narrative	Required References
	2015 IFC, 5303.16.12 Vent pipes for equipment in the vault shall terminate not less than 12 feet (3658 mm) above ground level.	
704.1 Applicability. Use and handling of *containers*, *cylinders*, *tanks* and *hydrogen gas systems* shall comply with this section. *Gaseous hydrogen systems*, equipment and machinery shall be *listed* or *approved*.	The hydrogen industry has successfully built, installed, and used *containers*, *cylinders*, and *tanks* in hydrogen service prior to the issuance of this code. These vessels are used to supply numerous applications and are not designed for any particular use of hydrogen. If the storage vessels met standards for hydrogen service at the time of manufacture, and are *approved* by the *AHJ*, they are acceptable for use. For standards of design used for *cylinders, containers*, *and tanks* serving *gaseous hydrogen systems*, see IFC Section 5303.2. For standards of design for *tanks* used for liquid hydrogen service, see IFC Section 5806.3. Components used in the assembly of hydrogen systems include *piping*, valves, fittings, regulators, pressure gauges, and measurement and sensing devices. There are no current *listing* standards for the broad category of *gaseous hydrogen systems per se*. There may be cases where a specific item of equipment uses components that are specified by a *listing* standard. In such cases, the components may have been incorporated into a package such that the components are part of the *listing*. To be *approved*, a *gaseous hydrogen system* must comply with the requirements of the IFC. Bulk systems are defined as systems with a contained volume of 5,000 cubic feet or more, and for detailed requirements, the IFC refers the user to NFPA 55, *Compressed Gases and Cryogenic Fluids Code.* The NFPA 55 requirements are supplemental and in addition to those found in Chapters 53 and 58 of the IFC.	*International Fire Code,* 2015 Edition, International Code Council NFPA 55, *Compressed Gases and Cryogenic Fluids Code, 2013 Edition,* National Fire Protection Association

Requirement	Narrative	Required References
704.1.2.1 Sizing. Gaseous hydrogen *piping* shall be sized in accordance with *approved* engineering methods.	*Piping systems* are sized based on demand. In order to be *approved*, the design must conform to the general requirements of the IFGC. The IFC in Section 105.1.2 requires that the applicant obtain construction and operational permits for compressed and cryogenic bulk and non-*bulk gas systems*. Designs that require construction documents within the context of the IFGC must be prepared by a *registered design professional*. See the discussion relative to the use of a design professional under the comments to IFGC Section 703.1.1 above.	*International Fire Code,* 2015 Edition, International Code Council
704.1.2.3 Piping design and construction. *Piping* and tubing materials shall be 300 series stainless steel or materials *listed* or *approved* for hydrogen service and the use intended through the full range of operating conditions to which they will be subjected. *Piping systems* shall be designed and constructed to provide allowance for expansion, contraction, vibration, settlement and fire exposure.	ASME B31 codes or other *approved* standards may serve as the basis for *approval*. Two ASME standards that are commonly used in the design of hydrogen *piping systems* include ASME B31.3, *Process Piping*, and ASME B31.12, *Hydrogen Piping and Pipelines*.[46] Both documents inform the basis for detailed design. ASME B31.3 defines the term *listed* to describe a material or component that conforms to a specification referenced within the ASME code, and it is not equivalent to the term *listing* as defined by the IFGC. For example, the ASTM A403 Standard specification is one of the *listed* standards used for wrought austenitic stainless steel fittings for pressure *piping* applications. Although the term *listed* is not defined in ASME B31.12, it is used in the same manner as in B31.3. In addition to allowing the use of components that are *listed*, the ASME B31 codes allow the use of components that are not *listed*, as long as they are qualified.	
704.1.2.3.3 Underground piping. Underground *piping*, including joints and fittings, shall be protected from corrosion and installed in accordance with *approved* engineered methods.	*Piping* in contact with the earth may corrode if improperly installed. There are numerous combinations of *piping* materials and soil conditions. The *AHJ* should review documentation provided by the designer that would indicate that the choice of materials is suitable. Another approach is to avoid contact with ground materials by using appropriate sleeves or other isolation barriers.	

Requirement	Narrative	Required References
	If the system requires construction drawings or any of the elements that fall under IFGC Section 106.3.1, the use of a *registered design professional* may be required depending on the laws of the local jurisdiction.	
704.1.2.4 Joints. Joints in *piping* and tubing in hydrogen service shall be *listed* as complying with ASME B31.3 to include the use of welded, brazed, flared, socket, slip and compression fittings. Gaskets and sealants used in hydrogen service shall be *listed* as complying with ASME B31.12. Threaded and flanged connections shall not be used in areas other than hydrogen cutoff rooms and outdoors.	ASME B31.3 defines the term *listed* to describe a material or component that conforms to a specification referenced within the ASME code, and it is not equivalent to the term *listing* as defined by the IFGC. For example, the ASTM A403 Standard specification is one of the *listed* standards used for wrought austenitic stainless steel fittings for pressure *piping* applications. Although the term *listed* is not defined in ASME B31.12, it is used in the same manner as in B31.3. Even though the code has few relevant requirements, the use of ASME B31.12, *Hydrogen Piping and Pipelines*, is required for gaskets and sealants to be used in hydrogen service. ASME B31.12 is a relatively new document published by ASME and is closely aligned with ASME B31.3 for *piping*. There are differences between the documents, especially for *piping systems* where higher pressures are involved. The document used in design is normally used consistently throughout the *piping system*, and ASME does not envision that users design some portions of the system to one code and other portions to another code. The owners of the system should verify which ASME code will be accepted for use by the *AHJ* before design and construction. The 2015 Edition of the IFGC uses the term *hydrogen cutoff room*, which appears to be an editorial error. This term was revised to be a *hydrogen fuel gas room* in the 2015 Editions of the IFC and IBC. Users should refer to the definition of *hydrogen fuel gas room* for further understanding.	ASME B31.3-2014, *Process Piping* Standard by ASME International, 02/27/2015, The American Society of Mechanical Engineers ASME B31.12-2014, *Hydrogen Piping and Pipelines* Standard by ASME International, 02/20/2015 The American Society of Mechanical Engineers

Requirement	Narrative	Required References
704.1.2.5 Valves and piping components. Valves, regulators and *piping* components shall be *listed* or *approved* for hydrogen service, shall be provided with access and shall be designed and constructed to withstand the maximum pressure to which such components will be subjected.	A number of *listing* standards have been published that address equipment at the component level, but a number of the more recent standards lean toward the use of hydrogen as an automotive fuel. The following *listing* standards have been published by the following *listing* entities:[47] CSA Group (formerly the Canadian Standards Association): • CSA HGV 4.1, *Hydrogen Dispenser* - published April 2013 • CSA HGV 4.2, *Hoses* - published April 2013 • CSA HGV 4.4, *Breakaway Devices* - published April 2013 • CSA HGV 4.6, *Manual Valves for use in Hydrogen Fueling Stations(s)* - published March 2013 • CSA HGV 4.7, *Automatic Valves for use in Hydrogen Fueling Station(s)* - published March 2013 • CSA HGV 4.8, *Fueling Station Compressor* - published January 2013 • CSA HGV 4.10, *Fittings* - published May 2012 UL Hydrogen Component Standards include the following: • UL 2267, *Standard for Safety of Fuel Cell Power Systems for Installation in Industrial Electric Trucks* • UL 2075, *Standard for Gas and Vapor Detectors and Sensors* • UL 2264, *Standard for Safety of Gaseous Hydrogen Generators* • UL 2265, *Standard for Safety of Hand-Held or Hand Transportable Fuel Cell Power Units with Fuel Containers* FM Global Hydrogen Component Standards include the following: • 3010, *Fire Alarm Signaling Systems* • 3600, *Electrical Equipment for Use In Hazardous (Classified) Locations - General Requirements* • 3610, *Intrinsically Safe Apparatus and Associated Apparatus for*	

Requirement	Narrative	Required References
	Use in Class I, II & III, Division 1, Hazardous (Classified) Locations • 6320, *Combustible Gas Detectors*	
705.2 Inspections. Inspections shall consist of a visual examination of the entire *piping system* installation and a pressure test. Hydrogen *piping systems* shall be inspected in accordance with this code. Inspection methods such as outlined in ASME B31.12 shall be permitted where specified by the design engineer and *approved* by the code official. Inspections shall be conducted or verified by the code official prior to system operation.	ASME B31.12 uses the term "examination" rather than "inspection" as described in this section of the code. Within the context of B31 codes, the term "visual examination" requires the examination of joints, and other *piping* elements that are or can be exposed to view before, during, or after manufacture, fabrication, assembly, erection, or testing. The examination typically includes verification of code and engineering design requirements for materials, components, dimensions, joint preparation, alignment, welding, bonding, or other joining methods, supports, assembly, and erection.[48] Testing of *piping systems* by the code official is not a normal circumstance. The role of the code official is to verify that the design of the *piping system* is in accordance with the requirements of the code. The role is one of oversight and not as participant in conducting a test program. The code official could ask one of the inspectors employed by the jurisdiction to witness the tests conducted on the system or to require that an independent third-party witness the tests on behalf of the jurisdiction. ASME B31.12 requires that the owner's inspector verify that the examination and testing of the *piping* was done in accordance with the requirements of the code. *Piping* integral to equipment that is addressed by a *listing* that has requirements for design, fabrication, examination, and testing of that *piping* is not within the scope of the ASME documents; rather, it is governed by the *listing*. The *listing* standards may cite the B31 series of documents or other codes or standards as pertinent to the *listing*. Other *piping* is within the scope of the ASME codes, including *piping* for un*listed* equipment supplied as part of an assembly.	ASME B31.12-2014, *Hydrogen Piping and Pipelines*, American Society of Mechanical Engineers

Requirement	Narrative	Required References
705.3 Pressure tests. A hydrostatic or pneumatic leak test shall be performed. Testing of hydrogen *piping systems* shall utilize testing procedures identified in ASME B31.12 or other *approved* methods, provided that the testing is performed in accordance with the minimum provisions specified in Sections 705.3.1 through 705.4.1.	It is common to perform a pneumatic leak test as an alternative to using a hydrostatic test so that the system remains dry. Compressed air, nitrogen, helium, and argon are typically used in lieu of carbon dioxide or other inert gases. There are test methods that can be used that expedite the determination of leaks by detection methods other than pressure decay, and the use of pressure decay to test hydrogen systems is not permitted by ASME B31.12, resulting in a potential conflict between ASME B31.12 and IFGC Section 705.3.5. The difficulty with pressure decay is that leaks on large capacity systems are difficult to determine due to the potentially large volume of test gas in the system and the lack of sensitivity represented by the pressure gages used. Temperature effects also influence a static pressure check as the temperature in the system varies throughout the day. More sensitive methods include the introduction of a tracer gas to the pressurizing atmosphere and using a detector probe to determine where a leak may occur. Bubble leak testing is frequently used as a sensitive means to determine leakage locations. Hydrogen gas molecules are quite small and even small leaks are of concern to users, installers, and inspectors alike. It should not be unusual for an installer to make a request to the *AHJ* for the use of "other" methods. *AHJ*s should question how and why the other methods may meet or exceed those required by the code. The use of any other method should be documented with a record of the procedures kept in the files of the jurisdiction. In the use of tracer gas testing, the system is pneumatically pressurized with an atmosphere of the test gas to the specified pressure. Outboard leakage from the *piping system* can be found using a leak detector that is sensitive to the tracer gas. Examples of tracer gas may include helium and sulfur hexafluoride, which can be used exclusively or in combination as a mixture in the pneumatic atmosphere, e.g. a mixture of helium and nitrogen or of nitrogen and sulfur hexafluoride or other inert such as a halocarbon.	

Requirement	Narrative	Required References
	The Nondestructive Testing Handbook explains a wide array of testing processes found in everyday application. The bubble leak process is explained in general terms as follows: A bubble leak test typically involves the use of a leak detector solution. In using a bubble leak test a thin film of test liquid is placed in contact with the lower pressure side of the pressure boundary (on the outside of a pipe or fitting that is maintained at the specified test pressure). In bubble tests a leak is indicated by the formation of visible bubbles in the detection liquid at the exist point of the leak. The rate of bubble formation, size of bubbles formed, and the rate of growth in size of individual bubbles provide the means for estimating the size of leaks.[49]	
705.3.6 Test gauges. Gauges used for testing shall be as follows: 1. Tests requiring a pressure of 10 psig (68.95 kPa gauge) or less shall utilize a testing gauge having increments of 0.10 psi (0.6895 kPa) or less. 2. Tests requiring a pressure greater than 10 psig (68.98 kPa gauge) but less than or equal to 100 psig (689.5 kPa gauge) shall utilize a testing gauge having increments of 1 psi (6.895 kPa) or less. 3. Tests requiring a pressure greater than 100 psig (689.5 kPa gauge) shall utilize a testing gauge having increments of 2 psi (13.79 kPa) or less. **Exception:** Measuring devices having an equivalent level of accuracy and resolution shall be permitted where specified by the	Pressure transducers or similar electronic devices are commonly used in sensitive leak testing for *piping systems* of all kinds. To be *approved*, the design engineer should provide documentation that describes the pressure transducers used to include a description of the calibrations conducted. The documentation should address both the resolution and accuracy of the equipment to demonstrate that the transducers are appropriate to the range of pressures to be encountered and that the ability to read pressure is equivalent to or better than that otherwise provided by a typical pressure gauge.	

Requirement	Narrative	Required References
design engineer and *approved* by the code official.		
705.4 Detection of leaks and defects. The *piping system* shall withstand the test pressure specified for the test duration specified without showing any evidence of leakage or other defects. Any reduction of test pressures as indicated by pressure gauges shall indicate a leak within the system. *Piping systems* shall not be *approved* except where this reduction in pressure is attributed to some other cause.	The provisions of the code require that there be no evidence of leakage throughout the required test period. Causes for pressure variation could include environmental as well as changes in ambient temperature conditions. The test method chosen and any allowable pressure drop should be clearly specified by the system designer to include a statement regarding the expected sensitivity of the test in terms that relate pressure drop to size of leak.	

International Mechanical Code

Section	Requirement	Narrative	Required References
301 General			
	301.7 Listed and labeled. *Appliances* regulated by this code shall be *listed* and *labeled* for the application in which they are installed and used, unless otherwise *approved* in accordance with Section 105.	The term *appliance* can include any apparatus or item of equipment that is designed to use energy for which the code provides specific requirements. The 2015 IMC Section 105 and its subsections contain the requirements for code modification and the use of alternate methods, materials, equipment, and *appliances*. The requirements relative to modification and the use of alternate methods are consistent with those in other codes published by the ICC. Section 105 provides the authority to the code official to allow the use of un*listed* equipment on a case by case basis, but in doing so the code grants the code official the power to use judgment as to acceptability.	
303 Equipment and Appliance Location			
	303.2 Hazardous locations. *Appliances* shall not be located in a *hazardous location* unless *listed* and *approved* for the specific installation.	Section 304.5 contains provisions for hydrogen generation systems and refueling *appliances*. Un*listed appliances* cannot be used within a *hazardous location* as defined. The definition of *hazardous location* used by the IMC is similar to the term *hazardous (classified) location* defined by NFPA 70, *National Electrical Code*.[50] The IMC requires that *appliances* that are to be located in a *hazardous location* be *listed* for use in such a location with *approval* to be granted by the *AHJ*. To do so, the classification of the area must be determined during the planning phase and the classification for the area should be designated on plans or construction drawings submitted for permit. Under the requirements of the NEC Article 500, Section 500.6, the	

Section	Requirement	Narrative	Required References
		classification of the area where hydrogen is stored or used under the requirements of the NEC will be Class I (*flammable gases*) with electrical equipment suitable for use with materials classified as Group B. If NEC Article 505 is used in lieu of Article 500, classification will be Class I, Group IIC. If other flammable materials are present, the classification could be different depending on the properties of the materials present. Whether or not a permit is required, the electrical classification in the area intended for the installation of electrically powered equipment should be designated on an electrical plan for the facility in which the equipment is to be installed: 2014 NFPA 70, Section 500.4 (A)	
	303.4 Protection from damage. *Appliances* shall not be installed in a location where subject to mechanical damage unless protected by *approved* barriers.	Barriers should be constructed to protect the equipment from mechanical damage caused by other equipment present or likely to be present in the work area. For areas subject to damage from vehicles, see requirements in Section 312 of the 2015 IFC.	
	303.6 Outdoor locations. *Appliances* installed in other than indoor locations shall be *listed* and *labeled* for outdoor installation.	No special consideration is necessary when the design is coordinated with the requirements described in the referenced provision. Following the instruction provided in the published requirement should result in *approval* of the proposed design.	
	303.7 Pit locations. *Appliances* installed in pits or excavations shall not come in direct contact with the surrounding soil. The sides of the pit or excavation shall be held back not less than 12 inches (305 mm) from the *appliance*. Where the depth exceeds 12 inches (305 mm) below adjoining grade, the walls of the pit or excavation shall be lined with concrete or	Equipment installed in a pit is normally installed on an equipment pad constructed to raise the equipment above floor level. Flooding is unlikely if the pit is located indoors and equipped with a drain or sump designed to collect and drain water that may enter the pit. *Flood hazard areas* are designated by the applicable governing authority and regulated by the building codes. Protection from flooding in *flood hazard areas* should be addressed by a design professional and construction plans should be noted accordingly. See the 2015 IBC Section 1612.	

Section	Requirement	Narrative	Required References
	masonry. Such concrete or masonry shall extend not less than 4 inches (102 mm) above adjoining grade and shall have sufficient lateral load-bearing capacity to resist collapse. The *appliance* shall be protected from flooding in an *approved* manner.	For *appliances* installed in areas outside of designated *flood hazard areas*, no special consideration is necessary when the design is coordinated with the requirements described in the referenced provision. Following the instruction provided in the requirement as published should result in *approval* of the proposed design. See the comments for elevation above grade in Section 304.10.	
304 Installation			
	304.1 General. Equipment and *appliances* shall be installed as required by the terms of their *approval*, in accordance with the conditions of the *listing*, the manufacturer's installation instructions and this code. Manufacturer's installation instructions shall be available on the job site at the time of inspection.	No special consideration is necessary when the design is coordinated with the requirements described in the referenced provision. Following the instruction provided in the published requirement should result in *approval* of the proposed design. The potential exists for *listing* standards to require additional *ventilation* or restrictions applicable to *ventilation* other than those found in the code. Conditions can exist where the requirements of the *listing* are more restrictive than the requirements of the code. Where there are conflicts between the code and the *listing* for a *listed* item of equipment or *appliance* such that the application of the requirements of the code would violate the requirements of the *listing*, the requirements of the *listing* would take precedent. For additional information, see the 2015 IMC, Sections 102.8 and 102.8.1, regarding conflicts.	
	304.3 Elevation of ignition source. Equipment and *appliances* having an ignition source and located in *hazardous locations* and public garages, private garages, *repair garages*, automotive motor fuel-dispensing facilities and parking garages shall be	This provision is limited to garages and *motor fuel dispensing facilities* used for dispensing fuels that have a vapor density greater than that of air. Ignition sources located in proximity to the ceiling or other high points in the room in which the equipment is installed should conform to the requirements of 2015 IMC 304.5.1. No special consideration is necessary when the design is coordinated with the requirements described in the referenced	

Section	Requirement	Narrative	Required References
	elevated such that the source of ignition is not less than 18 inches (457 mm) above the floor surface on which the equipment or *appliance* rests. For the purpose of this section, rooms or spaces that are not part of the living space of a *dwelling unit* and that communicate directly with a private garage through openings shall be considered to be part of the private garage. **Exception:** Elevation of the ignition source is not required for *appliances* that are *listed* as *flammable vapor* ignition resistant.	provision. Following the instruction provided in the published requirement can result in *approval* of the proposed design, providing the *flammable vapor* ignition resistant *listing* is applicable to the materials present based on the most restrictive Group designation as required by NEC Article 500, Sections 500.6(A) and (B) or 505.6(A), (B), and (C). Section 500.6 will apply when the Division system of classification is used, and Section 505.6 will apply when the Zone system of classification is used. Refer to NEC Article 500 for the applicable details.	
	304.10 Clearances from grade. Equipment and *appliances* installed at grade level shall be supported on a level concrete slab or other *approved* material extending not less than 3 inches (76 mm) above adjoining grade or shall be suspended not less than 6 inches (152 mm) above adjoining grade. Such support shall be in accordance with the manufacturer's installation instructions.	No special consideration is necessary when the design is coordinated with the requirements described in the referenced provision. Following the instruction provided in the published requirement should result in *approval* of the proposed design. An example of *other approved material* could include the use of raised platforms constructed of elements suitable for the building in which the equipment is installed. For example, noncombustible platforms would be used in buildings of noncombustible construction.	

Section	Requirement	Narrative	Required References
	304.12 Area served. *Appliances* serving different areas of a building other than where they are installed shall be permanently marked in an *approved* manner that uniquely identifies the *appliance* and the area it serves.	No special consideration is necessary when the design is coordinated with the requirements described in the referenced provision. Following the instruction provided in the published requirement should result in *approval* of the proposed design.	
[FG] 304.5 Hydrogen-generating and refueling operations.			
	[FG] 304.5 Hydrogen-generating and refueling operations. Hydrogen-generating and refueling *appliances* shall be installed and located in accordance with their *listing* and the manufacturer's instructions. *Ventilation* shall be required in accordance with Section 304.5.1, 304.5.2 or 304.5.3 in public garages, private garages, *repair garages*, automotive motor fuel-dispensing facilities and parking garages that contain *hydrogen-generating appliances* or refueling systems. For the purpose of this section, rooms or spaces that are not part of the living space of a *dwelling unit* and that communicate directly with a private garage through openings shall be considered to be part of the private garage.	No special consideration is necessary when the design is coordinated with the requirements described in the referenced provision. Following the instruction provided in the published requirement should result in *approval* of the proposed design. . See the comments under 303.2 and 304.3 above for additional information regarding the conditions of *listing*. If un*listed* equipment is to be used, see the narrative for Section 301.7. Section 304.5 and its subparts apply to *automotive motor fuel-dispensing facilities* as well as to *public, private, repair*, and *parking garages* when hydrogen generators or *appliances*, or fueling devices, are located within the space.	

Section	Requirement	Narrative	Required References
	[FG] 304.5.1 Natural ventilation. Indoor locations intended for hydrogen-generating or refueling operations shall be limited to a maximum floor area of 850 square feet (79 m^2) and shall communicate with the outdoors in accordance with Sections 304.5.1.1 and 304.5.1.2. The maximum rated output capacity of *hydrogen-generating appliances* shall not exceed 4 standard cubic feet per minute (0.00189 m^3/s) of hydrogen for each 250 square feet (23.2 m^2) of floor area in such spaces. The minimum cross-sectional dimension of air openings shall be 3 inches (76 mm). Where ducts are used, they shall be of the same cross-sectional area as the free area of the openings to which they connect. In such locations, equipment and *appliances* having an ignition source shall be located such that the source of ignition is not within 12 inches (305 mm) of the ceiling. **[FG] 304.5.1.1 Two openings.** Two permanent openings shall be provided within the garage. The upper opening shall be located entirely within 12 inches (305 mm) of the ceiling of the garage. The lower opening shall be located entirely within 12 inches	Historically, the model codes have established a *ventilation* rate using either natural or mechanical *ventilation* at a rate sufficient to dilute the anticipated release of gas-air mixtures to a concentration below 25% of their *lower flammable limit* (*LFL*). The use of 25% as the threshold provides a safety factor of 4, which accounts for variable conditions that may exist in the LFL as reported as well as ambient or environmental conditions in which such mixtures may be found. It is also recognized by the codes that in any release of a *flammable gas* there exists a flammable envelope that forms near the point of release where higher concentrations exist, and dilution is not instantaneous. The 25% limit assumes a homogeneous mixture. Regardless of the type of *ventilation* provided, e.g., natural or mechanical, the risk of ignition is not eliminated. The requirements of Sections 304.5.1.1 and 304.5.1.2 have been established by computational fluid dynamics modeling and analysis performed circa 2000 by Professor Michael Swain and colleagues at the University of Miami in Coral Gables, Florida. The area chosen for modeling was a ventilated garage with a room volume of 2,350 cubic feet (floor area of 256 sq. ft.) and leak rates of 1.0, 4.0, and 13.0 SCFM were evaluated in both naturally ventilated and unventilated garages. Several of the key results leading to the requirements now established in the code include the following: • Using a leak rate of 4.0 SCFM for a period of 20 minutes in a naturally ventilated garage with upper and lower openings the ignitable layer of gas (hydrogen concentrations greater than 4%) in the ventilated space was about 11 inches thick accumulating at the ceiling level.[45] • A 13 SCFM hydrogen release for a period of 20 minutes with the	

Section	Requirement	Narrative	Required References
	(305 mm) of the floor of the garage. Both openings shall be provided in the same exterior wall. The openings shall communicate directly with the outdoors and shall have a minimum free area of 1/2 square foot per 1,000 cubic feet (1 m^2/610 m^3) of garage volume. **[FG] 304.5.1.2 Louvers and grilles.** In calculating free area required by Section 304.5.1, the required size of openings shall be based on the net free area of each opening. If the free area through a design of louver or grille is known, it shall be used in calculating the size opening required to provide the free area specified. If the design and free area are not known, it shall be assumed that wood louvers will have 25 percent free area and metal louvers and grilles will have 75 percent free area. Louvers and grilles shall be fixed in the open position. **[FG] 304.5.2 Mechanical ventilation.** Indoor locations intended for hydrogen-generating or refueling operations shall be ventilated in accordance with Section 502.16. In such locations, equipment and *appliances* having an ignition source	same natural *ventilation* produced an ignitable layer at the ceiling that was 22 inches thick. • The same 13 SCFM release into an unventilated garage almost completely filled the entire garage with an ignitable mixture. The requirement to prohibit the installation of *appliances* with ignition sources within 12 inches of the ceiling found in Section 703.1.1 is based on a leak rate of 4.0 SCFM in a naturally ventilated garage. Section 304.5.2 applicable to hydrogen-generating and refueling operations directs the user to requirements of the IMC Section 502.16 designated for use in *repair garages* whenever the space is used for hydrogen generating or refueling operations. Key features include requirements for the following: • An *approved* mechanical ventilating system is required for areas used as *repair garages* when used for the repair of hydrogen fueled vehicles. • Inlets (used to provide fresh or return air into the room) serving the *ventilation* system are required to be installed proximate to floor level. Outlets (used to gather and remove the atmosphere from the room) are required to be installed at the high point of the room or space either on the exterior walls or on the roof. • When mechanical *ventilation* is provided the *ventilation* is required to be continuous and set to be activated by a *flammable gas detection system* that detects hydrogen at 25% of the *lower flammable limit* (*LFL*) or 1% by volume. In addition, sensing at the *LFL* requires that hydrogen fueling systems be shut down. • The rate of exhaust *ventilation* is required to be not less than 1 cubic foot per minute per 12 cubic feet of room volume.	

Section	Requirement	Narrative	Required References
	shall be located such that the source of ignition is below the mechanical *ventilation* outlet(s).	Section 304.5.2 directs the user to requirements of the IMC for *ventilation* designated for use in *repair garages* whenever the space is used for hydrogen generating or refueling operations. See the comments on Section 502.16	
	[FG] 304.5.3 Specially engineered installations. As an alternative to the provisions of Sections 304.5.1 and 304.5.2, the necessary supply of air for *ventilation* and dilution of *flammable gases* shall be provided by an *approved* engineered system.	The term *specially engineered* is not defined in the IFGC, but requirements are established for *design professionals* and others when construction documents or ancillary calculations, diagrams, and other data may be required to document the design. The administrative provisions of the 2015 IMC, Section 106.3.1, require the use of a *registered design professional* when construction documents are furnished as an element of the permit request. Within the context of the IMC, design professionals must be registered. The expectation of the *AHJ* is that any design produced should provide equivalent or superior safety to that established by the code. To be *approved*, the specially engineered system designer should demonstrate that the proposed design is equivalent to or better than what is otherwise required under the prescriptive requirements of Sections 304.5.1 and 304.5.2.	

Section	Requirement	Narrative	Required References
305 Piping Support			
	305.2 Materials. Pipe hangers and supports shall have sufficient strength to withstand all anticipated static and specified dynamic loading conditions associated with the intended use. Pipe hangers and supports that are in direct contact with *piping* shall be of *approved* materials that are compatible with the *piping* and that will not promote galvanic action.	Compliance with the requirements of the code used for the design of mechanical system *piping* could ensure *approval*. As an example, if ASME B31 codes are used for *piping system* design, refer to the requirements of the B31 code for *piping* support elements that include requirements for materials and strength. See the comments to 305.3 below regarding structural considerations. The B31 codes do not address the prevention of corrosion due to galvanic action or any other cause.	
	305.3 Structural attachment. Hangers and anchors shall be attached to the building construction in an *approved* manner.	The ASME B31 codes address *piping* support elements, but they do not address attachment of the elements to the building structure. Connection methods are dependent in part on the loads to be carried and typically are specified by a structural engineer with details provided in the structural plans.	
308 Clearance Reduction			
	308.1 Scope. This section shall govern the reduction in required clearances to combustible materials and combustible assemblies for chimneys, vents, kitchen exhaust equipment, mechanical *appliances*, and mechanical devices and equipment.	The terms *mechanical appliance* or *mechanical devices and equipment* do not have unique definitions in the IFC, IFGC, IMC, or IRC; and therefore the ordinarily accepted meanings apply within the context of the provision in which it is found. The term *appliance* is a defined term. Mechanical *appliances* and mechanical devices and equipment may include *hydrogen-generating appliances* and fuel dispensers, in which case the requirements can apply.	

Section	Requirement	Narrative	Required References
	308.2 Listed appliances and equipment. The reduction of the required clearances to combustibles for *listed* and *labeled appliances* and equipment shall be in accordance with the requirements of this section except that such clearances shall not be reduced where reduction is specifically prohibited by the terms of the *appliance* or equipment *listing*.	There are no specific reductions in clearance to combustibles that have been identified by the code. Reductions in required clearances to combustibles may be allowed only to the extent indicated by the *listing* standard.	
	308.4.1 Labeled assemblies. The allowable clearance reduction shall be based on an *approved* reduced clearance protective assembly that is *listed* and *labeled* in accordance with UL 1618.	Reduced clearances are limited to those specified by the *listing* standard. To be *approved*, such reductions must be in accordance with the limitations of the *listing*.	
401 General			
	401.6 Contaminant sources. Stationary local sources producing air-borne particulates, heat, odors, fumes, spray, vapors, smoke or gases in such quantities as to be irritating or injurious to health shall be provided with an exhaust system in accordance with Chapter 5 or a means of collection and removal of the contaminants. Such exhaust shall discharge directly to an *approved* location at the exterior of the building.	The termination point for exhaust ducts used to transport *flammable vapors* or gases should be in accordance with IMC 501.3.1. By definition, a *flammable vapor* includes *flammable gases* in concentrations within the flammable range. The generally accepted flammable range for hydrogen in air ranges from 4.0% to 75% by volume. When the concentration of *flammable gas* is less than the *lower flammable limit* (*LFL*), the duct may be viewed as other product conveying duct under the requirements of IMC 501.3.1, item 2. Exhaust systems designed to transport *flammable gases* only in the event of leakage or accidental discharge should be viewed as product conveying and subject to the requirements of IMC 501.3.1, item 2, rather than *environmental air* exhaust.	

Section	Requirement	Narrative	Required References
502 Required Systems		Section 502.1 requires an exhaust system to be provided for all occupied areas where machines, processes, *appliances*, or equipment in such areas may emit heat, odors, fumes, spray, gas, or smoke, in such quantities so as to be irritating or injurious to health or safety. The emission of hydrogen gas into the air can create a hazardous condition if it is allowed to accumulate or is not removed from the area.	
	502.3 Battery-charging areas for powered industrial trucks and equipment. *Ventilation* shall be provided in an *approved* manner in battery-charging areas for powered industrial trucks and equipment to prevent a dangerous accumulation of *flammable gases*.	The requirement for *ventilation* is limited to batteries of the type specified in IFC Table 608.1. Special *ventilation* is not required for most, but not all, battery types. A dangerous accumulation of hydrogen would be a concentration in excess of 1% by volume or 25% of the *lower flammable limit* (*LFL*). *Ventilation* that removes or exhausts air from the space where charging occurs is the preferable method, but *natural ventilation* can be used if it can be demonstrated that hydrogen in the room environment can be controlled to a maximum hydrogen concentration of 1% by volume. The American Petroleum Institute (API) in Recommended Practice 500 recommends the following[51]: "*Ventilation* rates should be based on the maximum hydrogen evolution rate for the applicable batteries. Lacking specific data, the maximum hydrogen evolution rate for all batteries should be considered as 1.27 x 10-7 cubic meters per second (0.000269 ft3 per minute) per charging ampere per cell at 25 °C, and standard pressure (101.325 kPa) with the maximum charging current available from the battery charger applied into a fully charged battery."	*Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Division 1 and Division 2,* API Recommended Practice 500,Third Edition, December 2012 , American Petroleum Institute, Section 8.2.6.7.2, Notes, p. 39

Section	Requirement	Narrative	Required References
		For example, a 120 amp-hr capacity, 12 volt (6 cells) lead-acid battery might have a charger that allows full capacity to be reached in 12 hours. Hence, the charging current per cell is (120 A-hr) / ((12 hr) (6 cell)) = 1.67 amp per cell. • The corresponding hydrogen generation rate would be (0.000269 ft^3 per minute) (1.67) = 0.000449 SCFM per cell. • In order to limit the average H2 concentration in the battery room to 1% (25% LFL), a *ventilation* rate of (0.000449 ft^3 per minute) (100) = 0.0449 scf/min-air per cell is needed. • If there are 10 ea. 6-cell batteries being charged in the room, the required minimum *ventilation* rate would be 0.049 scf/min/cell * 60 cells = 2.69 scf/min-air. • Consideration should be given to provide *ventilation* at a somewhat higher capacity to compensate for local accumulations of hydrogen and *ventilation* fan degradation due to wear and contamination.	
	502.4.3 Supervision. Mechanical *ventilation* systems required by Section 502.4 shall be supervised by an *approved* central, proprietary or remote station service or shall initiate an audible and visual signal at a constantly attended on-site location.	Compliance with the central station and notifying device requirements of NFPA 72 should ensure *approval*.	NFPA 72, *National Fire Alarm and Signaling Code*, 2013 Edition, National Fire Protection Association

Section	Requirement	Narrative	Required References
	502.5.3 Supervision. Mechanical *ventilation* systems required by Section 502.5 shall be supervised by an *approved* central, proprietary or remote station service or shall initiate an audible and visual signal at a constantly attended on-site location.	Compliance with the central station and notifying device requirements of NFPA 72 should ensure *approval*.	NFPA 72, *National Fire Alarm and Signaling Code*, 2013 Edition, National Fire Protection Association
	502.8.1.1 System requirements. Exhaust *ventilation* systems shall comply with all of the following:	The provisions in 502.8.1 apply to indoor areas with quantities exceeding the MAQ per control area.	
	1. The installation shall be in accordance with this code.	No special consideration is necessary when the design is coordinated with the requirements described in the referenced provision. Following the instruction provided in the published requirement should result in *approval* of the proposed design.	
	2. Mechanical *ventilation* shall be provided at a rate of not less than 1 cfm per square foot [0.00508 $m^3/(s \cdot m^2)$] of floor area over the storage area.	The *ventilation* rate equates to six air changes per hour in a room with a ceiling height of 10 feet. This means that the room or area has a flow rate of indoor air equivalent to one air change every 10 minutes. For rooms with ceilings higher than 10 feet, the rate of total air change is reduced.	
	3. The systems shall operate continuously unless alternate designs are *approved*.	The requirements of Chapter 5 recognize that the *ventilation* is provided as a safeguard against the buildup of gases or vapors to a level where a hazard condition exists regardless of occupancy. *Natural ventilation* designed with the ability to replace the atmosphere in the space at a rate not less than that specified by item 2 above could be used as the basis for an alternate design. Methodology to determine the adequacy of *natural ventilation* using calculations has been established by API Practice 500.[52]	

Section	Requirement	Narrative	Required References
	4. A manual shutoff control shall be provided outside of the room in a position adjacent to the access door to the room or in another *approved* location. The switch shall be a break-glass or other *approved* type and shall be *labeled*: VENTILATION SYSTEM EMERGENCY SHUTOFF.	A *constantly attended location* as defined by the IFC is an example of what might be another *approved* area in which to locate the required switch. The purpose of a break-glass switch is to avoid accidental activation while at the same time providing visibility for the switch. Enclosures that protect against accidental activation with readily recognizable means of identification of the switch location may also be acceptable.	
	5. The exhaust *ventilation* shall be designed to consider the density of the potential fumes or vapors released. For fumes or vapors that are heavier than air, exhaust shall be taken from a point within 12 inches (305 mm) of the floor. For fumes or vapors that are lighter than air, exhaust shall be taken from a point within 12 inches (305 mm) of the highest point of the room.	No special consideration is necessary when the design is coordinated with the requirements described in the referenced provision, which are self-explanatory. Following the instruction provided in the published requirement should result in *approval* of the proposed design.	
	6. The location of both the exhaust and inlet air openings shall be designed to provide air movement across all portions of the floor or room to prevent the accumulation of vapors.	No special consideration is necessary when the design is coordinated with the requirements described in the referenced provision. Following the instruction provided in the published requirement should result in *approval* of the proposed design.	
	7. The exhaust air shall not be recirculated to occupied areas if the materials stored are capable of emitting hazardous vapors and contaminants have not been removed. Air contaminated with explosive or *flammable vapors*, *fumes* or dusts; flammable, highly toxic or toxic gases;	No special consideration is necessary when the design is coordinated with the requirements described in the referenced provision. Following the instruction provided in the published requirement should result in *approval* of the proposed design.	

Section	Requirement	Narrative	Required References
	or radioactive materials shall not be recirculated.		
	502.16 Repair garages for natural gas- and hydrogen fueled vehicles. *Repair garages* used for the repair of natural gas- or hydrogen-fueled vehicles shall be provided with an *approved* mechanical *ventilation* system. The mechanical *ventilation* system shall be in accordance with Sections 502.16.1 and 502.16.2. **Exception:** Where *approved* by the code official, *natural ventilation* shall be permitted in lieu of mechanical *ventilation*.	No special consideration is necessary when the design is coordinated with the requirements described in the referenced provision. Following the instruction provided in the published requirement should result in *approval* of the proposed design. *Natural ventilation* designed with the ability to replace the atmosphere in the space at a rate not less than that specified by 502.16.1 can be used as the basis for an alternate design. Section 502.16.2 applies solely to mechanical *ventilation* systems. Methodology to determine the adequacy of *natural ventilation* using calculations has been established by API Practice 500.[53] The relationship between mechanical *ventilation* rates and effective *natural ventilation* rates depends on the density and concentration distribution of the *flammable gas* in the room as well as the location and area of the wall or ceiling openings. The administrative provisions of 2015 IMC Section 106.3.1 require the use of a *registered design professional* when construction documents are furnished as an element of the permit request. Within the context of the IMC, design professionals must also be registered.	
503 Motors and Fans			
	503.1 General. Motors and fans shall be sized to provide the required air movement. Motors in areas that contain *flammable vapors* or dusts shall be of a type *approved* for such environments. A manually operated	No special consideration is necessary when the design is coordinated with the requirements described in the referenced provision. Following the instruction provided in the published requirement should result in *approval* of the proposed design. When the operation of equipment that generates *flammable*	

Section	Requirement	Narrative	Required References
	remote control installed at an *approved* location shall be provided to shut off fans or blowers in *flammable vapor* or dust systems. Electrical equipment and *appliances* used in operations that generate explosive or *flammable vapors*, fumes or dusts shall be interlocked with the *ventilation* system so that the equipment and *appliances* cannot be operated unless the *ventilation* fans are in operation. Motors for fans used to convey *flammable vapors or dusts* shall be located outside the duct or shall be protected with *approved* shields and dustproofing. Motors and fans shall be provided with a means of access for servicing and maintenance.	*vapors* is interlocked with the *ventilation* system, a means should be provided to verify that there is airflow in the duct system prior to operation of the process equipment. Verification of airflow is typically accomplished by using a flow-sensing device in the duct to verify that airflow is present.	

Section	Requirement	Narrative	Required References
510 Hazardous Exhaust Systems		A hazardous exhaust system is not specifically defined by the IMC. It is required by conditions related to performance. In the case of *flammable gases*, a hazardous exhaust system is required if the absence of such an exhaust system under normal operating conditions has the potential to create a condition where *flammable vapor*, gas, *fume*, mist, or dust is present in concentrations exceeding 25 percent of the *lower flammable limit* of the substance for the expected room temperature. Although not required, it is also helpful to use a hazardous exhaust system for *flammable gas* processes, equipment, and *piping* that are either prone to leakage or other releases. An example would be *piping* or ducting with insecure connections such as hose clamps. See the comments on IMC Section 401.6 and the references to IMC Section 501.3 for the identification of product conveying duct.	
	510.7.3 Wall assemblies. Hazardous exhaust duct systems that penetrate fire-resistance-rated wall assemblies shall be enclosed in fire-resistance-rated construction from the point of penetration to the outlet terminal, except where the interior of the duct is equipped with an *approved* automatic fire suppression system. Ducts shall be enclosed in accordance with the International Building Code requirements for shaft construction and such enclosure shall have a minimum fire-resistance rating of not less than the highest fire-resistance-rated wall assembly penetrated.	When a hazardous exhaust system is installed through a fire-rated wall, a fire sprinkler system is required unless the duct is enclosed in fire-resistance-rated-construction as described in 510.7.3. Compliance with the requirements of referenced NFPA codes and standards should ensure *approval*. To be *approved*, the duct sprinkler system should be in accordance with the requirements of NFPA 13.[54]	

Section	Requirement	Narrative	Required References
	510.8 Suppression required. Ducts shall be protected with an *approved* automatic fire suppression system installed in accordance with the International Building Code. **Exceptions:** 1. An *approved* automatic fire suppression system shall not be required in ducts conveying materials, fumes, mists and vapors that are nonflammable and noncombustible under all conditions and at any concentrations. 2. Automatic fire suppression systems shall not be required in metallic and noncombustible, nonmetallic exhaust ducts in semiconductor fabrication facilities. 3. An *approved* automatic fire suppression system shall not be required in ducts where the largest cross-sectional diameter of the duct is less than 10 inches (254 mm). 4. For laboratories, as defined in Section 510.1, automatic fire protection systems shall not be required in laboratory hoods or exhaust systems	When a hazardous exhaust system is provided, a fire sprinkler system is required. Compliance with the requirements of referenced NFPA codes and standards should ensure *approval*. To be *approved*, the duct sprinkler system should be in accordance with the requirements of NFPA 13. When a fire sprinkler system is installed in a duct, means should be provided to prevent water accumulation in the duct. This is normally accomplished by using drains and a slope to the duct that will allow for water to be transported to the drain. This will avoid instances where undrained duct systems have collapsed, resulting in the loss of exhaust and causing collateral damage to areas in which the ducts were installed.	
	510.9 Duct construction. Ducts used to convey hazardous exhaust shall be constructed of materials *approved* for	Ducts used to transport *flammable gases* should be constructed of ferrous metal to resist the effect of high temperatures that could result in failure if metals of low melting point were used. Note that	

Section	Requirement	Narrative	Required References
	installation in such an exhaust system and shall comply with one of the following: 1. Ducts shall be constructed of *approved* G90 galvanized sheet steel, with a minimum nominal thickness as specified in Table 510.9. 2. Ducts used in systems exhausting nonflammable corrosive fumes or vapors shall be constructed of nonmetallic materials that exhibit a flame spread index of 25 or less and a smoke-developed index of 50 or less when tested in accordance with ASTM E 84 or UL 723 and that are *listed* and *labeled* for the application. Where the products being exhausted are detrimental to the duct material, the ducts shall be constructed of alternative materials that are compatible with the exhaust.	the requirements for the use of sheet steel do not include the use of sheet steel lined with corrosion-resistant materials. The use of item 2 of the provisions is not applicable to ducts used to transport *flammable vapors*. In some cases, hydrogen will be exhausted through systems that are also used to transport corrosive vapors. In such cases, non-metallic duct *listed* for the specific application may be *approved* for use under the provisions for alternate materials and methods as specified by the 2015 IMC, Section 105.2. Additional information can be found on the use of non-metallic duct in specialized applications through the use of an informational reference found at the following website[55]: https://www.fmglobal.com/fmglobalregistration/Vshared/FMDS0707.pdf Refer to Appendix A.2 for informational references applicable to exhaust duct systems.	
	510.9.3 Explosion relief. Systems exhausting potentially explosive mixtures shall be protected with an *approved* explosion relief system or by an *approved* explosion prevention system designed and installed in accordance with NFPA 69. An explosion relief system shall be designed to minimize the structural and mechanical damage resulting from an explosion or	The requirements for explosion prevention systems are found in NFPA 69, *Explosion Prevention Systems*. Although not specified by the IMC, the requirements for explosion relief through the use of venting systems are found in NFPA 68, *Standard on Explosion Protection by Deflagration Venting.* NFPA 69 refers the user to NFPA 68 when the techniques of explosion venting are used.[56] If either explosion prevention or explosion relief systems are to be provided, they should be designed in compliance with appropriate standards. If the use of a performance-based design option is	NFPA 69, *Standard on Explosion Prevention Systems*, 2014 Edition, National Fire Protection Association

Section	Requirement	Narrative	Required References
	deflagration within the exhaust system. An explosion prevention system shall be designed to prevent an explosion or deflagration from occurring.	considered for either prevention or relief systems, the designer may consider the use of the performance-based design option criteria included in either NFPA 68 or NFPA 69.	NFPA 68, *Standard on Explosion Protection by Deflagration Venting*, 2013 Edition, National Fire Protection Association

International Residential Code

Section	Requirement	Narrative	Required References
M1302 Approval			
	M1302.1 Listed and labeled. *Appliances* regulated by this code shall be *listed* and *labeled* for the application in which they are installed and used, unless otherwise *approved* in accordance with Section R104.11.	The 2015 IRC, Sections 104.10 and 104.11, address modifications and the use of alternate materials and methods, respectively. The requirements relative to modification and the use of alternate methods are consistent with those published in other codes published by the ICC. Sections 104.10 and 104.11 provide the authority to the code official to allow the use of un*listed* equipment on a case by case basis, but in doing so the code grants the code official the power to use judgment to determine acceptability. Refer to Section 1 of this guide for a general discussion of *listing* organizations and standards. *Hydrogen-generating appliances* and refueling systems are the subject of provisions found in IRC M1307.4. The code does not define refueling systems, but does regulate refueling operations without establishing requirements for fuel dispensers. The terms "fueling" and "refueling" are considered to be equivalent terms. The ISO has published several standards relevant to hydrogen generators. Three of the more relevant standards are: • ISO 22734-2:2011(en), *Hydrogen generators using water electrolysis process — Part 2: Residential applications*[57] • ISO 16110-1:2007, *Hydrogen Generators Using Fuel Processing Technologies*, Part 1 Safety[58] • ISO 16110-2:2010, *Generators Using Fuel Processing Technologies*, Part 2 Test Methods for Performance[59]	

Section	Requirement	Narrative	Required References
		The following abstract from the ISO website relative to ISO 22734-2-11 is useful in understanding the scope of the standard affecting residential applications[57]: • ISO 22734-2:2011 defines the construction, safety, and performance requirements of packaged hydrogen gas generation *appliances*, herein referred to as hydrogen generators, using electrochemical reactions to electrolyze water to produce hydrogen. • ISO 22734-2:2011 is applicable to hydrogen generators that use the following types of ion transport medium: a group of aqueous bases or solid polymeric materials with acidic function group additions, such as acid proton exchange membrane. • ISO 22734-2:2011 is applicable to hydrogen generators intended for indoor and outdoor residential use in sheltered areas, such as car-ports, garages, utility rooms, and similar areas of a residence. ISO 22734-2:2011 includes cord-connected equipment for outdoor and garage use only. • Portable generators as well as hydrogen generators that can also be used to generate electricity, such as reversible fuel cells, are excluded from the scope of ISO 22734-2:2011. • Hydrogen generators that also supply oxygen as a product are excluded from the scope of ISO 22734-2:2011.	

Section	Requirement	Narrative	Required References
M1307 Appliance Installation			
	M1307.1 General. Installation of *appliances* shall conform to the conditions of their *listing* and *label* and the manufacturer's instructions. The manufacturer's operating and installation instructions shall remain attached to the *appliance*.	No special consideration is necessary when the design is coordinated with the requirements described in the referenced provision. Following the instruction provided in the published requirement should result in *approval* of the proposed design. It would be reasonable for the *AHJ* to request the documentation describing the conditions for the *listing*, including the *listing* certificate or letter from the *listing* entity describing the *listing* standard and associated conditions of *listing*. The *AHJ* may require that installation instructions be maintained as a matter of record. Having installation instructions attached to the *appliance* which states that the equipment is required to be installed in accordance with the *listing* would appear to be the intent of the requirement. In cases where the installation instructions are more than what can typically be attached to the equipment, it is reasonable to require that the instructions become a portion of the plan of record.	

Section	Requirement	Narrative	Required References
	M1307.2 Anchorage of appliances. *Appliances* designed to be fixed in position shall be fastened or anchored in an *approved* manner. [Balance of section pertinent to water heaters in residential occupancies has been deleted as it has no application for hydrogen *appliances*].	No special consideration is necessary when the design is coordinated with the requirements described in the referenced provision. Following the instruction provided in the published requirement should result in *approval* of the proposed design.	
	M1307.3 Elevation of ignition source. *Appliances* having an ignition source shall be elevated such that the source of ignition is not less than 18 inches (457 mm) above the floor in garages. For the purpose of this section, rooms or spaces that are not part of the living space of a *dwelling unit* and that communicate with a private garage through openings shall be considered to be part of the garage.	Ignition sources in areas where *hydrogen-generating appliances* are installed or where fueling operations are conducted should be in accordance with M1307.4.2.	
	Exception: Elevation of the ignition source is not required for *appliances* that are *listed* as flammable-vapor-ignition resistant.	No special consideration is necessary when the design is coordinated with the requirements described in the referenced provision. Following the instruction provided in the published requirement should result in *approval* of the proposed design.	

Section	Requirement	Narrative	Required References
	M1307.3.1 Protection from impact. *Appliances* shall not be installed in a location subject to vehicle damage except where protected by *approved* barriers.	Methods of protection against vehicular impact can be found in Section 312 of the 2015 IFC. The use of requirements for "other barriers" described in IFC Section 312.3 that account for likely impact based on the installation location would be appropriate for installation in residential applications.	
M1307.4 Hydrogen Generating and Refueling Operations			
	M1307.4 Hydrogen generating and refueling operations. *Ventilation* shall be required in accordance with Section M1307.4.1, M1307.4.2 or M1307.4.3 in private garages that contain *hydrogen-generating appliances* or refueling systems. For the purpose of this section, rooms or spaces that are not part of the living space of a *dwelling unit* and that communicate directly with a private garage through openings shall be considered to be part of the private garage. **M1307.4.1 Natural ventilation.** Indoor locations intended for hydrogen-generating or refueling operations shall be	The release of hydrogen in garages has been the subject of research conducted by the University of Miami in Coral Gables, Florida. As demonstrated by the research, basic *ventilation* significantly reduces the risk of release of hydrogen into the space such that a flammable atmosphere would develop. The work of Professor Swain from the University of Miami has served as the basis for the provisions found in today's code. Research conducted by others, extensively in Europe, may be of interest. An article by Adams, P., et al. adds to the basis of knowledge using computational fluid dynamics calculations for hydrogen releases in various size enclosures representing small to large garages and the expected behavior of hydrogen in similar environments. [60] The code allows for the use of either passive (natural) *ventilation* or mechanical *ventilation* as a means to prevent the buildup of hydrogen in the typical residential garage, an enclosed space. If a garage is unventilated and hydrogen leakage is present, eventually hydrogen could accumulate and a hazardous atmosphere would develop.	

Section	Requirement	Narrative	Required References
	limited to a maximum floor area of 850 square feet (79 m^2) and shall communicate with the outdoors in accordance with Sections M1307.4.1.1 and M1307.4.1.2. The maximum rated output capacity of *hydrogen-generating appliances* shall not exceed 4 standard cubic feet per minute (1.9 L/s) of hydrogen for each 250 square feet (23 m^2) of floor area in such spaces. The minimum cross-sectional dimension of air openings shall be 3 inches (76 mm). Where ducts are used, they shall be of the same cross-sectional area as the free area of the openings to which they connect. In those locations, equipment and *appliances* having an ignition source shall be located so that the source of ignition is not within 12 inches (305 mm) of the ceiling. **M1307.4.1.1 Two openings.** Two permanent openings shall be constructed within the garage. The upper opening shall be located entirely within 12 inches (305 mm) of the ceiling of the garage. The lower	Historically, the model codes have established a *ventilation* rate using either natural or mechanical *ventilation* at a rate sufficient to dilute the anticipated release of gas-air mixtures to a concentration below 25% of their *lower flammable limit* (*LFL*). The use of 25% as the threshold provides a safety factor of 4, which accounts for variable conditions that may exist in the LFL as reported as well as ambient or environmental conditions in which such mixtures may be found. It is also recognized by the codes that in any release of a *flammable gas* there exists a flammable envelope that forms near the point of release where higher concentrations exist, and dilution is not instantaneous. The 25% limit assumes a homogeneous mixture. Regardless of the type of *ventilation* provided, e.g., natural or mechanical, the risk of ignition is not eliminated. The explicit intent of the requirements of the code expressed by the testimony provided in support of the addition of these requirements to the Mechanical and Residential Codes is to require that *ventilation* be provided only in areas where *hydrogen generating appliances* are installed or where fueling, or refueling operations are present.[61] The hazards of the vehicle itself related to potential leakage are addressed by controls provided on the vehicles. There is normally some small hydrogen leakage due to permeation through the polymer liners on Type 4 *cylinders* used to store the onboard fuel present in the vehicle. The referenced paper by Adams et al. on Allowable hydrogen permeation rate from road vehicles includes data on the distribution of residential garage *ventilation* rates	

Section	Requirement	Narrative	Required References
	opening shall be located entirely within 12 inches (305 mm) of the floor of the garage. Both openings shall be constructed in the same exterior wall. The openings shall communicate directly with the outdoors and shall have a minimum free area of 1/2 square foot per 1,000 cubic feet (1.7 m^2/1000 m^3) of garage volume. **M1307.4.1.2 Louvers and grilles.** In calculating free area required by Section M1307.4.1, the required size of openings shall be based on the net free area of each opening. If the free area through a design of louver or grille is known, it shall be used in calculating the size opening required to provide the free area specified. If the design and free area are not known, it shall be assumed that wood louvers will have a 25-percent free area and metal louvers and grilles will have a 75-percent free area. Louvers and grilles shall be fixed in the open position.	from various surveys in the U.S. and abroad. It concludes that the maximum allowable hydrogen permeation rate for a passenger car should be 6 to 8 ml/hr per liter of hydrogen tank water capacity. This is slightly higher than the permeation rates measured in GM and Japanese vehicle fuel tanks at 20°C. Higher temperatures cause higher permeation rates. The recommended limiting rate can be safely dispersed with residential garage *ventilation* rates as low as 0.03 air changes per hour, which is the lowest measured garage *ventilation* rate in the studies conducted. The requirements for *ventilation* are coordinated with a defined maximum rate of production from *hydrogen-generating appliances.* See narratives for IFGC 703.1.1 and IMC 304.5 for more detail.	

Section	Requirement	Narrative	Required References
	M1307.4.2 Mechanical ventilation. Indoor locations intended for hydrogen-generating or refueling operations shall be ventilated in accordance with Section 502.16 of the International Mechanical Code. In these locations, equipment and *appliances* having an ignition source shall be located so that the source of ignition is below the mechanical *ventilation* outlet(s).		
	M1307.4.3 Specially engineered installations. As an alternative to the provisions of Sections M1307.4.1 and M1307.4.2, the necessary supply of air for *ventilation* and dilution of *flammable gases* shall be provided by an *approved* engineered system.	The term *specially engineered* is not defined in the IFGC, but requirements are established for *design professionals* and others when construction documents or ancillary calculations, diagrams, and other data may be required to document the design. The administrative provisions of the 2015 IRC, Section 106. 1, require the use of a *registered design professional* when construction documents are furnished as an element of the permit request. Within the context of the IRC, design professionals must be registered. The expectation of the *AHJ* is that any design produced should provide equivalent or superior safety to that established by the code. To be *approved*, the specially engineered system designer should demonstrate that the proposed design is equivalent to or better than what is otherwise required under the prescriptive requirements of Sections M1307.4.1 and M1307.4.2.	

Section	Requirement	Narrative	Required References
M1903 Stationary Fuel Cell Power Plants			
	M1903.1 General. *Stationary fuel cell power plants* having a power output not exceeding 1,000 kW shall comply with ANSI/CSA America FC 1 and shall be installed in accordance with the manufacturer's instructions and NFPA 853.	No special consideration is necessary when the design is coordinated with the requirements described in the referenced provision. Following the instruction provided in the published requirement should result in *approval* of the proposed design. Fuel cell *listings* to this standard can be found on the CSA Group website at the following address: http://www.csagroup.org/global/en/services/testing-and-certification/certified-product-listing See narratives for IFGC 703.1 and IMC 304.5 for more detail.	
M1904 Gaseous Hydrogen Systems			
	M1904.1 Installation. *Gaseous hydrogen systems* shall be installed in accordance with the applicable requirements of Sections M1307.4 and M1903.1 and the International Fuel Gas Code, the International Fire Code and the International Building Code.	No special consideration is necessary when the design is coordinated with the requirements described in the referenced provision. Following the instruction provided in the published requirement should result in *approval* of the proposed design.	

Appendix A. Required and Informational References

Introduction to Appendix A

Required references provided in A.1 are those needed by users of the guidelines in the design or the *approval* process. Each reference has been cross referenced to the requirements of the applicable codes cited in Chapter 4 as determined by the explanatory text provided. The code text referenced in Chapter 4 is limited to those sections containing any of the following terms: *approved*, *certified*, *listed*, or *labeled*. They have been cross referenced by code and section number so that the user can determine what references might be needed to use the guidelines as intended. A required reference is different from references that are used to substantiate a statement within the narrative found in Chapter 4.

References that are not needed by the user to reach a decision in design or *approval* are included in A.2. These informational references are provided for further reading and greater understanding of a particular subject.

Appendix A.1. Required References (Normative)

Reference Document	Code and Section Number
International Code Council, Inc., 4051 West Flossmoor Road, Country Club Hills, IL, 60478-5795	
2015 International Building Code®	NFPA 2: 6.13 IFC: 5303.15
2015 International Fire Code®	NFPA 2: 4.14.1.1 IFGC: 633.1, 704.1, 704.1.2.1
2015 International Fuel Gas Code®	NFPA 2: 6.17.1.2, 7.1.15.1
2015 International Mechanical Code®	NFPA 2: 6.17.2
International Fire Code®, 2006 Edition	IFGC: 703.4
International Code Council, 2002 Final Action Agenda for the Proposed Changes to the 2000 Editions of The International Codes, October 1-5, 2002, Fort Worth Convention Center, Fort Worth, TX, International Code Council, Falls Church, VA 22041	IFGC: 703.1.1
ASME Publications. American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10016-5990	
ASME B31.12-2014, *Hydrogen Piping and Pipelines,* Standard by ASME International, 02/20/2015	IFGC: 704.1.2.4, 705.2
ASME B31.3-2014, *Process Piping,* Standard by ASME International, 02/27/2015	IFGC: 704.1.2.4
Compressed Gas Association 14501 George Carter Way, Suite 103 Chantilly, VA 20151-2923	
CGA G-5.5, *Hydrogen Vent Systems*, Third Edition, Compressed Gas Association, 2014	NFPA 2: 15.3.1.1.6.7 IFC: 2309.6.1, 2309.6.1.2.1
CGA G-5.5, *Hydrogen Vent Systems,* Second Edition*,* Compressed Gas Association, 2004 Reaffirmed 2007	IFGC: 703.4
ANSI/CGA H-5, *Standard For Bulk Hydrogen Supply Systems,* Second Edition, 2014	NFPA 2: 8.1.10.1, 11.3.1.3.3, M.1.2.6 (2008 Edition referenced)

Reference Document	Code and Section Number
CGA P-22, *The Responsible Management and Disposition of Compressed Gases and their Cylinders*, Third Edition, Compressed Gas Association, 2014	IFC: 5003.2.6
CGA S-1.1—*Pressure Relief Device Standards – Part 1 – Cylinders for Compressed Gases*, Compressed Gas Association, 2011	IFGC: 703.4
CGA S-1.2—*Pressure Relief Device Standards – Part 2 – Cargo and Portable Tanks for Compressed Gases*, Compressed Gas Association, 2005	IFGC: 703.4
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> This standard gives requirements for the specification, design, installation, operation, and maintenance of a safety instrumented system, so that it can be confidently entrusted to place and/or maintain the process in a safe state.

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ISA-TR84.00.04-2011, *Part 1 Guideline for the Implementation of ANSI/ISA-84.00.01-2004 (IEC 61511)*

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ISA-TR84.00.04-2005 *Part 2: Example Implementation of ANSI/ISA-84.00.01-2004 (IEC 61511 Mod)*

> This technical report is intended to be used in conjunction with ISA-TR84.00.04-2005 Part 1 to provide an example that illustrates how to apply ANSI/ISA-84.00.01-2004 (IEC 61511 Mod).

Appendix B. Use of Equivalency, Alternative Materials and Methods and Modifications (Informative)

B.1 Use of Equivalency, Alternative Materials, and Methods and Modifications

The *authority having jurisdiction (AHJ)* can grant authority to *approv*e the use of un*listed* equipment under the provisions for equivalency currently in the code. Alternatively, the code official may view the use of un*listed* equipment as a "modification" to the code based on practical difficulties in compliance, such as lack of availability.

The provisions for the use of equivalency are common to the NFPA codes, which can be equated to the use of alternative materials and methods in the ICC codes. NFPA 2, *Hydrogen Technologies Code,* Annex B, Section B.2, has provisions similar to those found in the ICC codes that address *equivalency, alternatives*, and *modifications.* For example, the IBC provisions for modification are in Section 104.10 of that code; the equivalency provisions are Section 104.11. Similar provisions for modification or equivalency can be found in IFC Sections 104.8 and 104.9, respectively.

B.1.1 Resolving Conflicts Within Applicable Codes and Codes vs. Reference Standards

Even though the code publishers may make a concerted effort to coordinate their codes, users can encounter requirements that appear to be or are in conflict. This is more frequent when a difference may exist between the code requirements and the requirements of a standard referenced by a code. There is a long-standing protocol for resolving such conflicts. For example, the IFC administrative procedures on conflicts say the following about internal and external conflicts.

> **IFC 102.7.1 Conflicts.** Where conflicts occur between provisions of this code and referenced codes and standards, the provisions of this code shall apply.

Case 1 (application of 102.7.1): Where a conflict occurs between the provisions of the code and a referenced code or standard, IFC Section 102.7.1 provides a hierarchy. The primary code in use will trump other codes that are referenced. For example, in a jurisdiction that adopts IFC as their *fire code*, IFC Section 5801.1 requires that hydrogen *motor fuel-dispensing stations* and *repair garages* and their associated above-ground hydrogen be designed, constructed, and maintained in accordance with both IFC and NFPA 2 requirements. Both of these documents are written as codes. If a conflict arises between the two documents, IFC takes precedence over NFPA 2.

> **IFC 102.7.2 Provisions in referenced codes and standards.** Where the extent of the reference to a referenced code or standard includes subject matter that is within the scope of this code, the provisions of this code, as applicable, shall take precedence over the provisions in the referenced code or standard.

Case 2.1 (application of 102.7.2): In cases where a referenced code or standard includes subject matter that is already addressed by the code adopted by the jurisdiction, the provisions of the adopted code will prevail over those of the referenced code or standard. For example, assume that the jurisdiction adopts the IFC and the Uniform Plumbing Code, published by the International Association of Plumbing and Mechanical Officials, and the jurisdiction is using NFPA 2 for provisions applicable to fueling stations. NFPA 2 Section 7.3.1.2.7.1 requires that the user test *piping systems* in accordance with the

IFGC. The provisions of the IAPMO Plumbing Code would take precedence over NFPA 2 under the authority granted by IFC Section 102.7.2.

Case 2.2 (application of 102.7.2): When hydrogen is to be vented to the atmosphere to defuel a vehicle before repair, IFC Section 2309.6.1.2 requires that the *defueling* system be *listed* and *labeled* or *approved* for the intended use. There are additional requirements that describe provisions delegated to address the manufacturer of equipment, vent diameter, and flow rate. NFPA 2 in regulating repair facilities requires that the vent pipe systems comply with standards published by the Compressed Gas Association, i.e., CGA G-5.5, *Hydrogen Vent Systems.* IFC Section 102.7.2 requires that the provisions of the IFC take precedence over the requirements of NFPA 2; however, the *AHJ* could *approve* a system designed to meet NFPA 2 requirements as they may be more suited to the overall installation than the limited requirements established by 2309.6.1.2.

> **IFC 102.10 Conflicting provisions.** Where there is a conflict between a general requirement and a specific requirement, the specific requirement shall be applicable. Where, in a specific case, different sections of this code specify different materials, methods of construction or other requirements, the most restrictive shall govern.

Case 3.1 (application of 102.10 first sentence - conflicts between general and specific requirements): For apparent conflicts between a general requirement and a specific requirement, the specific requirement takes precedence under IFC Section 102.10. For example, NFPA 2 Section 10.3.1.10 has specific requirements for testing *piping systems* used in filling stations. Following IFC Section 102.10, the specific requirements of Chapter 10 for *piping* regulated by Chapter 10 take precedence over the general requirements for testing in Chapter 7.

Case 3.2 (application of 102.10 second sentence - conflicts between different sections of the code): Section 421.6 requires that *hydrogen fuel gas rooms* be provided with an *approved gas detection system* in accordance with Sections 421.6.1 through 421.6.4. On the other hand, Section 421.6.1 requires that the *gas detection system* be *listed.* The requirement for the use of a *listed* detection system may be viewed as being more restrictive than a system that must simply be *approved,* and therefore Section 421.6.1 governs. If there were *listed* systems available, Section 421.6.1 would prevail. Lacking the availability of *listed* systems, the use of *approved* systems could satisfy the requirements of the code.

Appendix C. Typical Permit Process (Informative)

Introduction to Appendix C

An example of the permit process is provided to assist users and designers in understanding the sequence of events that are likely to be encountered in the typical jurisdiction. Understanding the process will assist the project proponents in preparing the documentation and design considerations that will be the subject of review by the jurisdiction, thereby serving to facilitate the overall design and construction process.

C.1 Typical Permit Process Overview[v]

To expedite project review and acceptance, applicants should have a basic understanding of the jurisdiction's process. By anticipating the jurisdiction's needs, designers can better be prepared to address the concerns that will likely be raised as the permit process unfolds. The applicant is responsible for obtaining such knowledge and for meeting the requirements of the different entities involved in the permitting process. Few jurisdictions have the time or the staff to guide one through the bureaucratic maze. A little time spent in learning the twists and turns of the permit process in a jurisdiction is time well spent.

This description of the permit process is provided for illustrative purposes. It does not represent any actual permit process and does not define how a jurisdiction should review permit applications. The intent of this discussion is to illustrate:

- The steps in such a process
- The reason for each step
- The degree of detail required for a proper review
- The interaction of the several jurisdictional entities on a project

A local jurisdiction may have a more or less sophisticated process; however, the essential elements will generally be similar.

C.2. Pre-Permit Application Phase

At this stage of the design, the general size of the facility, its schematic layout and elements of construction have been determined. The code impact on the design is to be evaluated before detailed drawings are started.

A meeting should be scheduled with the planning department for its review of the planning and zoning code provisions for the designated location in the community, which may include parking, truck loading, traffic patterns, and land use issues. The restrictions on land use and the materials proposed for use and the quantity of materials anticipated will be needed. For example, if hydrogen is to be delivered in liquid or gaseous form, whether it will be generated or stored and its specific use (industrial or commercial)

[v] The discussion on the typical permit process as included in this appendix is based on the previous work of Alfred Goldberg and Larry Fluer, the authors of the *H-6 Design Guide to the Uniform Codes for High Tech Facilities,* Codes and Standards Information Company Mill Valley, CA 94942, Copyright 1986, pp. A2-1 through A2-5.

must be known. In some cases only limited quantities of hydrogen may be allowed depending on the zone in which the project is anticipated.

There may be additional restrictions based on the juxtaposition of the project relative to people-intensive or -sensitive uses such as schools, churches and places of assembly, shopping malls, and similar activities.

A separate preliminary plan check meeting should be scheduled with the building inspection and fire departments to review the general requirements of the building and *fire codes*. At this point, only schematic drawings are likely to be available and the discussion will be related to:

- Operations to be conducted
- The general maximum quantities and form, i.e., gaseous or liquid, along with other hazardous materials expected to be stored or used on site
- Construction anticipated
- If buildings or structures are involved, the different occupancies expected along with the size of each occupancy
- The general exit provisions for buildings and structures or to and from the site

Decisions at these meetings should be confirmed in writing with the jurisdiction for their concurrence to minimize misunderstandings. There may be several such meetings with the local departments as the plans are further refined and completed. The applicant or designer should not expect the jurisdiction to provide design specifics, as it is the project proponent's responsibility to develop the design and to provide the plans for review, and it is the jurisdiction's responsibility to review the plans for code compliance. In confirming the decisions made at the meeting, the proponent should remain factual and limit the confirmation to the subjects discussed, taking care not to expand the confirmation into other subjects. It is normal for proponents to be eager to advance the process. If decisions made in the meeting require a response from either party, the proponent should avoid inserting statements into the communications that establish a deadline that was not mutually decided. For example, "If there is not a response to this communication by (date), we will assume that you are in concurrence with…". Most code officials appreciate a summary that accurately documents the discussion and decisions made during a meeting, and will respond to requests after considering the matters at hand. The proponents should work for a mutual understanding of the issues and to communicate the schedule needed to bring about the project in a timely way.

C.3. Filing the Building Permit Application

When structures or buildings are involved, the jurisdiction will have a building permit application form that is to be completed when filing for the permit. A permit is normally required whether the project involves new construction or what are referred to as tenant improvements or alterations to existing structures. An overhead shelter, even when limited to a *canopy*, is considered a structure and must meet the requirements of the local building code. The application typically requires the following minimal information:

- The address of the site or other identification of where the improvements will be located

- The names of the owner, contractor and designer
- The type of building construction to be used as described by the code adopted by the jurisdiction
- The gross floor area, and if multiple stories are involved, the area of each story and the number of stories proposed
- The proposed occupancies by class (as designated by the code) to be in the building or structure
- Potentially other information such as a small scale site plan, the location of streets, property lines, etc.

The permit application is usually prepared in at least two copies and two sets of drawings and specifications are to be filed with it. A plan check fee will be levied depending on the estimated cost of improvements. The costs are determined by the locality using standard costs for the type of construction, occupancy, and various add-ons such as building services that may be regulated by codes other than the building code, i.e., fire, mechanical, electrical, etc.

The building departments that also plan check the associated disciplines such as electrical, mechanical, and plumbing may require additional plan checking fees and additional sets of drawings for this purpose.

C.4. Processing the Permit Application

The local jurisdiction's internal review procedure for the permit application will generally involve the following minimal steps:

1. The first review is usually for conformance with the planning and zoning code. This review could involve special variances where, due to local conditions, the jurisdiction may have imposed criteria that were not in effect when the site was originally obtained.

2. The next review is by building inspection agency for compliance with the building and other codes under their jurisdiction. In some localities, this may include the fire service review within the building department. However, in most jurisdictions, the fire service review will be a separate step.

   In this review, requests for additional information by the plan checker or for clarifications are common. Many jurisdictions use a plan review checklist and will not contact the applicant until the review is complete. When completed, the checklist with the deficiencies noted goes to the applicant. Sometimes the plan checker will go over the list with the applicant and discuss the contents.

   The purpose of the plan check and the deficiencies list is to bring the design documents into code compliance. Where there are differences in agreement or understanding, the matters should be brought to the attention of the person responsible for the plan checking operation at a meeting. The decisions from the meeting should be documented and confirmed to establish the basis either of changes to the drawings or of possible appeal.

3. The fire service review will usually follow the building department review. A similar procedure should be followed with regard to their comments. In some jurisdictions, the comments of all the

locality's agencies will be accumulated and incorporated into a master list of deficiencies. This will require careful evaluation by the designer of the cited concerns. Contact with the various agency plan checkers is recommended when there are differences with their conclusions or where clarifications are needed.

4. In many jurisdictions, depending on local and state laws, there may be review of the application by:
   a. An environmental agency responsible for water, sewer and/or air pollution control
   b. The health department or other environmental entity regarding the quantities and types of hazardous materials to be stored or used
   c. The department of public works, or a similar agency charged with traffic controls, to determine the acceptability of the driveways to include entrances and exits
   d. Other reviews by separate agencies or within an agency previously discussed, which could include:
      - Accessibility (handicapped)
      - Energy conservation
      - Sound control
      - Hazardous waste disposal
      - Architectural review of building or structure design
      - Landscaping

Once the first review by all the agencies has been completed, the applicant is responsible for revising the drawings or otherwise indicating how the deficiencies are to be removed or reconciled. A revised set of documents is typically submitted to the jurisdiction. The review process to validate the resolution of the cited deficiencies is then a repetition of the original review, but usually takes less time.

C.5. Permit Issuance

Once all agencies are satisfied that their regulations and codes have been met, a representative of each reviewing agency signs the application, *approving* it for that agency. Once all *approval*s are on the application, the applicant is notified that the permit is ready for issuance.

The issuance of the permit will occur after the various fees levied by the locality are paid. These may include:

- The building permit fee (to cover the field inspection of the construction)
- The sewer and water connection fees
- A fee to cut the curb for the driveways

Some localities will require that the plumbing and electrical permits be obtained at the same time as the building permit.

The permit will be issued and provided to the applicant together with one copy of the *approved* application and one set of the *approved* plans and other documents submitted with the application. These are extremely valuable and important documents. Every effort should be made to provide secure places for them. At the completion of the construction, they should be handled as permanent records of

value and filed in a repository under the control of the proponent for permanent keeping, together with a complete set of all correspondence and other records of contact with the local agencies.

The above outline also applies to alterations and additions to existing facilities. The details of the process and time involved in the review will vary considerably, depending on the extent and complexity of the proposed work. However, the code compliance review requirements pertain, regardless of whether the work is new construction or an alteration of an existing facility. The reader is urged to become familiar with:

- The local jurisdiction's requirements and procedures, as familiarity will expedite the permitting process
- Appeals boards operated by the jurisdiction
- Departmental structure of the reviewing agencies
- Other regional or state agencies that may have concern with the proposed construction in the project locality

Appendix D. Bibliography (Informative)

Introduction to Appendix D

This appendix contains a list of references allows the reader to refer to documents used by the authors of the comment as to the basis for the comment provided in the explanatory text included in Chapter 4.

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The Hydrogen Safety Panel

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The **Hydrogen Safety Panel** was created to address concerns about hydrogen as a safe and sustainable energy carrier. Our principal objective is to promote the safe operation, handling, and use of hydrogen and hydrogen systems across all installations and applications. We believe this objective can be achieved through a variety of hydrogen safety efforts and activities, and that success will be measured by how effectively we are able to help:

- *identify and address safety-related technical data gaps*
- *make design, construction, and operations personnel aware of relevant issues and best practices that affect safe operation and handling of hydrogen and related systems*
- *convince design, construction, and operations personnel to give sufficient priority to safety in their daily, ongoing work*

The **Hydrogen Safety Panel** contributes to this objective by:

- *participating in safety reviews*
- *providing safety planning guidance*
- *reviewing project designs and safety plans*
- *sharing safety knowledge and best practices*
- *presenting and recognizing safety as a priority*
- *participating in incident investigations*

The Panel's approach is to focus on **engagement**, **learning**, and **discussion** rather than on audit or regulatory exercises, and to build on, rather than duplicate, the efforts of others such as the good work being done by codes and standards development organizations.

If you have interest in utilizing the expertise of the Panel, contact the program manager at at **hsp@h2tools.org**.

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