International Codes, Standards, and Regulations for Hydrogen Energy Technologies

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31.1 Overview
The subject of codes, standards, and regulations for hydrogen energy technologies is vast, and it is a rapidly moving, evolving target. Many dedicated people from industry, government, and trade associations, as well as fire safety specialists, permitting officials, and code and standards development organizations (CDOs and SDOs), are all working together to establish the codes, standards, and regulations that will enable wide-scale deployment of hydrogen energy technologies.

Hydrogen energy safety is based on three primary elements: regulatory requirements, capability of safety technology, and the systematic application of equipment and procedures to minimize risks. Industry currently implements many successful proprietary methodologies for safely handling large amounts of hydrogen. These experiences are making their way into developing standards through direct participation by industry experts. There are several codes, standards, and regulations specifically for hydrogen that are under construction at all levels of government in many countries. There are many efforts underway to standardize hydrogen system components for safety in a variety of potential commercial hydrogen market applications.

Through workshops, working groups, coordination committees, and similar activities, there is also increasingly effective collaboration between industry, CDOs and SDOs, and many other experts. This collaboration makes it possible to identify technical areas of expertise required to produce the codes and standards that stakeholders feel are required to facilitate commercialization of hydrogen and fuel cell technologies and infrastructure. Hydrogen experts have the opportunity to participate directly in technical committees and working groups where issues can be discussed with the appropriate industry groups.

31.2 Background
Before we get into the technical details, it is essential to clarify some of the key terminology.

31.2.1 What Are Codes, Standards, and Regulations?
There are many types of documents of interest to those of us involved in developing codes and standards. What are they and how do they differ? This section provides basic information on the definitions of codes, standards, regulations, technical specifications (TSs), technical reports (TRs), information reports, and recommended practices. It is intended to help the reader understand what is implied by each of these document types and to help assess which type may be most appropriate for a new activity.

31.2.1.1 Codes
The Merriam-Webster’s dictionary defines a code as a systematic statement of a body of law or a system of principles or rules. They generally apply to construction or the built environment. Codes establish minimum requirements for things like offset distances between permanent fixtures, ventilation requirements, plumbing and electrical requirements, and other items relating to a built environment. A code may reference a standard. If you are
adding a deck onto your home, or expanding your porch, or installing a hot tub on your
deck, you will need to get a permit. To verify the safety and grant approval for such a proj-
et, the jurisdiction having authority over your project will want to see proof that the job
will be done in a way that conforms to existing codes. The code may reference applicable
standards, such as Underwriters Laboratories (UL) standards.

Codes are meaningless unless a state or local jurisdiction adopts them. There are over
44,000 local code enforcement agencies in the United States alone. They have the option
of adopting any model code from any year and may make local code amendments. This
leads to the potential for a lot of variation in codes. Codes most often encountered in the
hydrogen and fuel cell arena include International Code Council (ICC) and National Fire
Protection Association (NFPA) codes.

31.2.1.2 Standards

Merriam-Webster defines a standard as “something set up as a rule for measuring or as
a model to be followed.” This does not appear to be very different from a code. In some
cases, they really are not very different. Often, when we talk about a standard for a hydro-
gen system or component, we are referring to standards for the component or system
rather than the standard for installation, although those exist as well. A standard might
be performance based, that is, each unit must meet the following tests, or it may be a design
standard, that is, the nozzle must be made of the following materials and have the following dimen-
sions. Standards for manufacturing or testing a unit are independent of where the unit will
be used. But standards are not mandatory until they are called out someplace, such as in a
code, regulation, procurement contract, or other requirements document. What standards
do allow, however, is a consensus process for developing minimum technical require-
ments to assure uniformity of the product, including safety and performance. Often, when
a regulator or code official is unfamiliar with an emerging technology or new equipment
design, having a standard gives that official a starting place for evaluating the technology.
In addition, it gives the official some confidence that the information is based on best prac-
tices and industry consensus. It takes much of the guesswork out of the equation.

The term International Standards typically refers to standards published by the International
Organization for Standardization (ISO) or the International Electrotechnical Commission
(IEC) or both. The capitalization is meant to avoid confusion with other standards devel-
oped internationally. An international standard is a standard that is adopted by an inter-
national standardizing/standards organization and made available to the public. An
International Standard is one where the international standards organization is ISO or IEC.

Both ISO and IEC have published guides for the preparation of documents prepared in
accordance with the ISO/IEC directives. These guides are available on the ISO website
(http://www.iso.org) and IEC website (http://www.iec.ch).

31.2.1.3 Regulations

Merriam-Webster defines a regulation as a rule dealing with details of procedure or an order
issued by an executive authority of a government and having the force of law. For example, in the
United States, we have regulations from the Department of Transportation that relate to
transporting dangerous and hazardous goods. The Federal Aviation Administration (FAA)
has regulations regarding what can and cannot be brought onboard an aircraft, how often
an aircraft is inspected, how many consecutive hours a pilot can be on duty, etc. These
regulations are generally safety-oriented.
31.2.1.4 Technical Specifications

TSs are used by ISO and IEC, among others, when the subject in question is still under development or where for any other reason, the possibility of an agreement to publish a standard is not imminent. In this case, it is used for prestandardization purposes.

A TS may also be used when the required support cannot be obtained for a final draft of international standard to pass the approval stage or in case of doubt concerning consensus. In ISO and IEC, TSs are subject to review by the technical committee or subcommittee not later than 3 years after their publication. The purpose of this review is to reexamine the situation that resulted in the publication of a TS and, if it is possible, to achieve the agreement necessary for the publication of an international standard to replace the TS.

31.2.1.5 Publicly Available Specifications

In ISO or IEC, a publicly available specification (PAS) may be developed when a specification is needed prior to all the requirements of a standard being met. A PAS may be an intermediate specification, published prior to the development of a full international standard, or, in IEC, may be a dual-logo publication published in collaboration with an external organization. It is a document not fulfilling the requirements for a standard. A PAS remains valid for an initial maximum period of 3 years. The validity may be extended for a single 3-year period, following which it shall be revised to become another type of normative document (such as an international standard) or shall be withdrawn.

31.2.1.6 Technical Reports

When a technical committee or subcommittee has collected data of a different kind from what is normally published as an international standard (this may include data obtained from a survey carried out among the members or data on the state of the art in relation to standards of national bodies on a particular subject), the work may be published in the form of a TR. TRs are entirely informative in nature. The technical committee or subcommittee responsible decides on withdrawal of a TR.

31.2.1.7 SAE Documents

The Society of Automotive Engineers (SAE) is an SDO, which is comprised of automotive and other mobility engineering professionals and focuses on developing documents that govern the engineering of powered vehicles. The SAE issues the following types of documents:

- SAE Standards: These TRs are a documentation of broadly accepted engineering practices or specifications for a material, product, process, procedure, or test method.
- SAE Recommended Practices: These TRs are documentations of practice, procedures, and technology that are intended as guides to standard engineering practice. Their content may be of a more general nature, or they may propound data that have not yet gained broad acceptance.
- SAE Information Reports: These TRs are compilations of engineering reference data or educational material useful to the technical community.

SAE has a committee dedicated to developing documents relating to fuel cell vehicles (FCVs).
So while codes, standards, and regulations are each important to protect the public, in most cases, each has a unique niche. Codes generally apply to the built environment. Standards generally apply to components, systems, and testing. And regulations generally apply to transportation or rules of procedure. Each SDO and CDO has specific rules for their process for consensus, and the requirements for different document types vary. For example, the ISO process for a TR requires a less stringent consensus process, and therefore less time, than the process for an International Standard, which has the most stringent requirements to assure consensus.

Now that we have a general feel for the differences, it is important to note one very real similarity. The development of a new code, standard, regulation, or any other document type listed previously takes 2–5 years on average (sometimes much longer). That is due to the fact that industry consensus is required, sometimes nationally or internationally. Often, there is too little data available upon which to proceed, and the process may be slow while appropriate testing is conducted or data are gathered.

As regulations are effectively laws, they can typically be obtained through the publishing government agency at no cost. However, as codes and standards are developed by organizations whose business is their development and promulgation, these documents are copyrighted. In addition, many of the pertinent codes and standards are in development. Therefore, the content is subject to change until the final approval stage and publication. Because of this, it is not practical to provide detailed technical information about each code and standard that applies to hydrogen energy technologies.

Instead, this chapter describes the basics of codes, standards, and regulations, highlights the main organizations involved in their development, provides a short overview of the scope of key documents, and provides resources for additional information.

### 31.3 Why Are Codes, Standards, and Regulations Needed?

For over 50 years, gaseous hydrogen has been used in large quantities as a feedstock in the petroleum refining, chemical, and synthetic fuel industries. Examples include making ammonia for fertilizer and removing sulfur in petroleum refining for such products as reformulated gasoline. Hydrogen is also used in the food processing, semiconductor, glass, and steel industries, as well as by electric utilities as a coolant for large turbine generators.

Existing industrial safety rules, regulations, consensus standards, and codes relating to the transporting and utilization of hydrogen are adequate for today’s markets. The use of hydrogen has resulted in an admirable safety record. However, in the case of widespread usage of hydrogen for future emerging applications, today’s safety rules, consensus standards, codes, etc. may not be adequate. Systematic efforts by local/state/federal government entities, producers of hydrogen products (e.g., automotive industry), codes and standards organizations, users, and others must be devoted to

1. Identifying safety-related issues associated with the production and use of hydrogen-fueled systems
2. Developing or updating and then validating regulations, codes, and standards relating to the safe transportation, use, and servicing of hydrogen-fueled systems
While hydrogen has been used extensively in a number of industrial applications, in energy applications, the only significant use of hydrogen has appeared in space programs. This is beginning to change, given the promise that hydrogen is an efficient energy carrier and an energetic fuel with minimal environmental impact. Systems are being implemented that produce hydrogen from primary energy sources (such as sunlight, wind power, biomass, hydroelectric, and fossil fuels) and use hydrogen in energy applications for home and office heating, for generating electricity, and as a transportation fuel.

Because of the growing applications for hydrogen energy, efforts are underway to create consensus standards for domestic and international use; develop enforceable building, fire, mechanical, plumbing, and other building code provisions; and to harmonize, to a practical extent, requirements from different countries to facilitate international trade.

Widespread hydrogen use requires that safety be intrinsic to all processes and systems. To develop a hydrogen infrastructure that has the public’s confidence in its safety and convenience, an industry consensus on safety issues is required. This includes the development of compatible standards and formats (e.g., the same couplings for dispensing the same form of fuel). Product certification protocols are also required.

Codes and standards development is occurring in advance of or in parallel with applications for hydrogen energy and hydrogen-fueled systems. Codes and standards development must be coordinated with technology development so that the technologies can be sited as they enter commercial or precommercial deployment phases. Efforts are also devoted to research and development to validate proposed requirements.

The US Department of Energy (DOE) held a National Hydrogen Energy Roadmap Workshop on April 2–3, 2002, to identify issues surrounding safety, codes, and standards for hydrogen energy systems. The roadmap developed at this seminal event, as well as regular updates in consultation with industry, continues to guide DOE funding priorities for codes and standards.

Following the development of the roadmap, clear roles for the various US SDOs were identified. This allowed work to begin in a coordinated fashion. The creation of National Hydrogen and Fuel Cells Codes and Standards Coordinating Committee (NHFCCSCC) has further increased coordination among US stakeholders by providing a monthly forum to discuss issues and timelines for the development of key codes and standards. This increased coordination helps reduce duplication of effort and provides a mechanism for more timely information exchange, benefiting the national effort.

31.4 Who Is Involved?

A large number of organizations are involved in creating consensus documents in a variety of technical disciplines. CDOs create requirements for the built environment, including building codes, fire codes, mechanical codes, and plumbing codes. SDOs create and maintain standards, TRs, best practices, etc. in the technical discipline for which they have the national or international remit. The best way to understand which organization is responsible for which disciplines is to look at the US national and international templates posted at http://www.hydrogenandfuelcellsafety.info/resources.asp and the matrix of hydrogen and fuel cell codes, standards, and regulations posted at www.fuelcellstandards.com.7
31.4.1 United States

In the United States, the development of the codes and standards necessary for commercialization of hydrogen and fuel cell systems is a priority for the US DOE and the hydrogen industry. The US model CDOs—the ICC and the NFPA—both provide processes for public code change proposals. Over the past 5 years, industry has been working closely with these organizations to include changes to facilitate the approval of hydrogen and fuel cell installations. This takes place through the organizations’ public code change processes. Members of the public may make recommendations on changes to the US model codes, with supporting justification for the changes. The technical committee responsible for maintaining the specific codes then meets to review all the proposed changes and make a recommendation to the voting members of the CDO (NFPA or ICC). The public then has a chance to review all the proposals and the committee recommendations and provide comments in the case of ICC or exceptions in the form of a notice to make a motion at the annual meeting in the case of the NFPA. Procedures and timelines differ between the ICC and NFPA. Each organization publishes their procedures as well as deadlines for the various code development cycles on their websites:

ICC: www.iccsafe.org
NFPA: www.nfpa.org

Local jurisdictions adopt building and fire codes according to their needs, and they may adopt a model code in its entirety or develop modifications. There are extensive efforts in the United States to identify areas where requirements for hydrogen energy systems may be technically different and work through the open code development processes to harmonize requirements.

Let us now take a look at some of the specific relevant US model code documents promulgated by NFPA and ICC that we need to consider in order to deploy hydrogen energy equipment.

31.4.1.1 National Fire Protection Association

National Fire Protection Association (NFPA) has several existing codes and standards that address the use of hydrogen and hydrogen technologies, including the following:

1. **NFPA 2 Hydrogen Technologies Code, 2011 edition**. This document is NFPA’s hydrogen technologies project, which consolidates the requirements of all of the following documents and addresses any areas that the current NFPA hydrogen documents do not address.

2. **NFPA 55 Standard for the Storage, Use, and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders, and Tanks, 2013 edition**. This document gives storage, handling, and use requirements for compressed gases including hydrogen. There are two chapters in this document devoted to gaseous and liquefied hydrogen storage systems.

3. **NFPA 52 Vehicular Gaseous Fuel Systems Code, 2013 edition**. This code covers natural gas vehicular fuel systems. These systems include storage of fuels at dispensing facilities and dispensing facility operations, design, maintenance. There are also some onboard vehicle requirements. This code no longer covers hydrogen fueling stations.


7. NFPA 497 Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas, 2012 edition. This document gives requirements for the electrical classification of areas where hydrogen would be used or stored. Electrical classification is a critical issue and can have a significant impact on project costs.

8. NFPA 88A Standard for Parking Structures, 2011 edition. This document covers the construction and protection of, as well as the control of hazards in, open and enclosed parking structures.

9. NFPA 86 Standard for Ovens and Furnaces, 2011 edition. This document contains requirements for hydrogen storage systems that are used for gas quenching operations.

10. NFPA 5000 Building Construction and Safety Code, 2012 edition. This document contains construction requirements for buildings storing hydrogen. Hydrogen is not addressed directly, but relevant consideration for hydrogen is addressed generally as a flammable gas in the hazardous material chapter.

11. NFPA 1 Uniform Fire Code, 2012 edition. An extract document that contains large pieces of NFPA 52 and 55 (among many other documents). The fire code is meant to address operational safety as opposed to the building code that addresses construction safety.

### 31.4.1.2 International Code Council

The ICC also promulgates model codes for adoption in the United States and elsewhere. Although the ICC does not have separate standards or codes dedicated to alternative fuels or hydrogen, provisions for hydrogen technologies are predominantly found in the International Fire Code and the International Fuel Gas Code. For example, the International Fire Code includes harmonized separation distance requirements for bulk hydrogen storage, using methodologies developed by Sandia National Laboratories and industry over the past several years.

### 31.4.1.3 National Standards and Recommended Practices

US SDOs are organizations with a remit to develop standards for specific technology areas. For example, the American Society of Mechanical Engineers (ASME) develops and maintains Boiler and Pressure Vessel Standards. The Compressed Gas Association (CGA) develops and publishes technical information, standards, and recommendations for safe
and environmentally responsible practices in the manufacture, storage, transportation, distribution, and use of industrial gases. There are many US SDOs involved in developing requirements for hydrogen energy systems. The US national template for hydrogen vehicle systems and refueling facilities is updated regularly and posted on several websites. An Internet search for the template will also yield a number of presentations made at conferences on the development and maintenance of the template.

The National Renewable Energy Laboratory (NREL) has recently published *Vehicle Codes and Standards: Overview and Gap Analysis*. This report covers six of the most commonly available fuels designated by the DOE as vehicle alternative fuels, including hydrogen. Table 13 in this report provides specific section references in the various codes and standards for hydrogen fuel, equipment, and processes. This 17-page table also provides the edition citation for the model code references for hydrogen. This is a particularly useful reference to help determine which codes and standards may apply for a particular type of equipment or application—particularly in the United States—and when new provisions became available.8

As stated previously, there are numerous CDOs and SDOs involved in developing and maintaining the codes and standards that relate to hydrogen energy systems. For example, hydrogen-related standards for onboard vehicles fall under the purview of the SAE. Component documents are developed by the ASME, the National Institute of Standards and Technology (NIST), the American Society for Testing and Materials (ASTM), the CGA, UL, CSA America, and others as appropriate.

An excellent resource for understanding which organizations are involved in standards development and the progress of these efforts is through the NHFCCSCC. This group meets monthly, usually by teleconference, so that all the stakeholders have the regular opportunity to discuss the issues, challenges, and timescales. Minutes of these meetings are posted in the *Hydrogen and Fuel Cell Safety Report*, a monthly online publication that provides news about developing hydrogen and fuel cell codes and standards and related safety information (see Section 31.5 for more information on this resource).* These can be reviewed each month as they are posted or by viewing the related webpages dedicated exclusively to this group where this information is archived.

Here is a brief description of the scope of the national CDOs and SDOs in the development of standards for hydrogen energy systems:

- SAE: FCV standards, including terminology, safety, recyclability, and interface issues between the vehicles and the refueling station.
- ASME: Pipelines, piping, and hydrogen storage containers.
- NIST: Weights and measures for commercial sale of hydrogen.
- ASTM: Sampling and standard test methods—in particular, to measure hydrogen fuel quality.
- CGA: Pipelines, pressure equipment, and serve as the administrator of the US Technical Advisory Group (TAG) for ISO/TC 197 (the ISO Technical Committee on Hydrogen Technologies—described in the next section).
- UL: Hydrogen sensors, flammable gas detectors, and certification.

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• CSA America: Hydrogen dispensing, on-site hydrogen production, and certification. CSA currently has three activities dedicated to hydrogen energy technologies:
  • HPIT 1—Compressed Hydrogen Powered Industrial Truck On-board Fuel Storage and Handling Components
  • HPIT 2—Compressed Hydrogen Station and Components for Fueling Powered Industrial Trucks
  • CHMC 1—Test Method for Evaluating Material Compatibility for Compressed Hydrogen Applications

31.4.2 International Standards
Internationally, there are two main technical committees involved in developing and maintaining international standards for hydrogen and fuel cell technologies:
  • IEC/TC 105 is the IEC Committee on Fuel Cell Technologies.
  • ISO/TC 197 is the ISO Technical Committee on Hydrogen Technologies.

A description of the scope of the documents developed by these organizations, as well as the status of the documents and points of contact for each work item, is published online at www.fuelcellstandards.com.

The approval process for installation of hydrogen and fuel cell equipment varies between countries. The process may depend on whether the installation is in an industrial or a residential environment, as different authorities have responsibility for the industrial and residential permitting procedures in many countries.

Most countries have regulatory requirements in place for fuel gases. In most cases, hydrogen is not currently covered by existing regulations as a fuel gas; therefore, more time may be required for preparing technical information for the permitting authority and for the review of that information.

Building regulations, codes, and standards describe a set of rules that specify an acceptable level of safety for constructed objects, both buildings and nonbuilding structures. Requirements in these documents may be country-specific and typically deal with issues including

• Design and construction to ensure structural stability of the building and adjoining buildings
• Fire safety, means of escape, prevention of internal and external fire spread, and access and facilities for the fire services
• Ventilation
• Drainage and waste disposal
• Use of combustion appliances and fuel storage
• Protection from falling, collision, and impact
• Energy efficiency and conservation
• Access to and use of the building
• Electrical safety

Some buildings may be exempt from these controls, such as temporary buildings, buildings not frequented by people (unless it is located close to a building that is), small detached
buildings (such as garages, garden storage, sheds, and huts), and simple extensions (such as porches, covered ways, and conservatories). However, it is good practice to have an exemption confirmed by the appropriate authority prior to construction.

In Europe, the principal regulations covering hydrogen facilities arise from the national legislation passed to implement the explosive atmosphere (ATEX) directives and the pressure equipment directive. Their requirements are not specific to hydrogen and would equally apply to any fuel that is capable of generating a flammable atmosphere, for example, natural gas or liquefied petroleum gas (LPG), or equipment that contains a fuel under pressure. For some components of the installation, for example, if the hydrogen is produced by internal reformation of natural gas, the requirements of European regulation, the gas appliances directive, may also be applicable.

More detailed information on the applicable European directives can be found in the Installation Permitting Guide. This document was created in response to the growing need for guidance to facilitate small hydrogen and fuel cell stationary installations in Europe. This document is not a standard but is a compendium of useful information for a variety of users with a role in installing these systems. Please see http://www.hyperproject.eu/ for the interactive version of this guide.

Please see www.fuelcellstandards.com for information on international standards and regulations applicable to hydrogen and fuel cells. This website contains details on North American, Pacific Rim, European, and international codes, standards, and regulations, including both those already published and those in development.

31.4.2.1 International Standards and ISO/TC 197

The scope of ISO/TC 197 is standardization in the field of systems and devices for the production, storage, transport, measurement, and use of hydrogen. The first meeting of ISO/TC 197 was held in June 1990 in Zurich, Switzerland. The most recent meeting was held on December 5–6, in Paris, France.

ISO/TC 197 has established liaison relationships with other applicable ISO and IEC technical committees, and where appropriate, with subcommittees.

New working groups are formed when a member country submits a new work item proposal (NWIP) to the technical committee, and it is approved through ballot with affirmative votes and agreement to participate in the work. Working groups whose documents are finished are no longer active. As a result, the list of active working groups is ever-changing. ISO/TC 197 working groups are assigned work items. In most cases, a working group may be assigned more than one document.

The following is a list of all ISO/TC 197 working groups that have been created, and the documents they were responsible for:

- ISO/TC 197/WG 1 Liquid hydrogen—Land vehicle fuel tanks
- ISO/TC 197/WG 2 Tank containers for multimodal transportation of liquid hydrogen
- ISO/TC 197/WG 3 Hydrogen fuel—Product specification
- ISO/TC 197/WG 4 Airport refuelling facility
- ISO/TC 197/WG 5 Gaseous hydrogen—Land vehicle filling connectors
- ISO/TC 197/WG 6 Gaseous hydrogen and hydrogen blends—Land vehicle fuel tanks
- ISO/TC 197/WG 7 Basic considerations for the safety of hydrogen systems
- ISO/TC 197/WG 8 Hydrogen generators using water electrolysis process
• ISO/TC 197/WG 9 Hydrogen generators using fuel processing technologies
• ISO/TC 197/WG 10 Transportable gas storage devices—Hydrogen absorbed in reversible metal hydride
• ISO/TC 197/WG 11 Gaseous hydrogen—Service stations
• ISO/TC 197/WG 12 Hydrogen fuel: Product specification—Proton exchange membrane (PEM) FCVs
• ISO/TC 197/WG 13 Hydrogen detectors
• ISO/TC 197/WG 14 Hydrogen fuel: Product specification—PEM fuel cell applications for stationary appliances
• ISO/TC 197/WG 15 Gaseous hydrogen—Cylinders and tubes for stationary storage
• ISO/TC 197/WG 16 Basic considerations for the safety of hydrogen systems
• ISO/TC 197/WG 17 Safety of pressure swing adsorption systems for hydrogen separation and purification
• ISO/TC 197/WG 18 Land vehicle fuel tanks and TPRDs
• ISO/TC 197/WG 19 Gaseous hydrogen: Fueling stations—Dispensers
• ISO/TC 197/WG 20 Gaseous hydrogen: Fueling stations—Valves
• ISO/TC 197/WG 21 Gaseous hydrogen: Fueling stations—Compressors
• ISO/TC 197/WG 22 Gaseous hydrogen: Fueling stations—Hoses
• ISO/TC 197/WG 23 Gaseous hydrogen: Fueling stations—Fittings
• ISO/TC 197/WG 24 Gaseous hydrogen: Fueling stations—Part 1: General requirements

An up-to-date listing of which documents have been published, which have been withdrawn, and which projects have been cancelled is maintained on the ISO/TC 197 website. Further information such as the status and target publication date of ISO documents under development can also be found on the ISO website.

In addition, [www.fuelcellstandards.com](http://www.fuelcellstandards.com) tracks the development of over 200 worldwide standards, allowing the user to search by geographic regions or application. The user can drill down to learn about the scope, stage of development, and contact points for developing documents, as well as ordering information for published documents.

For details on progress and technical issues being addressed by those developing codes and standards, the Fuel Cell and Hydrogen Energy Association publishes regular, timely updates of developing documents in their Hydrogen and Fuel Cell Safety Report (see Section 31.5 for more information).

### 31.4.2.2 International Standards and IEC/TC 105

The International Electrotechnical Commission (IEC) has a technical committee for fuel cells, which is labeled as IEC/TC 105. The work of this technical committee applies to fuel cells of all types, and therefore, it is not limited to only fuel cells that use hydrogen as its fuel. The scope of IEC/TC 105 is to prepare international standards regarding fuel cell technologies for all fuel cell applications, such as stationary power systems, for transportation both as propulsion systems and auxiliary power units; portable power systems; and micropower systems.
The following documents have been published:

- IEC/TC 105 WG 1 Fuel cell technologies—Part 1: Terminology
- IEC/TC 105 WG 2 Fuel cell technologies—Part 2: Fuel cell modules
- IEC/TC 105 WG 3 Fuel cell technologies—Part 3-1: Stationary fuel cell power systems—Safety
- IEC/TC 105 WG 4 Fuel cell technologies—Part 3-2: Stationary fuel cell power systems—Performance test methods
- IEC/TC 105 WG 5 Fuel cell technologies—Part 3-3: Stationary fuel cell power systems—Installation
- IEC/TC 105 WG 6 Fuel cell system for propulsion and auxiliary power units
- IEC/TC 105 WG 7 Fuel cell technologies—Part 5-1: Portable fuel cell power systems—Safety
- IEC/TC 105 WG 8 Fuel cell technologies—Part 6-100: Micro fuel cell power systems—Safety
- IEC/TC 105 WG 9 Fuel cell technologies—Part 6-200: Micro fuel cell power systems—Performance test methods
- IEC/TC 105 WG 10 Fuel cell technologies—Part 6-300: Micro fuel cell power systems—Fuel cartridge interchangeability
- IEC/TC 105 WG 11 Fuel cell technologies—Part 7-1: Single cell test methods for polymer electrolyte fuel cell (PEFC)
- IEC/TC 105 WG 12 Stationary fuel cell power systems—small stationary fuel cell power systems with combined heat and power output.


31.4.2.3 National Input to Developing International Standards

Individual countries that participate in ISO and IEC provide input to the developing international standards through their national standard body. In the United States, this is the American National Standards Institute (ANSI). The management of the national TAG is assigned to a relevant SDO. In the United States, the secretariat for the ISO/TC 197 US TAG is the Compressed Gas Association (CGA), while the secretariat for the IEC/TC 105 US TAG is CSA International.

31.4.2.4 Global Technical Regulations

As described earlier, regulations carry the force of law. Many countries have regulations to cover topics covered by the codes in the United States, such as fire safety, gas use, buildings, and electrical safety.

In the case of hydrogen, there has been recent success in the development of a global technical regulation (GTR).

A GTR is (1) a process for developing and promulgating motor vehicle safety standards and/or regulations for motor vehicles by the participating counties and (2) the standards and/or regulations emanating from that process.
The World Forum for Harmonization of Vehicle Regulations of the United Nations Economic Commission for Europe (UN/ECE/WP29) has the lead role in the global harmonization of automotive regulations—focusing on vehicles at the time of manufacturing. The GTR concept was created by the 1998 UN global agreement to internationally harmonize vehicle regulations and make vehicles and vehicle parts produced under GTRs available for sale in any country. The signatories to the global agreement include

- United States
- European Community
- Canada
- Japan
- France
- Germany
- Russian Federation
- Republic of Korea
- People’s Republic of China

With respect to hydrogen and fuel cells, UNECE recently adopted a UN GTR governing the safety of hydrogen and fuel cell vehicles.

Additional information regarding GTRs and the process can be found at the following website: [www.unece.org](http://www.unece.org).

### 31.4.3 Other Regulations

We have previously discussed the US model codes promulgated by the ICC and NFPA in the United States. In addition, one must comply with environmental regulations and Occupational Safety and Health Administration (OSHA) regulations. These are not, however, particular to hydrogen and will therefore not be covered in this chapter.

Many other countries cover similar safety principles in national regulations. There are regulations for gas safety, construction, hazardous substances, health and safety at work, pressure systems, electricity, and many others. In most cases, these regulations are also not specific to hydrogen.

In Japan, there is a national regulation for hydrogen refueling stations. As the international standards for hydrogen energy systems are published, there is an increased opportunity to reference these consensus documents in national codes and regulations. This approach allows harmonized requirements for global commercialization.

### 31.5 Resources Available in the Hydrogen and Fuel Cell Safety Report

The US hydrogen and fuel cell industry works closely with the DOE, the US UL, national CDOs and SDOs, the international SDOs, and other key stakeholders to keep interested parties informed about developments in hydrogen and fuel cell requirements through a bimonthly electronic newsletter, the Hydrogen and Fuel Cell Safety Report, which is available online at [www.hydrogenandfuelcellsafety.info](http://www.hydrogenandfuelcellsafety.info). Interested parties may sign up to receive an e-mail announcing when the new issue is posted.
In addition, this website posts minutes from the meetings of the National Hydrogen and Fuel Cells Codes & Standards Coordinating Committee. The website also collects technical resources, including information on hydrogen properties; proceedings from workshops, including permitting workshops; case studies; the US national and international codes and standards templates; educational websites; R&D data; links to CDO and SDO websites and activities; and anything else that can be shared to facilitate the development of safety, codes, and standards and installation permitting.

References

6. The descriptions of each type are available from the SAE website at www.sae.org.