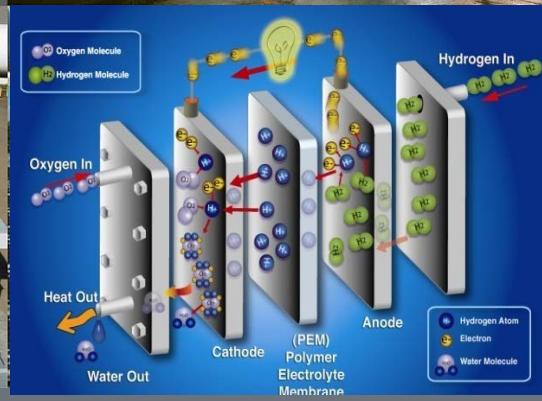
Hydrogen Equipment Certification Guide

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy



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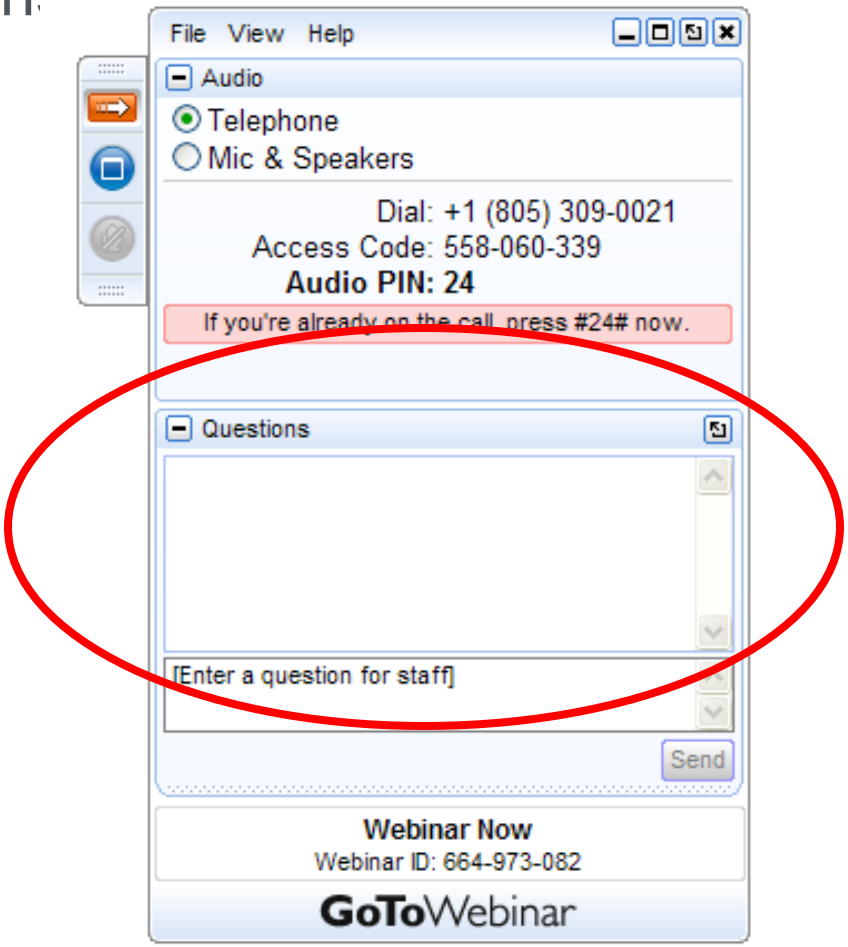
Pacific Northwest National Laboratory (PNNL)
Hydrogen Safety Program Manager

DOE Host:
Will James – DOE Fuel Cell Technologies Office

U.S. Department of Energy
Fuel Cell Technologies Office
December 10th, 2015

Question and Answer

- Please type your questions into the question box



HYDROGEN
Safety Panel

Hydrogen Equipment Certification Guide: Introduction and Kickoff for the Stakeholder Review

Nick Barilo
PNNL Hydrogen Safety Program Manager

Webinar – December 10, 2015

Webinar Objectives

- To provide a preview of the Hydrogen Equipment Certification Guide to the hydrogen and fuel cell stakeholder community
- To provide an opportunity for addressing questions and gathering feedback before the Guide is finalized

Work Performed Under the U.S. DOE Fuel Cell Technologies Office - Safety, Codes and Standards Subprogram

Codes & Standards Objectives:

- Support and facilitate development and promulgation of essential codes and standards to enable widespread deployment and market entry of hydrogen and fuel cell technologies and completion of all essential domestic and international regulations, codes and standards (RCS)
- Conduct R&D to provide critical data and information needed to define requirements in developing codes and standards.

Hydrogen Safety Objectives:

- Ensure that best safety practices underlie research, technology development, and market deployment activities supported through DOE-funded projects.
- Develop and enable widespread sharing of safety-related information resources and lessons learned with first responders, authorities having jurisdiction (AHJs), and other key stakeholders.

Authors - Hydrogen Safety Panel

The Hydrogen Safety Panel (HSP) is a team of highly experienced individuals created to address concerns about hydrogen as a safe and sustainable energy carrier.

Hydrogen Safety Panel members at the California Fuel Cell Partnership in West Sacramento, CA, for the 21st meeting

Principal Objective: Promote the safe operation, handling, and use of hydrogen and hydrogen systems across all installations and applications by:

- identifying and addressing safety-related technical data gaps
- raising the awareness of design, construction, and operations personnel of relevant issues and best practices that affect safe operation and handling of hydrogen and related systems
- persuading design, construction, and operations personnel to give sufficient priority to safety in their daily, ongoing work

Hydrogen Safety Panel Membership

Name	Affiliation
Nick Barilo, Manager	Pacific Northwest National Laboratory
Richard Kallman, Chair	City of Santa Fe Springs, CA
David Farese	Air Products and Chemicals
Larry Fluer	Fluer, Inc.
Bill Fort	Consultant
Donald Frikken	Becht Engineering
Aaron Harris	Air Liquide
Chris LaFleur	Sandia National Laboratories
Miguel Maes	NASA-JSC White Sands Test Facility
Steve Mathison	Honda Motor Company
Larry Moulthrop	Proton OnSite
Glenn Scheffler	GWS Solutions of Tolland
Steven Weiner	Excelsior Design, Inc.
Robert Zalosh	Firexplo

Formed in 2003 to support U.S. DOE Hydrogen and Fuel Cells Program, the Hydrogen Safety Panel:

- has a combined 400+ years of experience, representing many hydrogen sectors and technical areas of expertise
- reviewed 281 projects (427 reviews) covering a broad portfolio
- includes committee members from NFPA 2 and 55, and technical committees of ASME, SAE and ISO

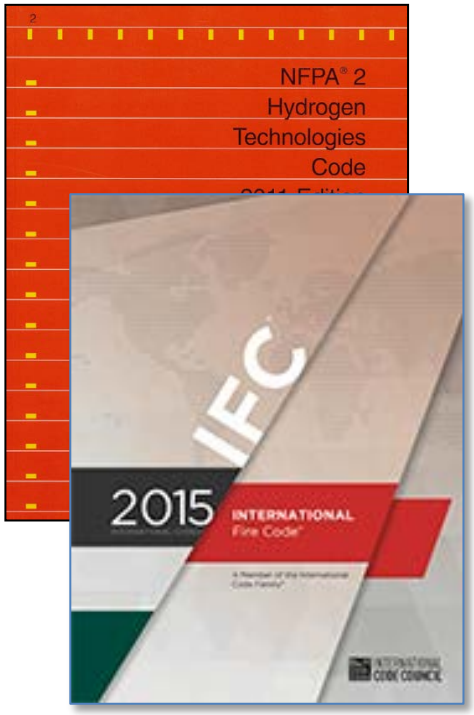
Hydrogen… An Old Fuel with New Applications

- Hydrogen has been used in industry for >50 years
  - Petroleum refining, glass purification, aerospace applications, fertilizers, annealing and heat treating metals, pharmaceutical products, etc.
- Hydrogen is now transforming the energy landscape through the use of fuel cells for the public, private and commercial sectors with new applications involving:
  - Transportation
    - Light and medium duty trucks
    - Heavy duty and transit trucks and buses
    - Auxiliary power for refrigeration trailers and trucks
    - Forklifts
    - Maritime
  - Stationary power
    - Backup power for cell tower sites
    - Combined heat and power
    - Data centers, etc.
  - Portable Power

Codes and Standards

Safe practices in the production, storage, distribution and use of hydrogen are well established and essential for developing hydrogen and fuel cell technologies.

- Codes and standards have progressively evolved to address public safety and acceptance of these new technologies.
- **Inherent in the provisions of codes and standards are requirements for the use of *approved*, *certified*, *listed*, and *labeled* methods and equipment.**



Certification Presents Challenges

- In the early market the availability of systems or equipment that are listed, labeled or certified is limited
- Significant cost can be involved since the technology and products are still rapidly changing and each new iteration can require recertification
- When equipment is not listed or available, “approval” by the code official is required before installation occurs

The scarcity of listed hydrogen equipment places an extraordinary burden on code officials to ensure (approve) that the products employed include the appropriate inherent or automatic safety measures.

What's the Criteria for Approval?

The *Guide* has been developed to assist code officials, designers, owners, evaluators and others with the application of the listing and approval requirements pertinent to the design and/or installation of hydrogen equipment as regulated by the model codes.

Potential Benefits From the Use of the *Guide*

- Enables designers, users and code officials to better apply the requirements where the use of *listed, labeled, certified* or *approved* equipment or methods is required and to increase awareness and understanding of what the equipment is expected to do
- Increased consistency in the application of requirements with the expectation of an expedited permitting process
- Consistent application of requirements among providers, regardless of hydrogen experience results in a level playing field as the technology emerges

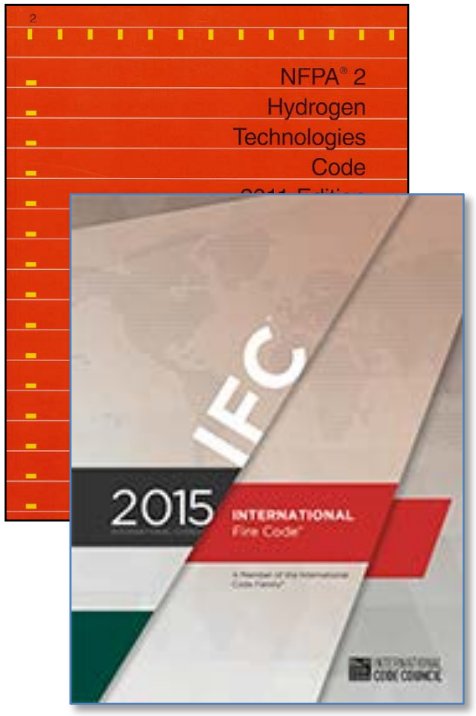
How is This *Guide* Different from Other Guides or Commentaries?

- The *Hydrogen Equipment Certification Guide* focuses on the use of the terms:
  - *Listed*
  - *Labeled*
  - *Approved*
  - *Certified*
- Requirements that do not use the above terms arecovered by other guides (NFPA , ICC, etc.).
- The *Guide* spans an array of codes expected to be encountered by users and code officials.
- The target users include designers, equipment manufacturers, and code officials where hydrogen systems are being installed or operated

Photo: h2tools.org

Codes & Standards Covered by the *Guide*

- *2015 International Fire Code*
- *2015 International Building Code*
- *2015 International Fuel Gas Code*
- *2015 International Residential Code*
- *2015 International Mechanical Code*
- *2011 NFPA 2 Hydrogen Technologies Code*
- *2015 NFPA 1 Fire Code* (as used by NFPA 2 as a source document for requirements relevant to hydrogen as established by NFPA 55)
- *2013 NFPA 55 Compressed Gases and Cryogenic Fluids Code* (as used by NFPA 2 as a source document for requirements relevant to hydrogen)



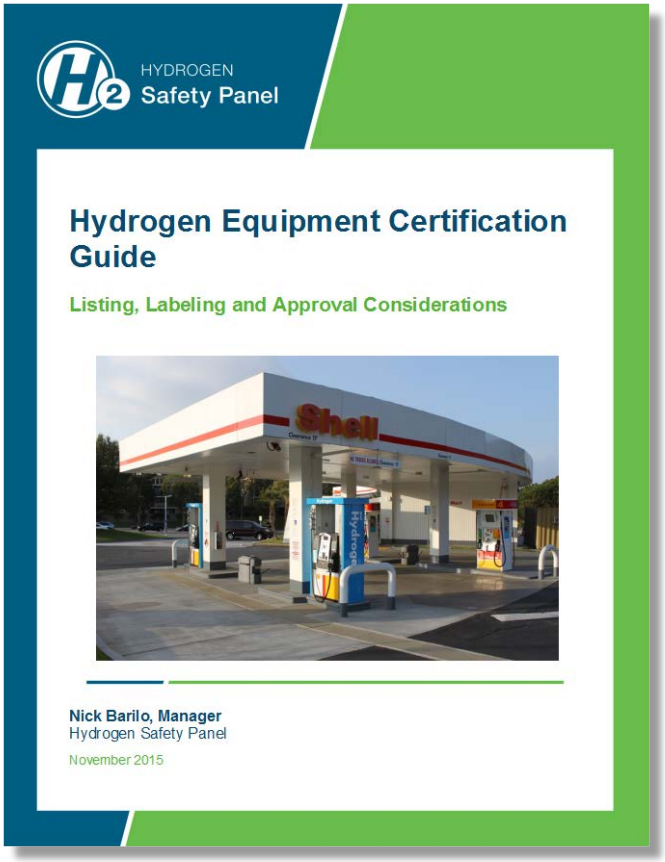
Focus of the *Guide*

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

- ***Approved*** – Acceptable to the authority having jurisdiction.
- ***Certified*** – To attest as being true or as represented or as meeting a standard.
- ***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.
- ***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.

Layout of the Guide

- Chapter 1. Introduction – Purpose, Scope and Background
- Chapter 2. Overview of the Certification Process
- Chapter 3. Selected Definitions
- Chapter 4. Guidance and Explanation
- Appendix A. References
- Appendix B. The Use of Equivalency, Alternative Materials, Methods and Modifications
- Appendix C. Typical Permit Process
- Appendix D. Bibliography



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Sample from Chapter 4

Section	Requirement	Narrative	Required References
	and Sections 2311.7.1.1 and 2311.7.1.2. Exception: *Repair garages* with natural ventilation when *approved*.		
	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 repairing nonodorized LNG-fueled vehicles.	UL 2075, *Gas and Vapor Detectors and Sensors,* could be used for listing; however as of June 2015 there were no flammable *gas detection systems listed* for use with hydrogen found in the UL On-line Certifications Directory.[48] FM Global published an *approval* standard for *Combustible Gas Detectors,* Class 6320, in November of 2014, which could also be used for listing.[49] Until such time as the market place produces *listed* flammable *gas detection systems* specified for use with hydrogen, systems must be *approved*. The *AHJ* may as a minimum require the following criteria to be met or provided: • Manufacturer's instructions for installation and maintenance to include limitations on sensor placement, wiring and related elements. • A list of desensitizing gases or vapors that could interfere with the ability of the system to detect the presence of hydrogen. • Details of accuracy of the sensing device as it relates to hydrogen gas. • Requirements for calibration to include the method to be used and any related calibration gases, mixtures or other allied equipment and techniques to be applied.	

Value to Designers, Code Officials and Owners/Operators

- Where approvals are required, and listed equipment is not available the *Guide* provides direction and/or background to assist the users with elements of consideration needed to address the requirements for safety compatible with the requirements of the code.
- Resources in the form of informational documents and references are provided to aid the user where further research or background is needed in the approval process.
- “Required references” are identified when the referenced code section requires the use of a resource outside of the code itself. The required references comprise a library of documents that may be needed to interpret the requirements depending on the applicable code in use. The documents are code and section specific thereby limiting the need for outside resources to only those documents necessary for design or application.

How to Use the *Guide* - General

- After the user has become familiar with the overall content of the *Guide* it can be used as a companion to site specific codes applicable to equipment design or installation.
- Chapter 4 is arranged on a code specific basis and contains extract text from the applicable code(s) to aid the user in identifying the provision(s) of interest. The text is further arranged in Section number order and each section containing the trigger terms, i.e., *approved, listed, labeled* or *certified* are highlighted. Related text may be included in limited cases necessary for application.
- Definitions used within the extract code text or the accompanying explanations along with their source documents are included in Chapter 3.
- Required references needed by the user are located in Appendix A.1 and cross referenced by Section number when use is required.
- References used in the narrative text of Chapter 4 are located in Appendix D.

How to Use the *Guide* - Continued

- **Limitations:** The *Guide* has been designed to follow the organization of the applicable code. Requirements are listed in code order and are not sorted by subject. Users cannot use the *Guide* alone as a substitute to the code, nor can it be assumed that the explanatory material included in the *Guide* can be used on a stand alone basis. Requirements and explanations must be applied in accordance with the context found within the source code.
- When the user encounters a section in the code which 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 made in the narrative or reference documents.

How to Use the *Guide* – Example #1 Inspection of Piping Systems IFGC Section 705

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.[i]

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 which 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.

How to Use the *Guide* – Example #2 Gas Detection Listed *or* Approved NFPA 2 Chapter 6

6.12.1	Gas detection equipment shall be *listed* or *approved*.	Although a listing standard exists that could be used (UL 2075) there were no flammable *gas detection systems listed* for use with hydrogen found in the UL On-line Certifications Directory.[i] There are other types of hydrogen gas detectors in addition to the generic *combustible gas detector*. These include electrochemical sensors, metal oxide sensors, metal oxide semiconductors, optical beam scattering detectors, etc. As for generic *combustible gas detectors*, some manufacturers will 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 documentation provided to the *AHJ* that substantiates performance and reliability. See Appendix A.2 of the guide for informational references. Factory Mutual Global published an *approval* standard for *Combustible Gas Detectors*, Class 6320, in November of 2014.[ii] Until such time as the market place produces *listed* flammable *gas detection systems* specified for use with hydrogen, systems must be *approved*. The *AHJ* may request the following criteria to be considered by the designer in determining *approval*. *approval* • Manufacturer's Instructions for installation and maintenance to include limitations on sensor placement, wiring and related elements. • A list of desensitizing gases or vapors that could interfere with the ability of the system to detect the presence of hydrogen. • Details of accuracy of the sensing device as it relates to hydrogen gas. • Requirements for calibration to include the method to be used and any related calibration gases, mixtures or other allied equipment and techniques to be applied, along with recommended frequency. • Requirements for compatibility for those systems to be connected to other notification equipment that may be *listed* or *approved*. • Suitability for installation in a hazardous (classified) location under the requirements of NFPA 70, *National Electrical Code* if the installation is to be installed in a hazardous (classified) location. • Operating procedures to be followed when the gas detection system is off line for maintenance, or otherwise not functional.

How to Use the *Guide* – Example #3 Use of Alternate Materials and Methods IMC Section 510.9

510.9 Duct construction. Ducts used to convey hazardous exhaust shall be constructed of materials *approved* for 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.

Ducts used to transport *flammable gases* should be constructed of ferrous metal as a means to resist the effect of high temperatures that could result in failure if metals of low melting point were used. Note that 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 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 web site[i]: https://www.fmglobal.com/fmglobalregistration/Vshared/FMDS0707.pdf

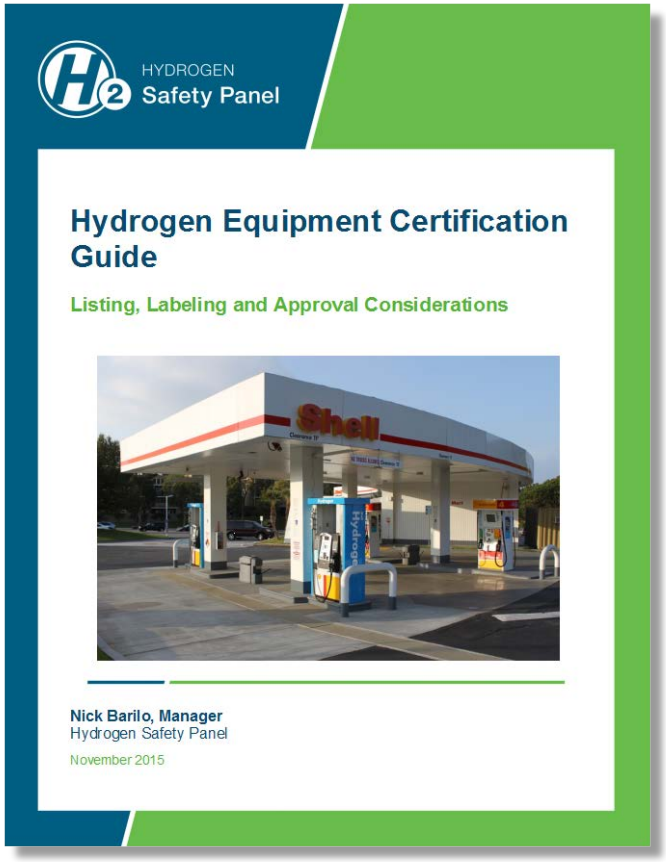
Refer to Appendix A.2 for informational references applicable to exhaust duct systems.

[i] FM Global, Property Loss Prevention Data Sheets FM 7-7, *Semiconductor Fabrication Facilities*, Section 2.2.11, 2015, and FM Global, Property Loss Prevention Data Sheets FM 7-78, *Industrial Exhaust Systems,* 2011: https://www.fmglobal.com/fmglobalregistration/Downloads.aspx

Limitations on Use of the *Guide*

The *Guide* provides guidance only…

- It is **not** a regulatory document
- Is **not intended** to provide *formal interpretations* or positions on compliance with the codes and standards addressed therein, which can only be provided by the code development organizations or by the responsible regulatory official



Disclaimer

While the Guide provides methods for the AHJ to evaluate alternative approaches to certification, listing, and labeling requirements, it is not intent of the Guide to circumvent certification and listing if the AHJ determines it to be necessary for approval.

Expanding the Initial Review

- Review and comments are requested to ensure that the *Guide* is a quality document that meets the needs of those involved in the design, use or approval of hydrogen equipment.
- Send comments to hsp@h2tools.org
- Comments due No Later Than February 29, 2016.
- The final document will be made available on the Hydrogen Tools Portal in August/September 2016.

HYDROGEN Safety Panel

Hydrogen Equipment Certification Guide - Stakeholder Comment Form

Submit comments to hsp@h2tools.org

Commenter's Name: Commenter's Phone:
Commenter's Affiliation: Commenter's Email:

Page and Paragraph	Subject or Code Section	Comment

PLEASE NOTE: Contact information is only for discussing your comments with you if the need arises. There will be no attribution to individuals or organizations responding.

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The comment form is part of the download for the draft certification guide. Submit comments to h2p@h2tools.org.

Timeline and Schedule for the *Guide*

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Thank You for Your Attention!

The authors wish to thank the U.S. Department of Energy's Fuel Cell Technologies Office (Sunita Satyapal, Director and Charles James, Safety, Codes and Standards Lead), Dave Conover from the Pacific Northwest National Laboratory and the California Fuel Cell Partnership for their support of this work.

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Thank You for Your Attention!

The authors wish to thank within the U.S. Department of Energy, the Office of Energy Efficiency and Renewable Energy's Fuel Cell Technologies Office (Sunita Satyapal, Director) and the Safety, Codes and Standards subprogram (Charles James, Lead).

U.S. DEPARTMENT OF ENERGY

Energy Efficiency & Renewable Energy

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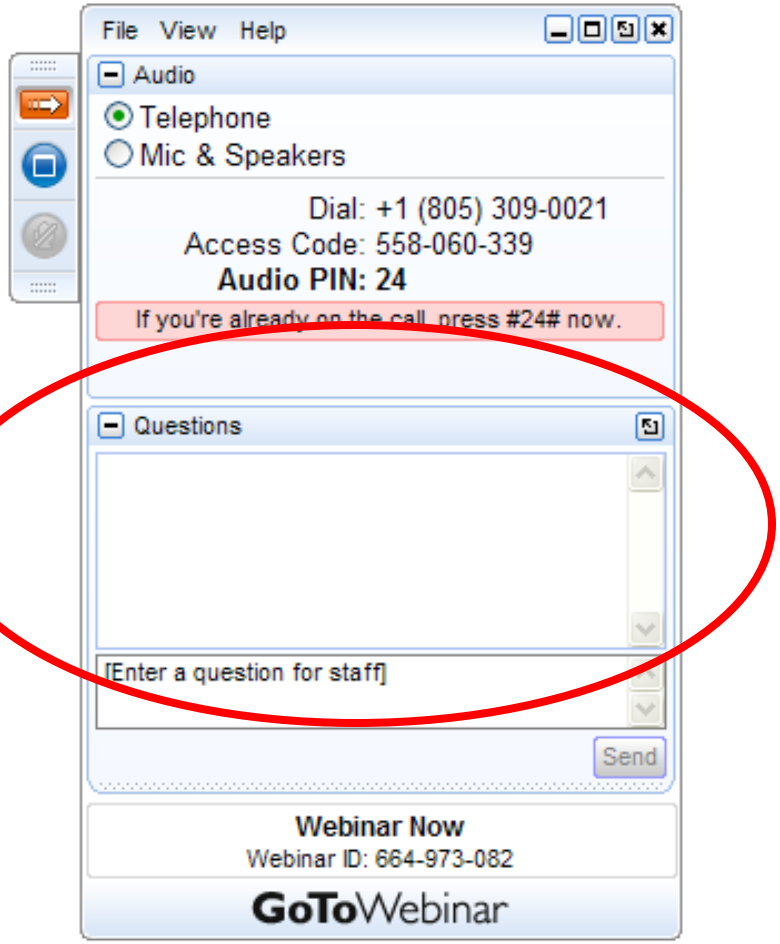

Thank You

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