

U.S. DOE Hydrogen and Fuel Cell Activities

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Fuel Cell Technologies Program

*Hydrogen and Fuel Cell Technical Advisory Committee
October 15, 2010*

Key Challenges

The Program has been addressing the key challenges facing the widespread commercialization of fuel cells

Technology Barriers*

Fuel Cell Cost & Durability


Targets*:
Stationary Systems: \$750 per kW, 40,000-hr durability
Vehicles: \$30 per kW, 5,000-hr durability

Hydrogen Cost

Target*: \$2 – 3 /gge, (dispensed and untaxed)

Hydrogen Storage Capacity

Target: > 300-mile range for vehicles—without compromising interior space or performance



Economic & Institutional Barriers

- Safety, Codes & Standards Development
- Domestic Manufacturing & Supplier Base
- Public Awareness & Acceptance
- Hydrogen Supply & Delivery Infrastructure

Market Transformation

Assisting the growth of early markets will help to overcome many barriers, including achieving significant cost reductions through economies of scale.

* Targets and Metrics are being updated in 2010.

Objectives



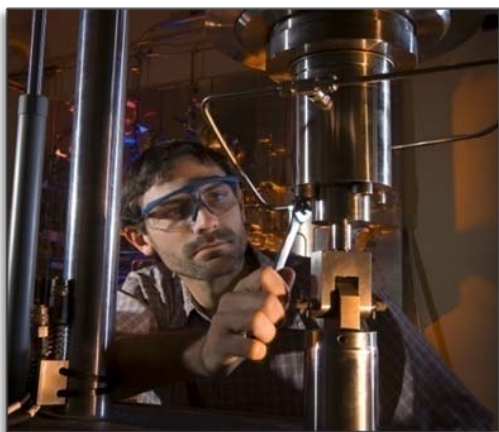
Safety

Develop and implement safety practices and procedures to ensure the safe operation, handling and use of hydrogen and fuel cell technologies.



Codes and Standards

Support critical R&D for the development of scientifically and technically sound codes and standards that enable the safe use of hydrogen and fuel cell technologies and facilitate harmonization of domestic and international regulation, codes and standards (RCS).



- To synchronize codes and standards development and adoption with technology commercialization needs
- To coordinate enabling R&D with the codes and standards development cycle
- To promote domestic and international consistency
- To make approved codes and standards readily available
- To streamline and standardize the permitting process for hydrogen facilities
- To minimize knowledge gaps by disseminating safety information
- To generate hydrogen safety information due to lack of available data

The Federal government is uniquely positioned to facilitate progress towards harmonized codes & standards and improved safety because of the number of diverse parties interested in codes and standards activities

- Conduct research to support the development of codes and standards and facilitate international harmonization of codes and standards, including fuel quality standards.
- Support and facilitate the promulgation of essential codes and standards by 2015 to support the widespread commercialization and market entry of these technologies.
- Support and facilitate the completion of all essential domestic and international RCS by 2020.
- Support and facilitate the development of the Phase I Global Technical Regulations (GTR) for hydrogen-fueled vehicles under the United Nations (UN) Economic Commission for Europe, World Forum for Harmonization of Vehicle Regulations and Working Party on Pollution and Energy Program (ECE-WP29/GRPE) by 2012 and Phase II by 2015.
- Develop appropriate test methodologies, such as for measuring hydrogen cycling effects, and component testing for certification; coordinate with established testing facilities such as Underwriters Laboratories.
- Complete critical assessment of indoor refueling and system operation and recommend relevant code modifications.
- Understand and mitigate risk to facilitate the safe use of hydrogen and fuel cell technologies and insurability.
- Promote widespread sharing of safety-related information, procedures and lessons learned with first responders, Authorities Having Jurisdiction (AHJ) and other stakeholders.

National Codes and Standards Template

National Template: Vehicle Systems & Refueling Facilities

STANDARDS DEVELOPMENT ORGANIZATIONS

— LEAD STANDARDS DEVELOPMENT ORGANIZATIONS (SDOs)

Interface

Vehicles

CONTROLLING AUTHORITIES:

DOT/NHTS (crashworthiness)
EPA (emissions)

General FC Vehicle Safety:

SAE

Fuel Cell Vehicle Systems:

SAE

Fuel System Components:

SP

Containers:

SAE

Reformers:

SAE

Emissions:

SAE

Recycling:

SAE

Service/Repair:

SAE

National Template: Stationary & Portable Systems

STANDARDS DEVELOPMENT ORGANIZATIONS

— LEAD STANDARDS DEVELOPMENT ORGANIZATIONS (SDOs)

Hydrogen Generator

CONTROLLING AUTHORITIES:

EPA (emissions)
DOT/PHMSA (pipeline)
OSHA, State and Local Gov't
(zoning, building permits)

Electrolyzers:

UL SP

Reformers:

UL SP API

Perform. Test Procedures:

ASME SP

Chemical Hydrides:

UL SP NFPA

Portable Fuel Cells

CONTROLLING AUTHORITIES:

CPSC, DOT/PHMSA,
OSHA, EPA (methanol)
State and Local Government
(zoning, building permits)

Handheld Systems:

UL SP

Portable Systems:

SP UL G

Handheld Fuel Containers:

UL SP G

Portable Fuel Containers:

G SP ASME

H₂ Fuel Specifications:

G SAE

Perform. Test Procedures:

gti ASME SP

Stationary Fuel Cells

CONTROLLING AUTHORITIES:

OSHA, State and
Local Government
(zoning, building permits)

H₂ ICES:

UL SP

H₂ Fueled Turbines:

API SP UL ASME

FC Systems:

SP ASME UL

FC Installation:

NFPA

FC Performance

Test Procedures:

ASME SP gti

Interface

Installation Piping:

ASME SP G NFPA

Storage:

ASME G SP API NFPA

Compressors Safety Cert.:

SP UL

Comp. Design, Perf. & Safety:

API

Sensors/Detectors:

UL SP NFPA

Fuel specifications:

G SAE API

Weights/Measures:

NIST API ASME

Dispensers:

NFPA SAE SP UL API

Non-vehicle Dispensing:

G

Codes for Built Environ.:

NFPA G

Interconnection:

NFPA UL NFPA

Regulatory Hierarchy of Hydrogen Codes and Standards

Level 1:

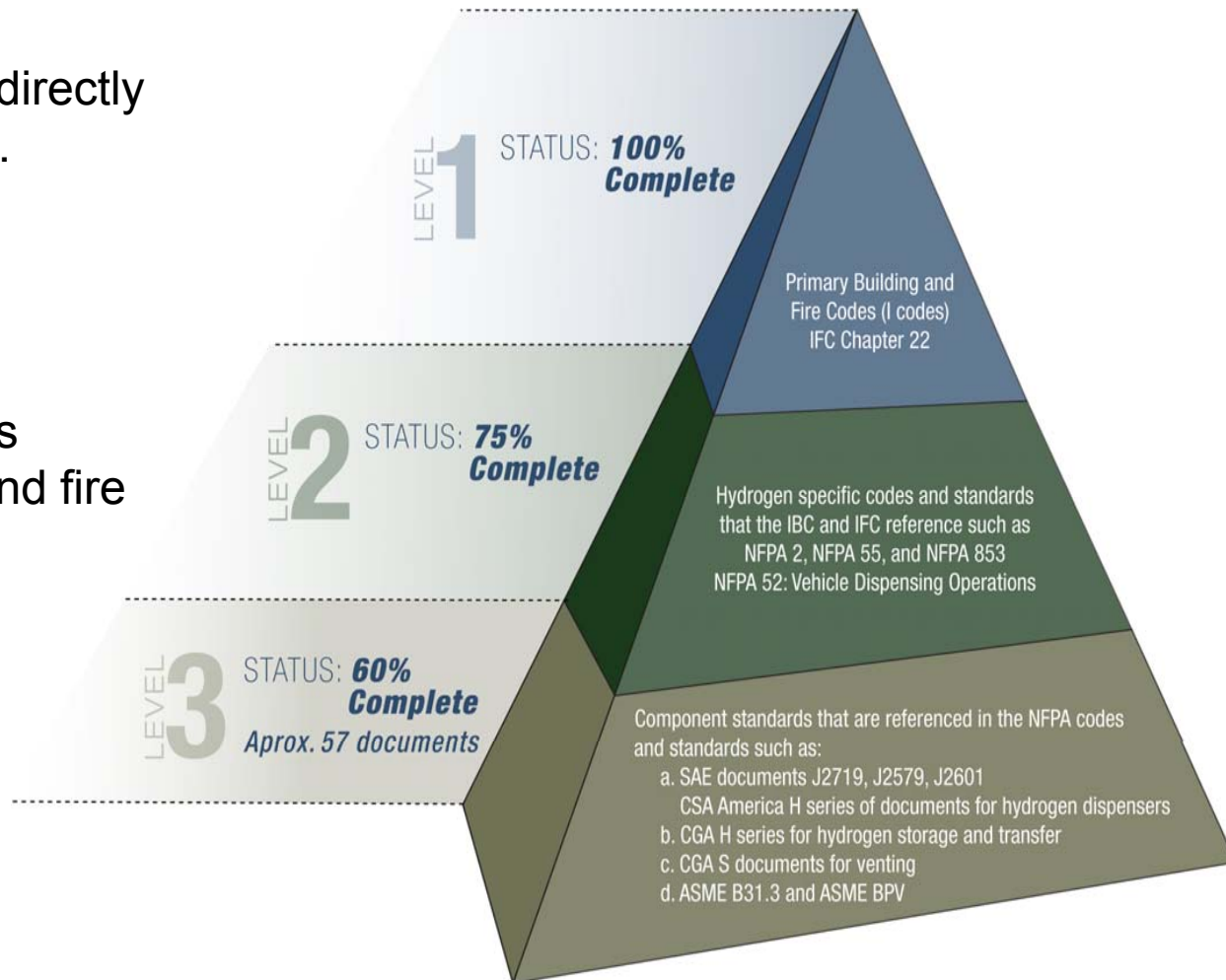
Building and fire codes directly adopted by jurisdictions.

Level 2:

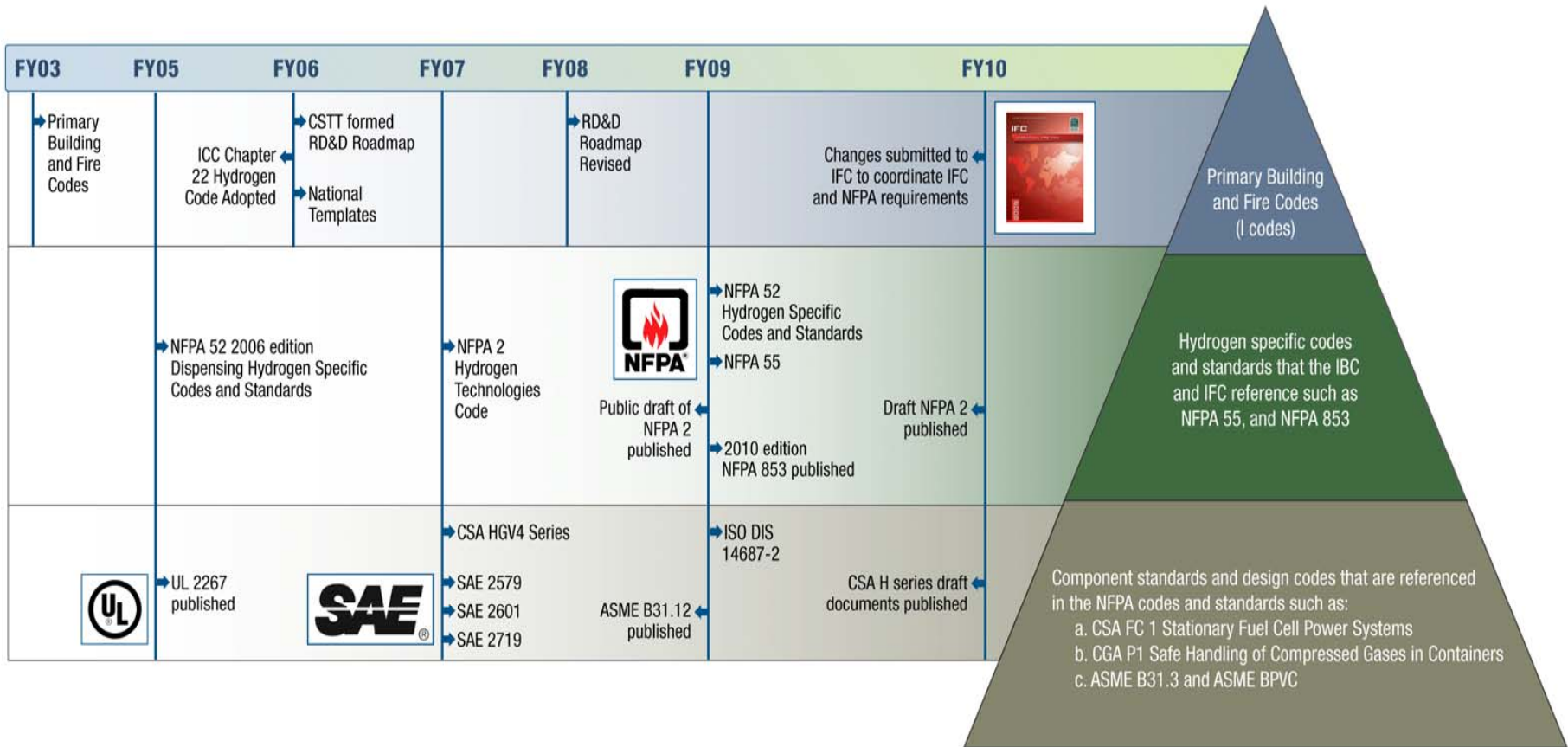
Hydrogen specific codes referenced in building and fire codes.

Level 3:

Component standards referenced in hydrogen specific codes.

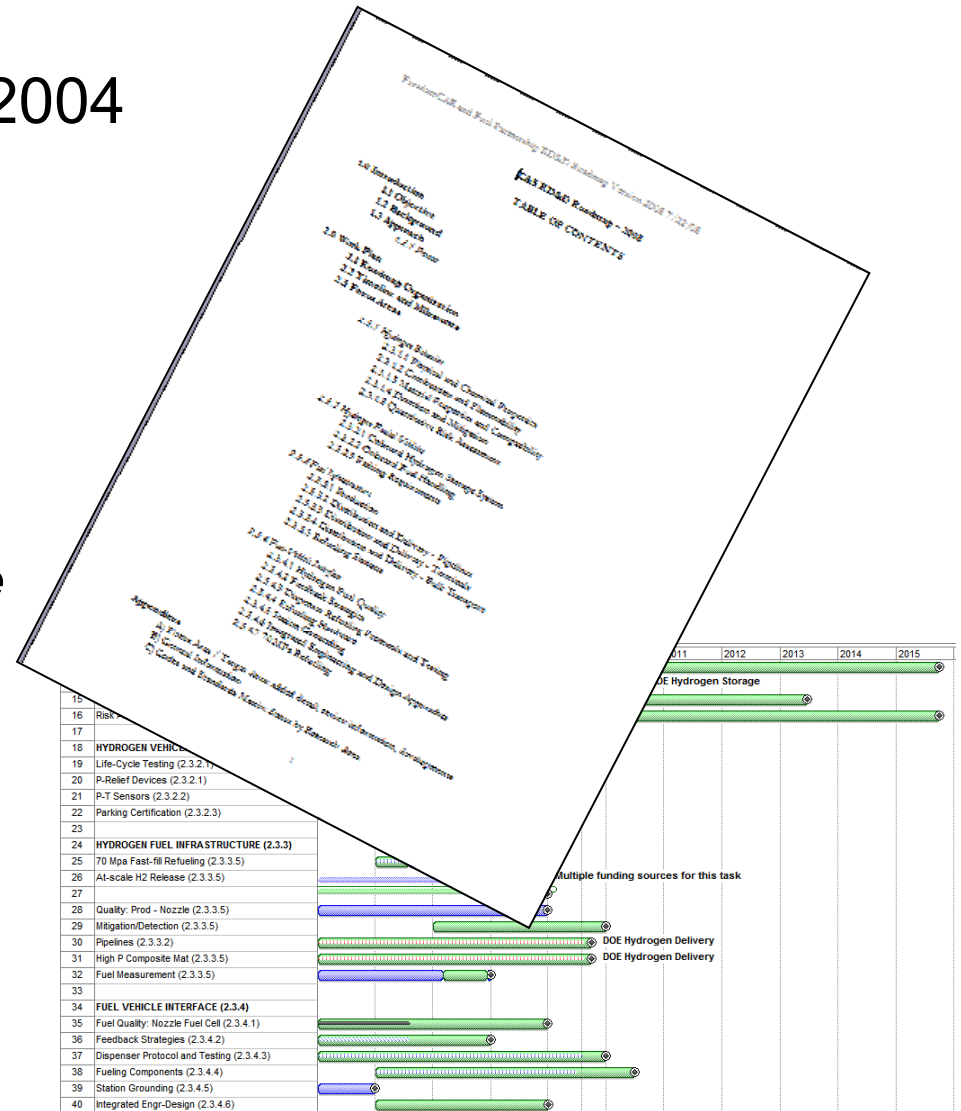


Timeline of Hydrogen Codes and Standards



Technology Roadmap

- Initial Version: Completed 2004
- Updated in 2006 and 2008
- Details Needs & Gaps in each Target Area:
 - *Hydrogen Behavior*
 - *Hydrogen Fuel Infrastructure*
 - *Fuel-Vehicle Interface*
 - *Hydrogen Vehicle*



Technology Roadmap



DOE Hydrogen Storage

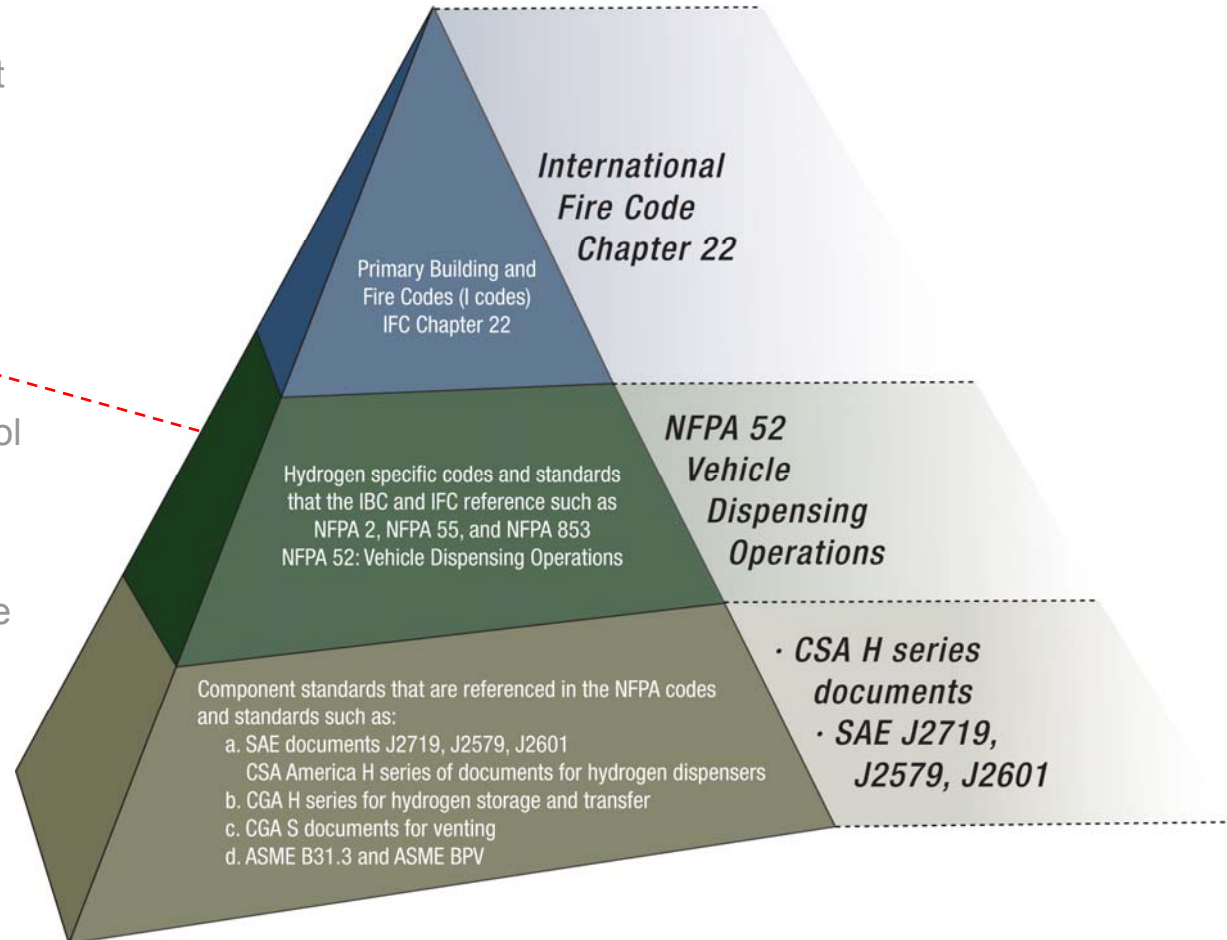
Multiple funding sources for this task

DOE Hydrogen Delivery

DOE Hydrogen Delivery

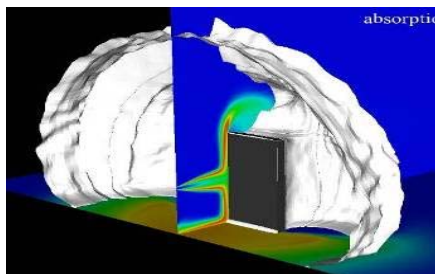
Sample of Regulatory Hierarchy of Hydrogen Codes and Standards

- Hydrogen Behavior
 - Physical properties
 - Flammability and transport
 - Material compatibility
 - Detection
- Hydrogen Fuel Infrastructure
 - Production
 - Distribution and delivery
 - **Fueling station**
- Fuel-Vehicle Interface
 - Fueling nozzle and protocol
 - Fuel quality
 - Cross-cutting issues
- Hydrogen Vehicle
 - Onboard hydrogen storage
 - Onboard fuel handling
 - Parking requirements



Separation Distances

Provided technical data and incorporated risk-informed approach that enabled NFPA2 to update bulk gas storage separation distances in the 2010 edition of NFPA55



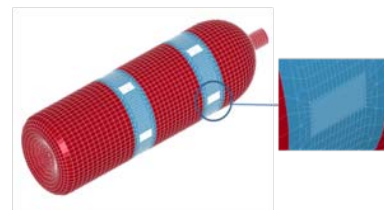
Barrier walls reduce separation distances – simulated position of allowable heat flux iso-surface for 3-minute employee exposure (2009 IFC).

Fuel Quality Specification

- Technical Specification (TS) published and harmonized with SAE J2719, Committee Draft (CD) prepared
- Developing standardized sampling and analytical methodologies with ASTM
- Draft International Standard (DIS) to be submitted to ISO TC197 Dec 2010

Materials and Components Compatibility

- Performed testing of forklift tank materials to enable design qualification
- Added two additional Nickel alloy chapters to the Technical Reference



Safety Sensor Development

- Completed extensive life testing - 4,000 hrs and 10,000 thermal cycles - of a robust, ceramic, electrochemical Hydrogen safety sensor with exceptional baseline stability and resistance to H₂ signal degradation

Technical Performance Requirements	
Sensitivity: 1 vol% H ₂ in air	Temperature: -40°C to 60°C
Accuracy: 0.04-4% 1% of full scale	Durability: 5 yrs without calibration
Response time: <1 min at 1% And <1 sec at 4% Recovery <1 min	Low cross-sensitivity to humidity, H ₂ S, CH ₄ , CO, and VOCs

Hydrogen Safety Training for First Responders



First Responder Education

- Completed upgrade of web-based Introduction to Hydrogen Safety for First Responders – averaging 300-500 unique visits/month for a total of 17,000 visits since January 2007
- Held two pilot courses for the advanced-level, prop-based course at the Hazardous Materials Management and Emergency Response (HAMMER) training center
- Held three official deployments of the advanced-level, prop-based reaching 90 students from 18 states.

Codes and Standards Training and Outreach

Permitting Tools for Code Officials

- Expanded Permitting Compendium – *online database*
- Published Introduction to Hydrogen for Code Officials – *online course*
- Permitting Workshops – *classroom training (over 300 code officials trained)*

The screenshot shows the 'Introduction to Hydrogen for Code Officials' course page. It features a navigation bar with 'COURSE MATERIALS', 'LIBRARY', and 'EXIT' tabs. Below the navigation bar, there are four checkboxes for course sections: 'Hydrogen & Fuel Cell Basics', 'Hydrogen & Fuel Cell Applications', 'Permitting Hydrogen Fueling Stations', and 'Permitting Fuel Cell Facilities'. The main content area is titled 'Construction Approval' and includes a paragraph about national codes and standards, followed by a list of model code provisions covering fueling station design, equipment design, barrier wall design, and weather protection. Three diagrams illustrate different hydrogen fueling station layouts: 'CAR WASH', 'FOOD MARKET', and 'FUEL DISPENSER ISLAND WITH CANOPY'. A sidebar on the right provides links to view examples of related hydrogen codes and standards, including fueling station design, equipment design, barrier wall design, and weather protection. The footer of the page shows 'Slide 3 of 21' and navigation buttons for 'Back' and 'Next'.

The screenshot shows the 'Permitting Hydrogen Facilities' web page. The header includes the U.S. Department of Energy logo and the 'hydrogen.energy.gov' search bar. The main heading is 'Permitting Hydrogen Facilities'. Below the heading, there is a navigation menu with links for 'Permitting Process', 'Codes & Standards Search', 'Hydrogen Fueling Stations', 'Telecommunication Fuel Cell Use', and 'Hazard & Risk Analysis'. The main content area is divided into two columns: 'Hydrogen Fueling Stations' and 'Telecommunication Fuel Cell Use'. Each column features a photograph of a fueling station and a telecommunications tower, respectively, with buttons for 'Model Codes Search' and 'Technology Overview'. A footer section contains a link to 'Printable Version' and a contact information footer.

Hydrogen Safety Knowledge Tools



H₂ Safety Best Practices

Welcome!

H₂BestPractices Home

Hydrogen Properties

Hydrogen Compared with Other Fuels

Safety Practices

Safety Culture

Safety Planning

Incident Procedures

Communications

Design and Operations

Facility Design Considerations

Storage & Piping

Operating Procedures

Equipment Maintenance

Laboratory Safety

What is a best practice?
A best practice is a technique or available knowledge and technology that is consistently used to achieve the best possible outcome.

What is H₂BestPractices?
A wealth of knowledge and experience of industrial and aerospace settings is being converted to electricity through development, demonstration, and deployment of hydrogen fuel cell vehicles. Many of which are in the public domain. This website provides reference links found at various sources.

Best Practices are organized into hand columns. Because of the interactive nature of the site, a web-based electronic document is available for each topic.

Website features

Please notice the mouse-over feature for the cursor over the word. All the definitions are also an **Acronyms** list and a **Index** to the alphabetized list of references. This online manual is directly linked to the following safe practices and procedures when proper procedures and good engineering practices are of importance of avoiding complacency.

Last Updated: September 14, 2010
A collaboration of the
Pacific Northwest National Laboratory
and Los Alamos National Laboratory
with funding from the U.S. Department of Energy.

h2bestpractices.org/

H₂ Incident Reporting and Lessons Learned

Welcome!

Navigation ?

Clear Find Records >>

Settings

- Laboratory (63)
- Fueling Station (19)
- Commercial Facility (19)
- Hydrogen Delivery Vehicle/Tube Trailer (14)
- Power Plant (13)
- Nuclear Processing/Waste Facility (10)
- Refinery (8)
- Hydrogen Storage/Use Facility (8)
- Chemical Plant (6)
- Battery/Charging Facility (6)
- Hydrogen Production Facility (5)
- Government Facility (4)
- City/Street (3)
- Hazardous Waste Facility (2)
- Passenger Vehicle (2)
- Paper Mill (1)
- Furnace Room (1)
- Compressor Room (1)
- Spacecraft (1)
- Processing Facility for Slag Water (1)

Show All Options

What is H₂Incidents?

H₂Incidents is a database-driven website that captures records of events involving hydrogen. The focus of the database is on characteristics learned from those events. All identifiers are removed to ensure confidentiality.

More About H₂Incidents...

How does H₂Incidents work?

You can access incident reports on the latest posted incidents using the search form. It also contains a total for the number of incidents you can view a complete, alphabetized list of incidents.

To look for incidents related to specific factors, damage and injuries, equipment, or location, use the search form to find those that interest you. At an advanced search form for some more options.

If you have an incident you would like to report, please enter as much of the information, your company's name, and contact information as possible.

www.h2incidents.org/

U.S. DEPARTMENT OF ENERGY

hydrogen.
energy.gov

SEARCH [input] Search Help

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 - > Bibliographic Database
 - > Newsletter
- > Codes & Standards
- > Education
- > Basic Research
- > Systems Analysis
- > Systems Integration

Home > Safety > Bibliography Database

Printable Version

Hydrogen Safety Bibliographic Database

The [Hydrogen Safety Bibliographic Database](#) provides references to reports, articles, books, and other resources for information on hydrogen safety as it relates to production, storage, distribution, and use. The database includes references related to the following topics:

- Hydrogen properties and behavior
- Safe operating and handling procedures
- Leaks, dispersion, and flammable vapor cloud formation
- Embrittlement and other effects on material properties
- Fuel cells and other energy conversion technologies
- Sensors, tracers, and leak detection technologies
- Accidents and incidents involving hydrogen

In addition to bibliographic references, the database provides select full text documents or links to other Web sites that offer these documents. To obtain full text documents that aren't included in the database, contact your local library.

Looking for a safety-related bibliographic reference that isn't currently available in this database? We welcome your [suggested additions](#).

www.hydrogen.energy.gov/biblio_database.html

Compressed Natural Gas (CNG), Hydrogen and Hydrogen Blend Fuels

12/2009 –DC

Workshop Objectives:

1. Share safety requirements and regulatory framework in each country to harmonize domestic and international codes and standards
2. Collect data and information from demonstration activities and real-world applications in Canada, Brazil, China, India and the U.S.
3. Discuss safety and testing of storage tanks and identify research, regulations, codes and standards needed to ensure their safe use
4. Compare properties, behavior and R&D efforts for CNG, hydrogen and hydrogen blend (HCNG) fuels
5. Conduct follow-up workshops, conduct collaborative R&D & testing, share hydrogen roadmaps and education and training plans

Workshop Outcomes:

Brazil, Canada, China, India and the U.S. to identify activities to collaborate in the following areas:

1. R&D and Testing: Conduct life cycle tests and analysis of high-pressure CNG and hydrogen tanks
2. Codes and Standards: Harmonize regulations, codes and standards for CNG, hydrogen and HCNG vehicles & fueling facilities
3. Education and Training: Conduct programs to train labor force & increase education and outreach
4. Regulations: Encourage participation in international forums and the development of Global Technical Regulations (GTR) for hydrogen fueled vehicle

International Hydrogen Fuel and Pressure Vessel Forum

09/2010 – Beijing, PRC

Workshop Objectives:

1. Address and share data and information on specific technical topics that emerged at the Washington, DC, workshop.
2. Review test protocols and requirements under specific RCS for on-board hydrogen tanks, including SAE J2579 and Global Technical Regulations
3. Identify and discuss key issues requiring additional R&D and testing to ensure safe use of storage tanks for hydrogen, CNG, and blend fuels
4. Enhance domestic and international harmonization of regulations, codes and standards for storage tanks for hydrogen, natural gas, and blend fuels
5. Identify and initiate future collaborations to address R&D, testing, and validation needs and to harmonize requirements in regulations, codes and standards among participating nations

Workshop Outcomes:

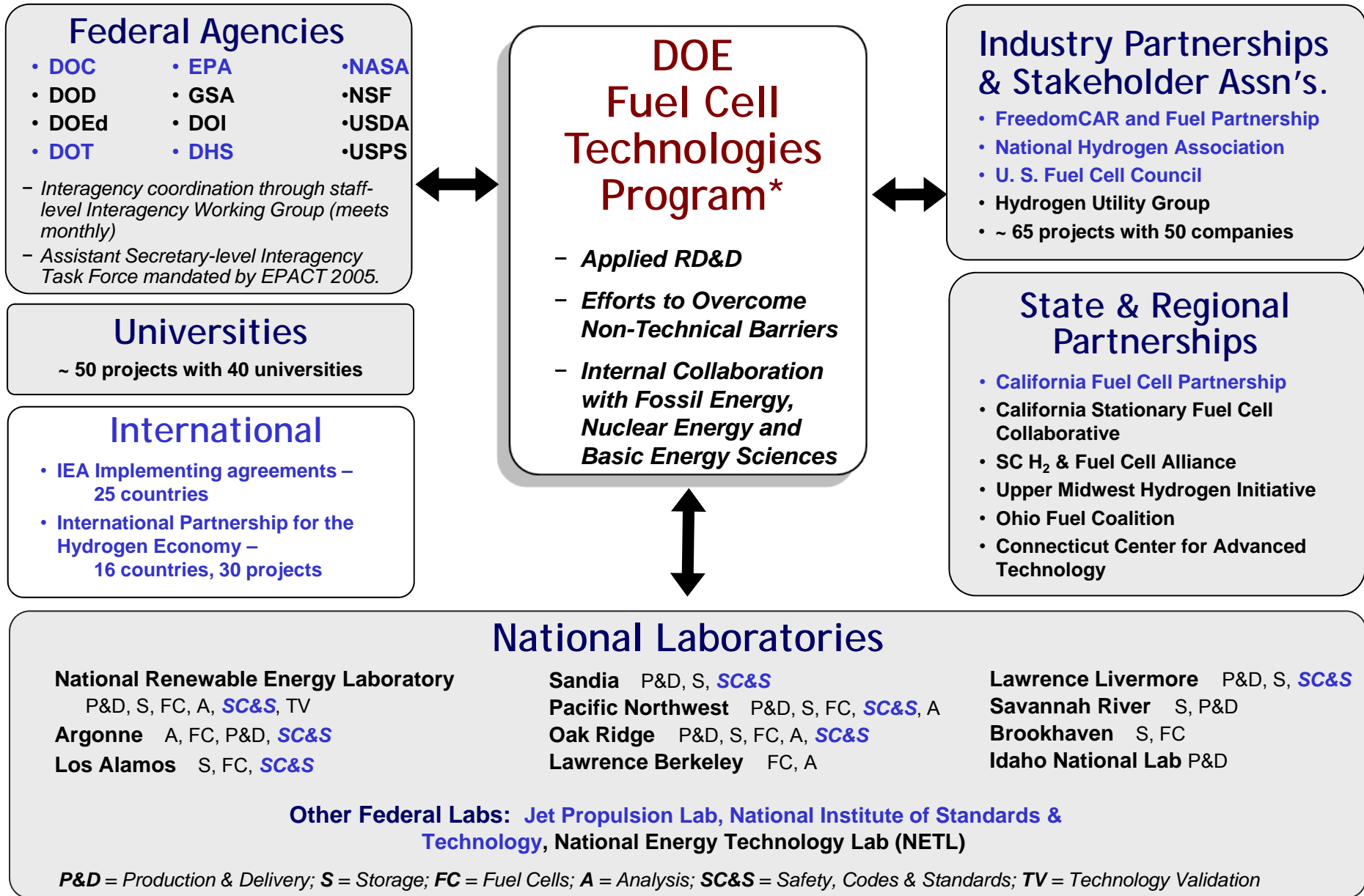
1. Delineation and discussion of codes and standards development process and regulatory structure and procedures in China on pressure vessels
2. More specific data and information on Type 4 tank testing procedures and results in China
3. Information and data on composite tank manufacture, testing/certification, and field performance from two major international tank manufacturers
4. Identification and characterization of need to harmonize testing and certification of composite tanks by a global automotive OEM
5. Discussion and identification of testing and data needed for safe deployment of pressure vessels for vehicles
6. Procedures and timeline established to strengthen collaboration between China and the US on data sharing and harmonizing tank test procedures, requirements, and regulations.

Thank you

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www.hydrogenandfuelcells.energy.gov

Additional Slides





International Partnership for Hydrogen and Fuel Cells in the Economy

Partnership among 18 member countries & the European Commission



International Energy Agency – Hydrogen Implementing Agreements

21 member countries and the European Commission Advanced Fuel Cells Implementing Agreement – 19 countries



International Association for Hydrogen Safety (HySafe)

Facilitate the international coordination, development and dissemination of hydrogen safety Knowledge by being the focal point for hydrogen safety research, education and training



International Conference on Hydrogen Safety

International safety conference organized by HySafe and the HIA

The fourth international conference will be held in San Francisco September 12 – 14, 2011