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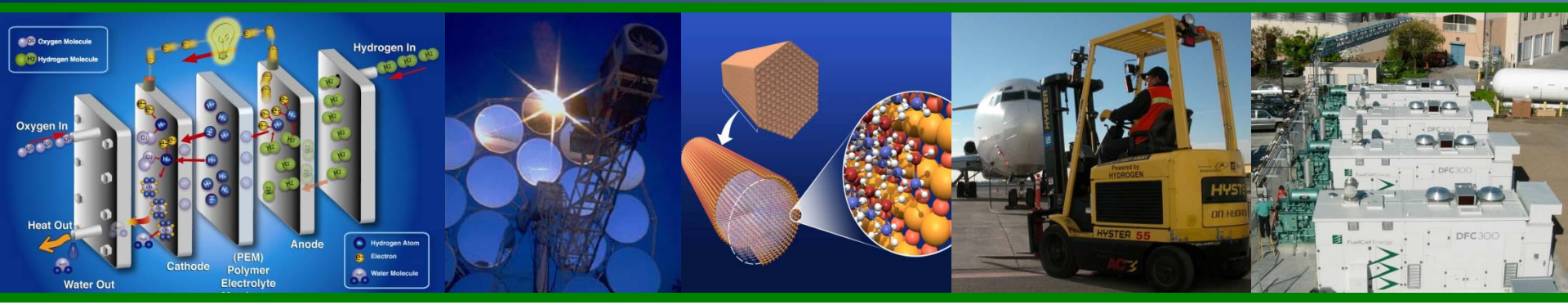

Safety, Codes and Standards

Fuel Cell Technologies Program

Antonio Ruiz

2010 Annual Merit Review and Peer Evaluation Meeting
(09 June 2010)

Goal & Objectives

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The Safety, Codes and Standards subprogram aims to facilitate the development and adoption of codes and standards for hydrogen and fuel cell technologies. The subprogram also aims to identify and promote safe practices industry-wide so that fuel cell and hydrogen technologies can be adopted safely and expediently.

Safety:

Develop and implement practices and procedures to ensure the safety in the operation, handling, and use of hydrogen and fuel cells for all DOE-funded projects, and utilize those practices and lessons learned to promote the safe use of hydrogen.

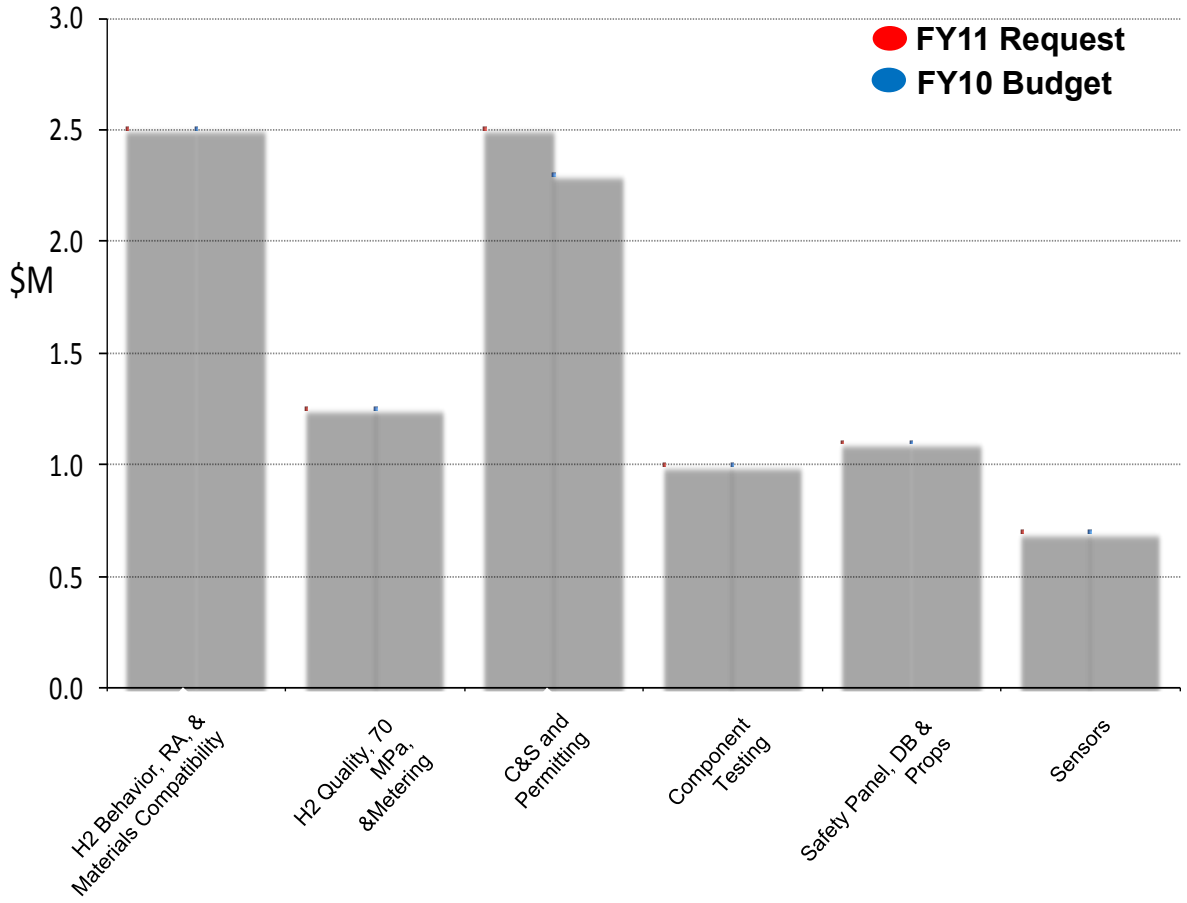
Codes and Standards:

Perform the underlying research to enable codes and standards to be developed for the safe use of hydrogen fuel cells in all applications. The subprogram also seeks to facilitate the timely development and harmonization of domestic and international codes and standards.

Budget

FY 2010 Appropriation: **$8.8 M**

FY 2011 Request: **$9.0 M**



FY 2010 EMPHASIS

- Creating technical information and performance data to validate codes and standards
- Developing tools to facilitate permitting of hydrogen fueling stations and stationary fuel cell installations
- Testing, measuring, and verifying hydrogen fuel quality
- Assessing risks and establishing protocols to identify and mitigate risks
- Harmonizing hydrogen fuel quality and other key international standards
- Disseminating hydrogen “best practices” and safety information

Challenges

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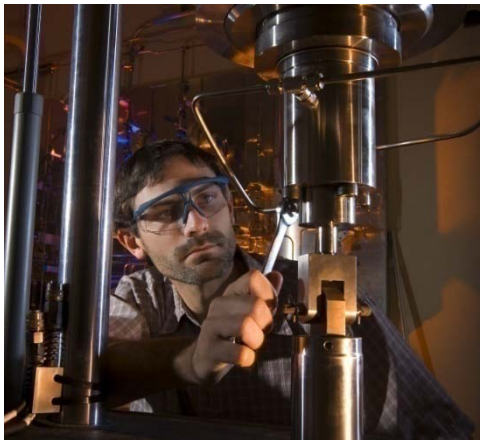
- To synchronize codes and standards development and adoption with technology commercialization needs
- To coordinate enabling R&D with the codes and standards development cycle
- To promote domestic and international consistency
- To make approved codes and standards readily available
- To streamline 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



2010 Progress & Accomplishments Overview

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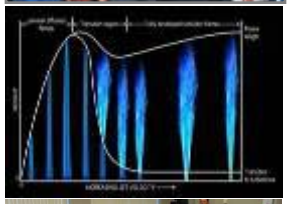

ACTIVITIES *(key examples)*	***PROGRESS*** *(key examples)*
Perform R&D to develop critical data needed for key codes and standards (C&S) development	Developed hydrogen release behavior data and incorporated quantitative risk assessment approach for separation distances into the National Fire Protection Association (NFPA) hydrogen code in 2010
Harmonize domestic and international C&S	Through R&D, enabled harmonized domestic and international Fuel Quality Specifications
Simplify permitting process	Developed safety course for researchers and for code officials. Conducted permitting workshops that reached >250 code officials
Promote adoption of current C&S and increase access to safety information	Expanded web-based resources, including: *Hydrogen Safety Best Practices Manual* & *Hydrogen Permitting Compendium*

Codes and Standards Accomplishments

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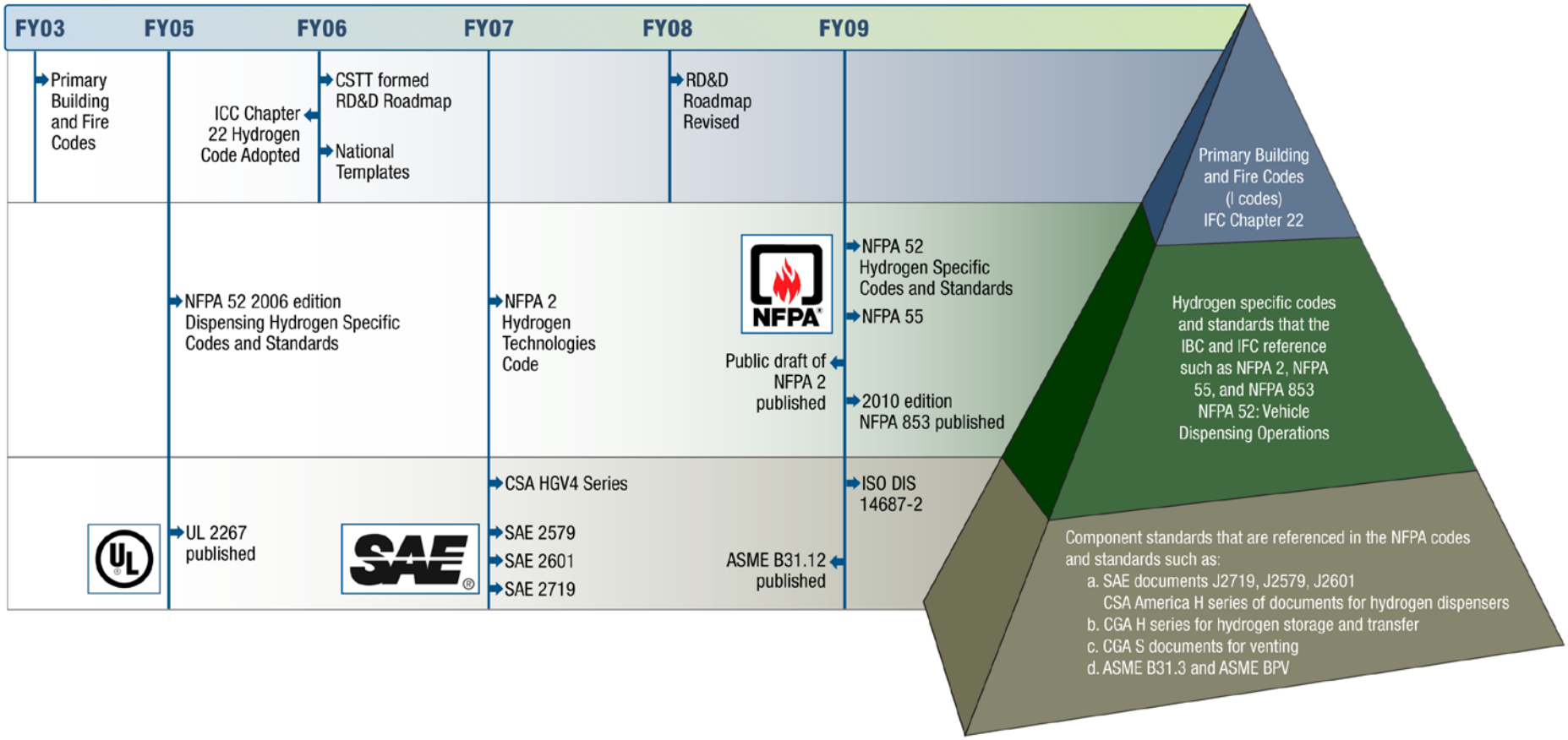
Timeline of Hydrogen Codes and Standards



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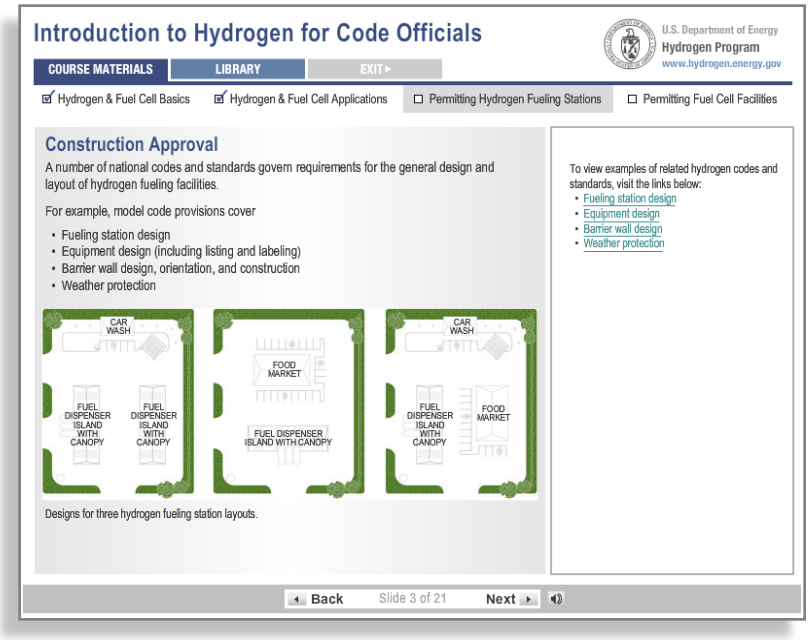
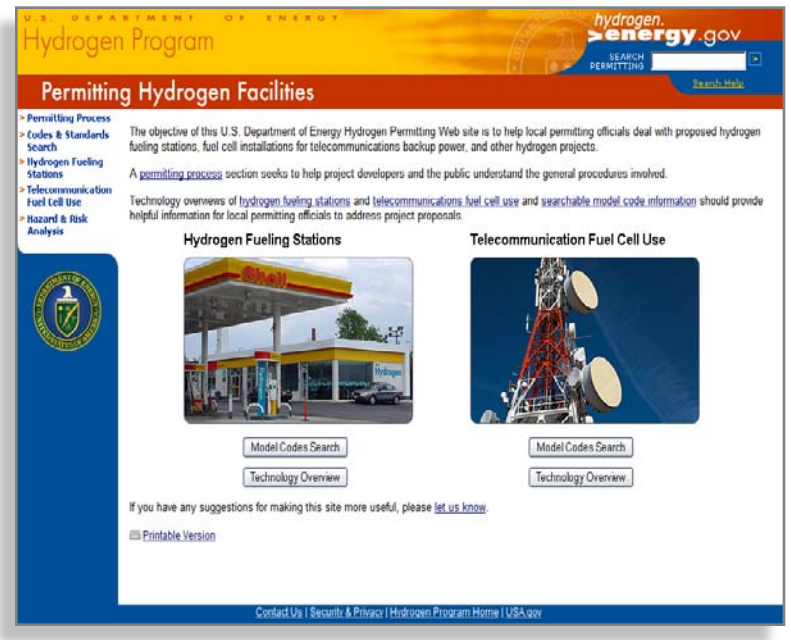
Codes and Standards Training and Outreach

Permitting Tools for Code Officials

- Added Permitting Compendium – *online information database*
- Introduction to Hydrogen for Code Officials – *online course*
- Permitting Workshops – *classroom training*





www.hydrogenandfuelcells.energy.gov/codes

2010 Progress & Accomplishments

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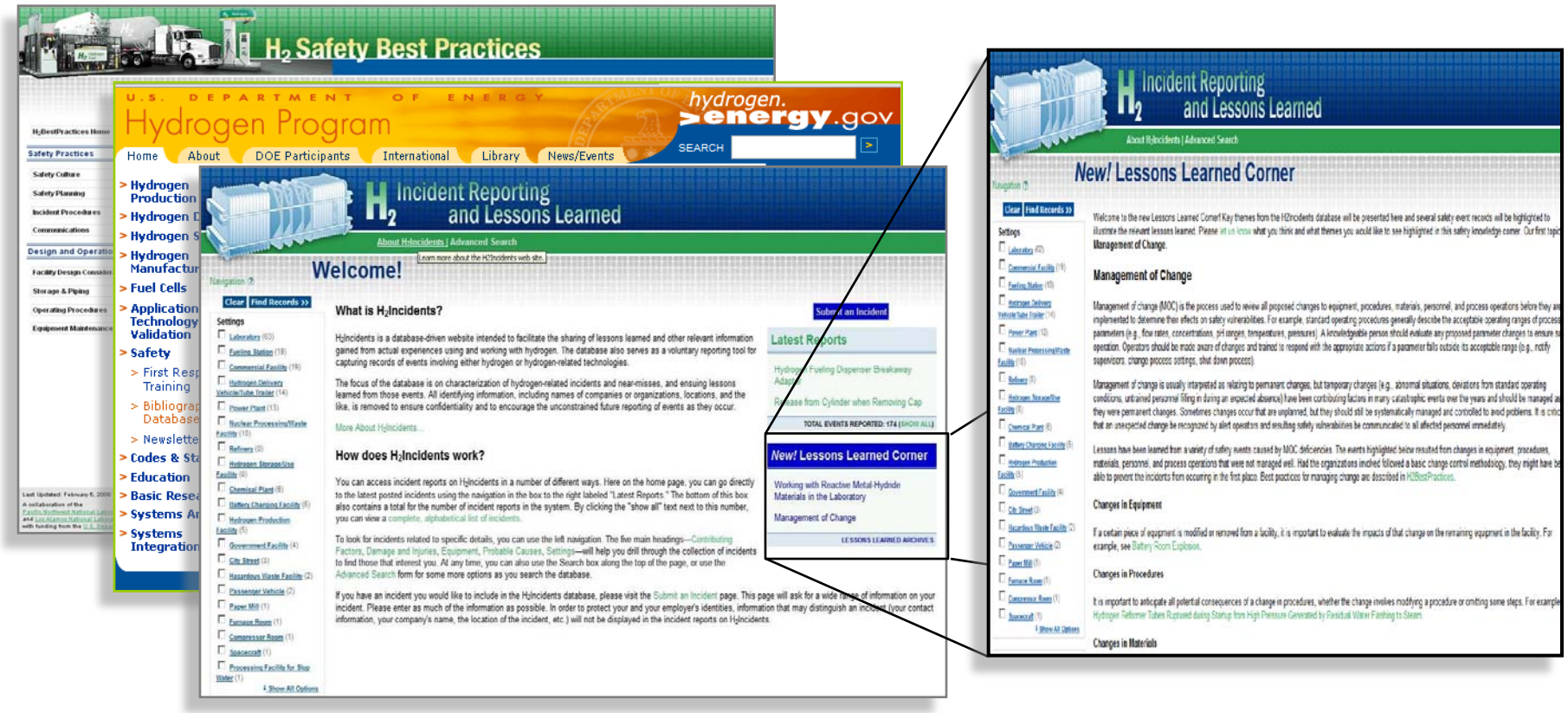
Hydrogen Safety Knowledge Tools

Expanded and Improved Safety Databases

H2 Lessons Learned Corner



www.hydrogenandfuelcells.energy.gov/codes

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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 9,300 visits since January 2007
- Delivered first responder training course utilizing fuel cell vehicle prop -- over 90 first responders from 18 states have participated

www.hydrogen.energy.gov/firstresponders.html

2010 Progress & Accomplishments

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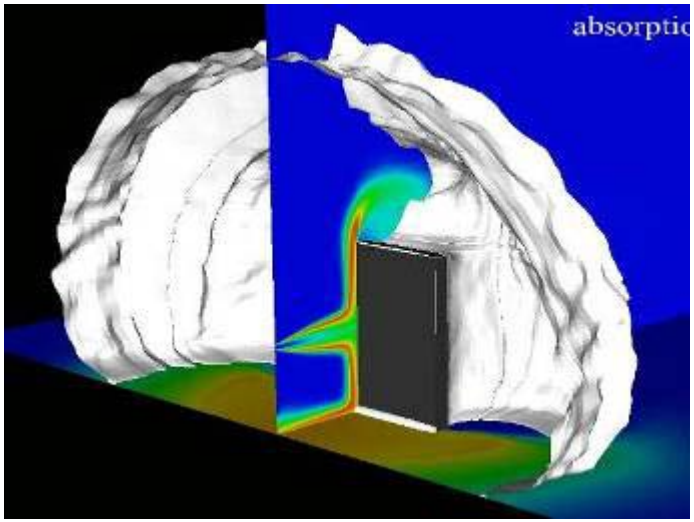
Separation Distances



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

- Provided technical data and incorporated risk-informed approach that enabled NFPA2 to update bulk gas storage separation distances in the 2010 edition of NFPA55
- Quantified how barrier walls can reduce hazards leading to fifty percent distance reduction credit
- Technical data and methodology are published in archival documents

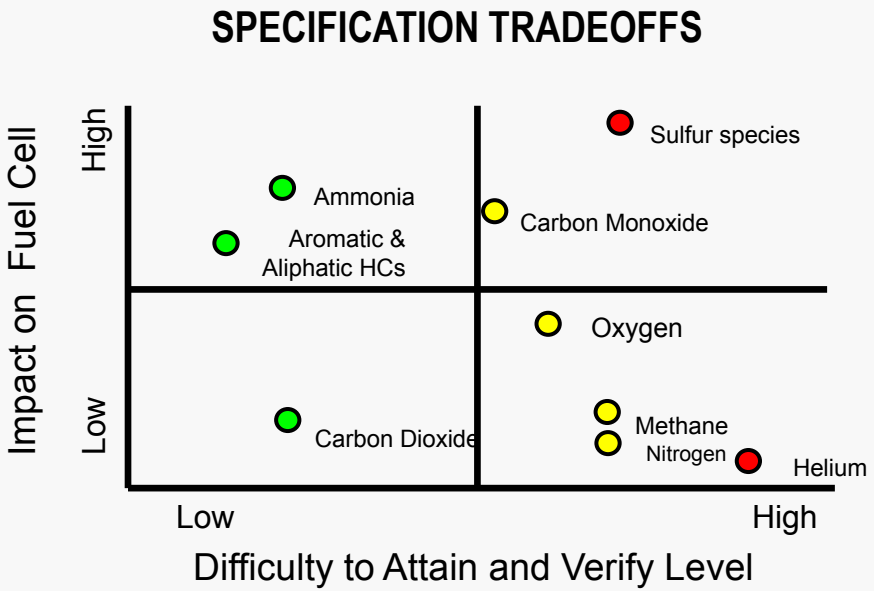
Sample Table

Exposure	NFPA 2005 Separation Distance	NFPA 2010 Separation Distance
Lot Lines	5 ft	10 ft
Air intakes (HVAC, compressors, other)	50 ft	10 ft
Ignition sources such as open flames or welding	25 ft	10 ft
Flammable Gas storage systems - non-bulk - bulk	 10 ft 10 ft or 25 ft	 5 ft 15 ft
Ordinary combustibles	50 ft	5 ft

Hydrogen Fuel Quality Specification

- Technical Specification (TS) published and harmonized with SAE J2719, Committee Draft (CD) prepared
- Draft International Standard (DIS) to be submitted to ISO TC197 Dec 2010
- Unified testing underway at LANL, HNEI, USC, Clemson-SRNL, UConn for critical contaminants
- Collaborative testing underway in Japan (JARI) and France (CEA-Liten)
- Developing standardized sampling and analytical methodologies with ASTM
- Applied ANL fuel cell stack and PSA models to support testing and to address fuel quality-fuel cost tradeoffs
- Coordinated overall approach and testing with Fuel Cell, Delivery, and Storage Tech Teams

Fuel Quality - ISO DIS 14687-2
Hydrogen Fuel Product Specification



Source: Shell Hydrogen

2010 Progress & Accomplishments

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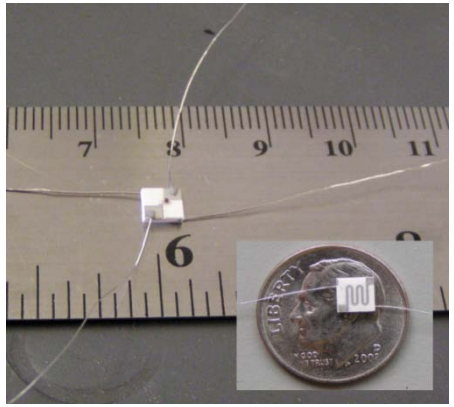
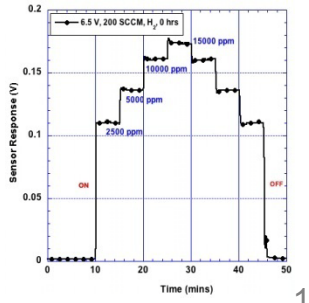
Hydrogen Safety Sensor Development

- Demonstrated zirconia-based sensor with 0-4% hydrogen sensitivity
- In collaboration with ElectroScience Laboratories Corp., produced a manufacturing platform for a miniature, low power, pre-commercial prototype
- Demonstrated a reproducible sensor response
- Completed the first series of life-testing (>2000 hrs) experiments, demonstrating long life
- Have begun to develop control-point methods to control selectivity to hydrogen
- Obtained valuable industry input from fuel cell manufacturers and potential end users to strategize
  the eventual transfer of the technology to a supplier
  for commercialization

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_2S, CH_4, CO, and VOCs





2010 Progress & Accomplishments

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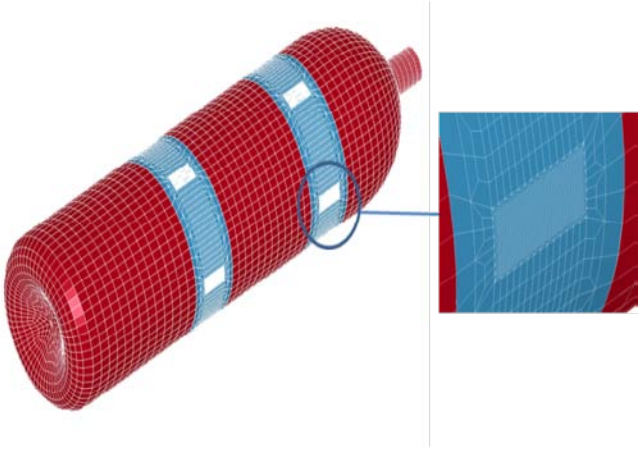
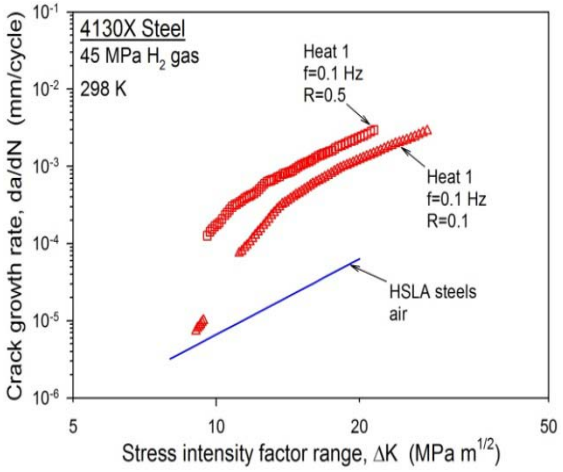
Materials and Components Compatibility

- Completed report of fracture threshold measurement of tank steels to enable revision of same kd-10
- Completed testing to enable deployment of 100 MPa stationary storage tanks
- Performed testing of forklift tank materials to enable design qualification
- Added two additional Nickel alloy chapters to the Technical Reference
- Forklift tank lifecycle testing program underway to support the development of CSA HPIT1





Online Technical Reference

Table of Contents

Designation	Nominal composition	Code	Revision date
Introduction		INTR	(3/08)
Plain Carbon Ferritic Steels			
C-Mn Alloys	Fe–C–Mn	1100	(5/07)
Low-Alloy Ferritic Steels			
Quenched & Tempered Steels			
Cr-Mo Alloys	Fe–Cr–Mo	1211	(12/05)
Ni-Cr-Mo Alloys	Fe–Ni–Cr–Mo	1212	(12/05)
High-Alloy Ferritic Steels			
High-Strength Steels			
9Ni-4Co	Fe–9Ni–4Co–0.20C	1401	(1/05)
Ferritic Stainless Steels	Fe–15Cr	1500	(10/06)
Duplex Stainless Steels	Fe–22Cr–5Ni+Mo	1600	(9/08)
Semi-Austenitic Stainless Steels	Fe–15Cr–7Ni	1700	(3/08)
Martensitic Stainless Steels			
Precipitation-Strengthened	Fe–Cr–Ni	1810	(3/08)
Heat Treatable	Fe–Cr	1820	(6/08)
Austenitic Steels			
300-Series Stainless Alloys			
Type 304 & 304L	Fe–19Cr–10Ni	2101	(5/05)
Type 316 & 316L	Fe–18Cr–12Ni+Mo	2103	(3/05)
Type 321 & 347	Fe–18Cr–10Ni + Ti/Nb	2104	(12/08)

www.sandia.gov/hydrogen/research/safetyCodesStandards

CNG – H2 Fuels Workshop

Promote the exchange of information among experts on CNG & H_2 fuels for vehicles and to share lessons learned from deployment of these vehicles.

Washington, D.C. December 10-11, 2009

Workshop Objectives:

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

Workshop Outcomes:

Brazil, Canada, China, India & U.S. will develop projects & activities to cooperate & collaborate in the following areas:

1. R&D & Testing: Conduct life cycle tests and analysis of high-pressure CNG & hydrogen tanks
2. Codes and Standards: Harmonize regulations, codes and standards for CNG, HCNG & H_2 vehicles & fueling facilities
3. Education & Training: Conduct programs to train labor force & increase education and outreach
4. Regulations: Encourage participation in efforts to develop Global Technical Regulations (GTR) for hydrogen fueled vehicle systems

Upcoming Events:

1. Tank Workshop: Fall 2010 (China)
2. Fourth International Conference on Hydrogen Safety (ICHS-4): September 12-14, 2011 (San Francisco, CA)





www.hydrogenandfuelcells.energy.gov/wkshp_cng_and_h2.html

Early Market Fuel Cell Technologies Workshop

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Coordinate R&D and code development efforts to enable the rapid deployment of early market fuel cell applications.

Sandia National Laboratories – Livermore, CA – April 28, 2010

Workshop Structure:

1. Early Market Fuel Cells Panel: Industry perspective on barriers to technology deployment
2. Code Development Panel: Coordination of the fire code, the fork lifts and the fuel cell system component
3. Enabling Research Panel: Implementation of R&D in materials, components and risk analysis in the code development process
4. Identification of Codes and Standards Gaps for early market FC technologies

Workshop Outcomes:

1. Broad industry, Standards Development Organization (SDO), and National Lab participation
2. FC technology deployment is enabled by the DOE Safety, Codes and Standards program providing the technical basis for C&S
3. Coordinated early market standards development efforts in NFPA, UL, and CSA Standards
4. More than 25 gaps identified in the areas of fire codes, component codes, and enabling research
5. Facilitated integration of DOE C&S program elements with the early market FC applications

CSA STANDARDS

UL

plug power FUEL CELL SYSTEMS

NUVERA FUEL CELLS

AIR PRODUCTS

NFPA®

Vehicular Tank Workshops

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Coordinate R&D, regulation & codes and standards to enable the deployment of hydrogen storage tanks in early market fuel cell applications.

Sandia National Laboratories – Livermore, CA – April 29, 2010

Workshop Structure:

1. Provide initial follow up to the DOE-DOT Workshop on Lessons Learned for Use of CNG-H2 Fuels in Vehicles
2. Address specific technical topics from the DOE-DOT Workshop in more detail – including Type 4 tank & PRD testing; tank service life cycle testing, monitoring, & enforcement of inspection requirements; Type 4 tank certification testing in China
3. Discuss harmonization of key regulations, codes & standards for on-board hydrogen tanks, including SAE J2579 & Global Technical Regulations for hydrogen fueled vehicles
4. Identify & discuss key issues requiring additional R&D, testing, and modeling & validation

Workshop Outcomes:

1. Translation and presentation of report on Type 4 tank certification testing in China
2. Potential refinements to tank testing protocols to better address service life and possible failure modes
3. Proposals to monitor, inspect, and enforce service life requirements of high-pressure gaseous tanks
4. Identification of priorities for hydrogen component certification
5. Discussion of NDE methods to monitor safety of tanks during service and for recertification of tanks
6. Confirmation of industry interest in validating 70MPa fast-fill model

NASA

Clean Vehicle Education Foundation

Sandia National Laboratories

CSA STANDARDS

Other Presenters: California Department of Agriculture, Division of Measurement Standards; Smart Chemistry; Powertech; & Sloane Solutions

2010 – 2012 Milestones

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FY 2010	FY 2011	FY 2012
Technical Reference for Hydrogen Compatibility of Materials to include internationally published data	NFPA2: Hydrogen Technologies Code	Risk mitigation for emerging technologies such as advanced storage materials
Separation Distances for Bulk Storage incorporated into NFPA 55	International Standard – ISO 14687 – 2: Hydrogen fuel specification	Validated separation distance table for LH2 installations
Go/no-go for mode of operation and fabrication processes with critical evaluation of mass manufacturing potential	Risk analysis of indoor refueling and operation of industrial trucks	

Session Instructions

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- This is a review, not a conference.
- Presentations will begin precisely at the scheduled times.
- Talks will be **20 minutes** and **Q&A 10 minutes**.
- Reviewers have priority for questions over the general audience.
- Reviewers should be seated in front of the room for convenient access by the microphone attendants during the Q&A.
- Please mute all cell phones, BlackBerries, etc.

Reviewer Reminders

- Deadline for final review form submittal is **June 18th**
- ORISE personnel are available on-site for assistance. A reviewer lab is set-up in room 8216 and will be open Tuesday –Thursday from 7:30 AM to 6:00 PM and Friday 7:30 AM to 3:00 PM.
- Reviewer feedback session – **Wednesday, at 6:15pm, (after last Hydrogen Safety, Codes & Standards session) in this room.**

For More Information

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Safety, Codes and Standards

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Carl Rivkin (NREL)

Steve Weiner (PNNL)

Catherine Padró (LANL)

BACK-UP

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Hydrogen Safety Panel

Objective: To provide expertise and guidance to the DOE and assist with identifying safety-related technical data gaps, best practices and lessons learned. Also, to help the DOE integrate safety planning into funded projects to ensure that all projects address and incorporate hydrogen and related safety practices.

By the Numbers:

- 235 safety plans reviewed
- 39 safety reviews conducted
- 13 Panel meetings held
- 8 follow-up interviews conducted
- 6 "good example" safety plans provided
- 5 "white paper" recommendations submitted
- 2 incident investigations completed

Technical Safety Planning

- Safety planning work expanded: Reviewed 56 safety plans since January 2009.

Project Safety Reviews

- Safety reviews are focused on engagement with project teams: 19 safety reviews conducted since January 2009; 41 recommendations included in six site visit reports issued in 2009-2010.

"Not only did it reinforce the importance of safety, we benefited from having experts available for discussions."

- Florida Solar Energy Center

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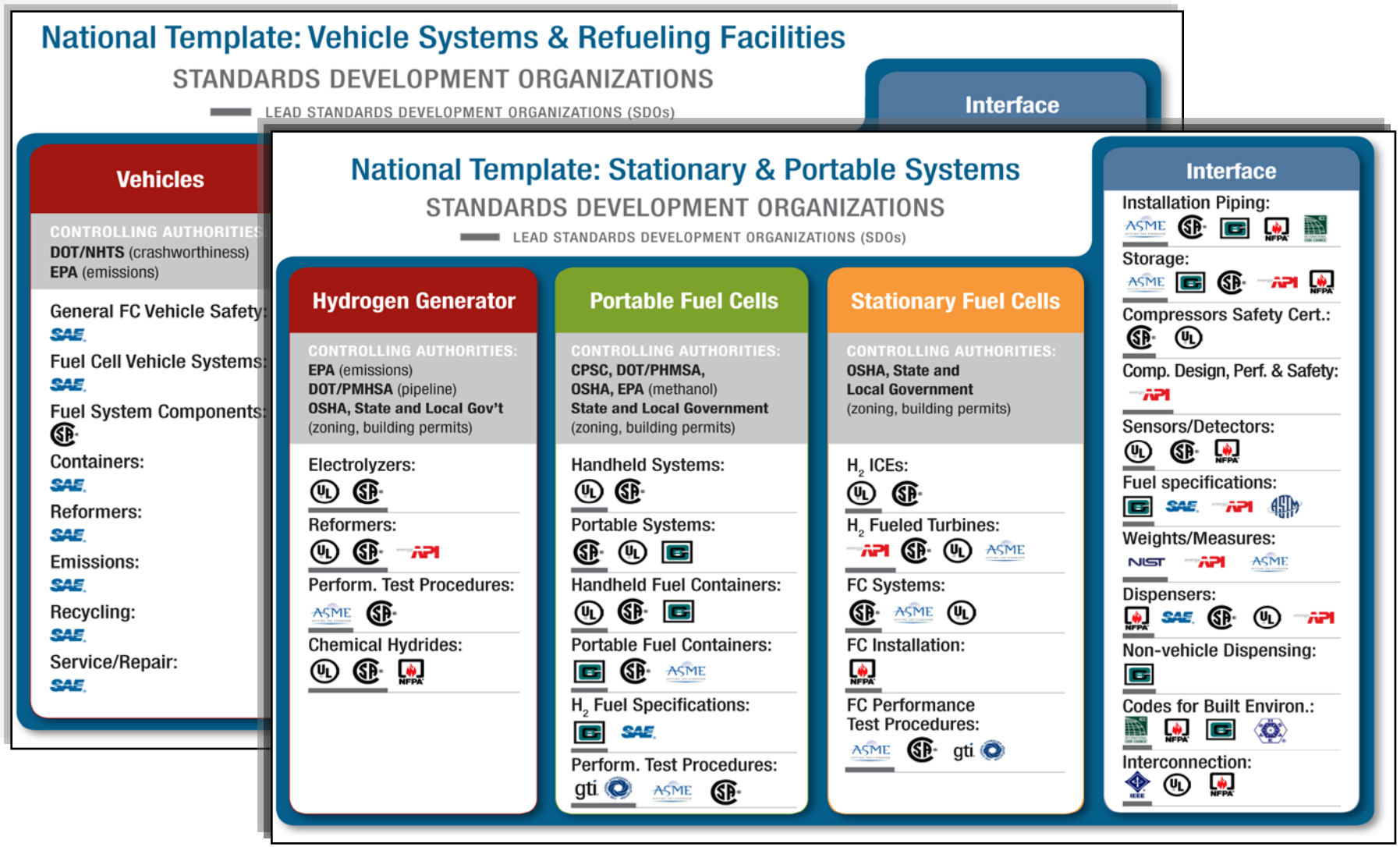
National Codes and Standards Template



www.hydrogenandfuelcells.energy.gov/codes/pdfs/cs_templates.pdf