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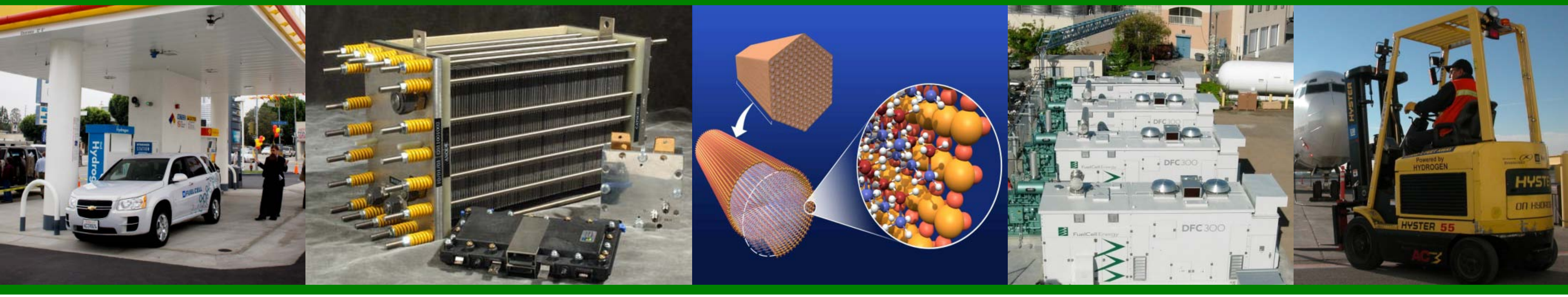

Safety, Codes and Standards
- Session Introduction -

Antonio Ruiz

2011 Annual Merit Review and Peer Evaluation Meeting

May 11, 2011

Goal & Objectives

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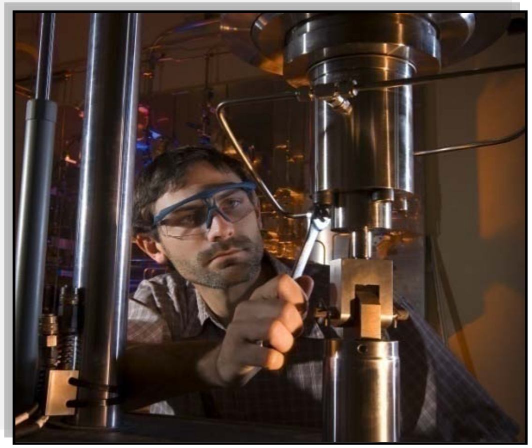
Enable the widespread commercialization of hydrogen and fuel cell technologies through the timely development of regulations, codes, and standards



Goals

- Develop and implement safety practices and procedures to ensure the safe operation, handling, and use of hydrogen and fuel cell technology
- Conduct critical R&D needed for the development of technically sound codes and standards and facilitate harmonization of domestic and international regulations, codes, and standards.

Objectives

- Ensure the safety of all projects funded by the DOE Fuel Cell Technologies Program
- Make available safety-related information resources and lessons learned with key stakeholders (first responders, regulators, and others)
- Identify and mitigate risk and understand insurability issues for widespread commercialization.
- Conduct R&D to provide critical data and information needed to define requirements in developing codes and standards.
- Develop and validate appropriate test methodologies for certifying hydrogen and fuel cell systems and components.

Challenges

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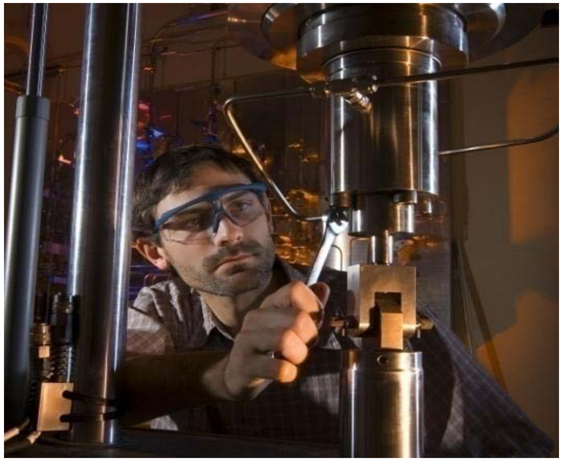
Lack of data needed for the development of critical codes and standards to enable the widespread commercialization of hydrogen and fuel cell technologies



Lack of…

- Synchronized codes and standards development and adoption with technology deployment and commercialization needs
- Coordination of R&D with codes and standards development cycle and revision schedule
- Domestic and international harmonization
- Adoption of the latest developed codes and standards
- Standardization of the permitting process for hydrogen infrastructure
- Data and hydrogen safety information (e.g., best practices and frequency data)
- Readily available training material for first responders and other key stakeholders

Budget

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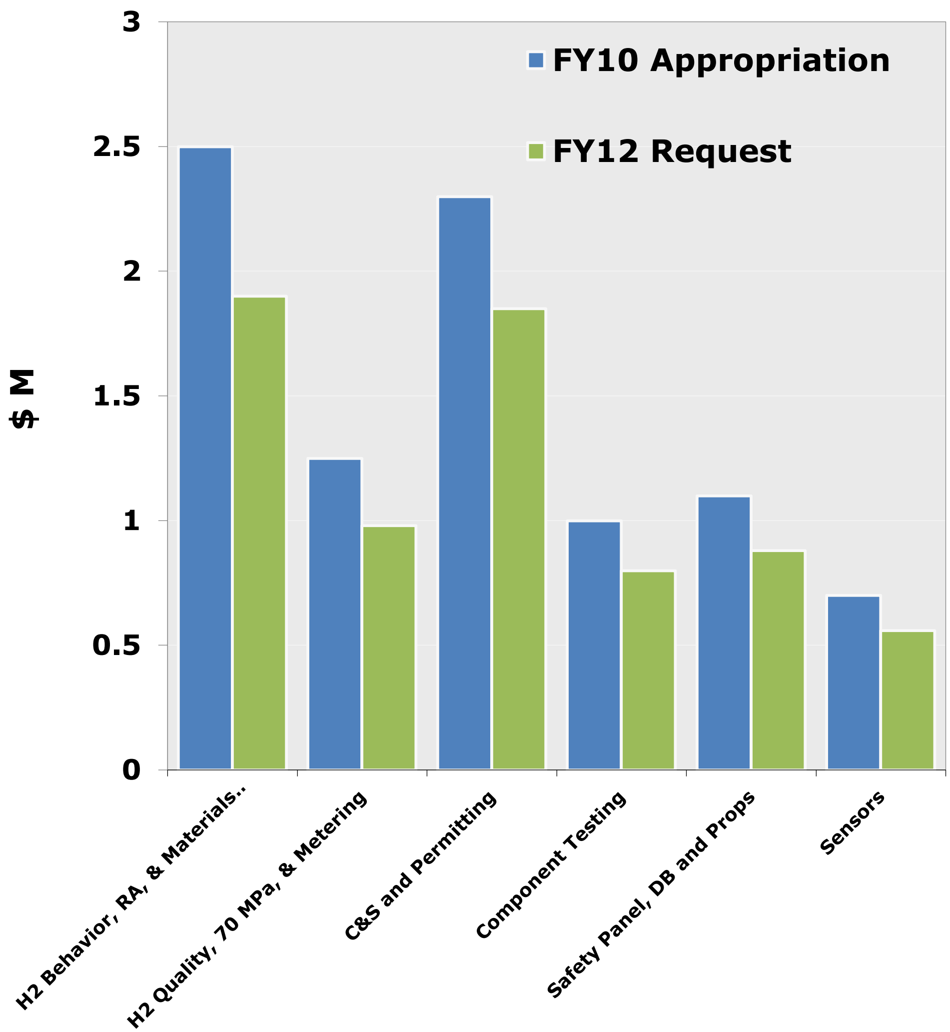
FY 2010 Appropriation = $8.7 M

FY 2012 Request = $7 M



Emphasis:

- Develop technical information and performance data to enhance codes and standards
- Facilitate the permitting of hydrogen fueling stations and early market applications
- Test, measure and verify hydrogen fuel specification
- Assess risks and establish protocols to identify and mitigate risk
- Harmonize test protocols for qualification and certification
- Harmonize hydrogen fuel quality and other key international standards
- Disseminate hydrogen “best practices” and safety information

Progress: National Codes & Standards Template

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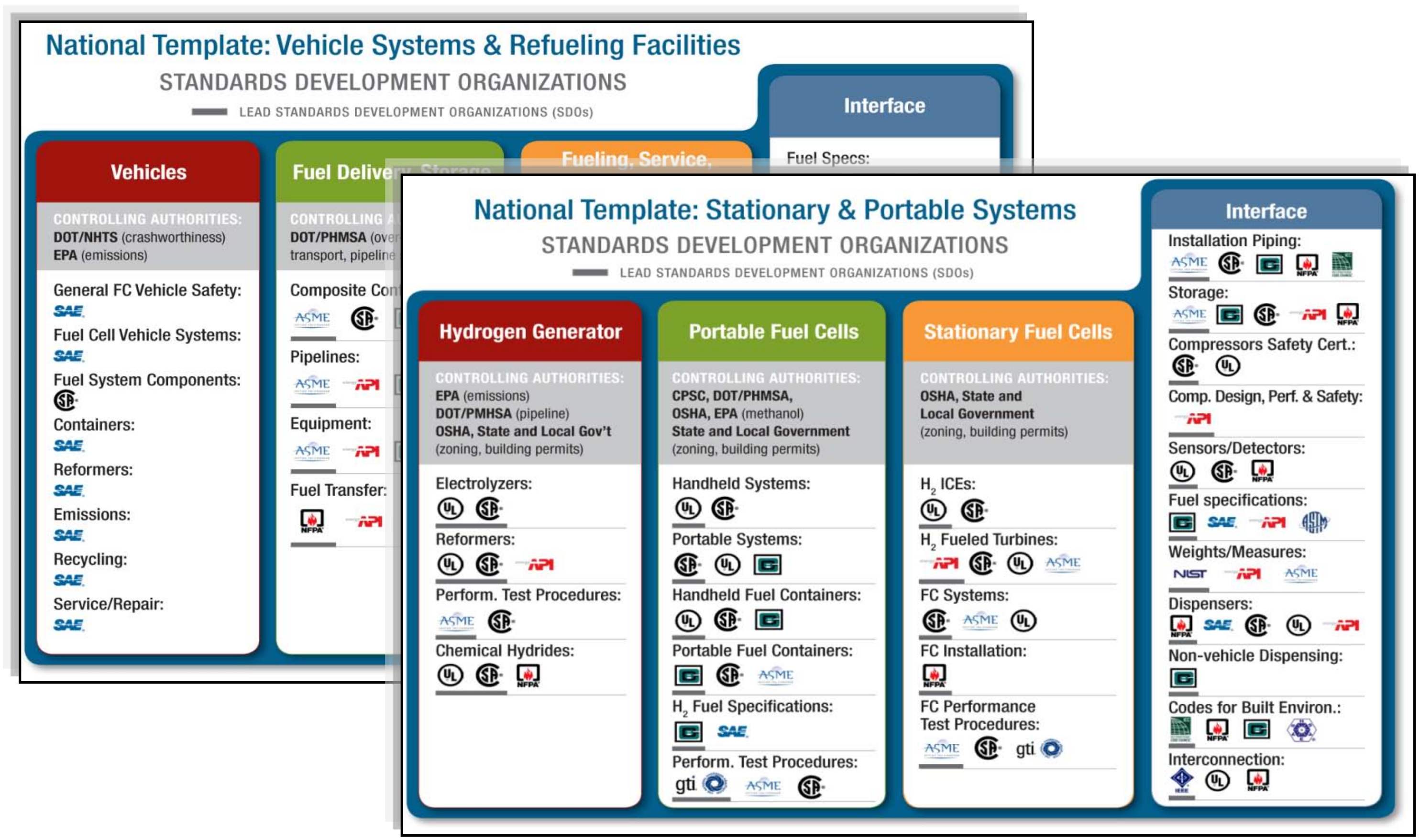
National Codes and Standards Template



- *National template continues to be used to delineate critical roles of standards development organizations*

Progress

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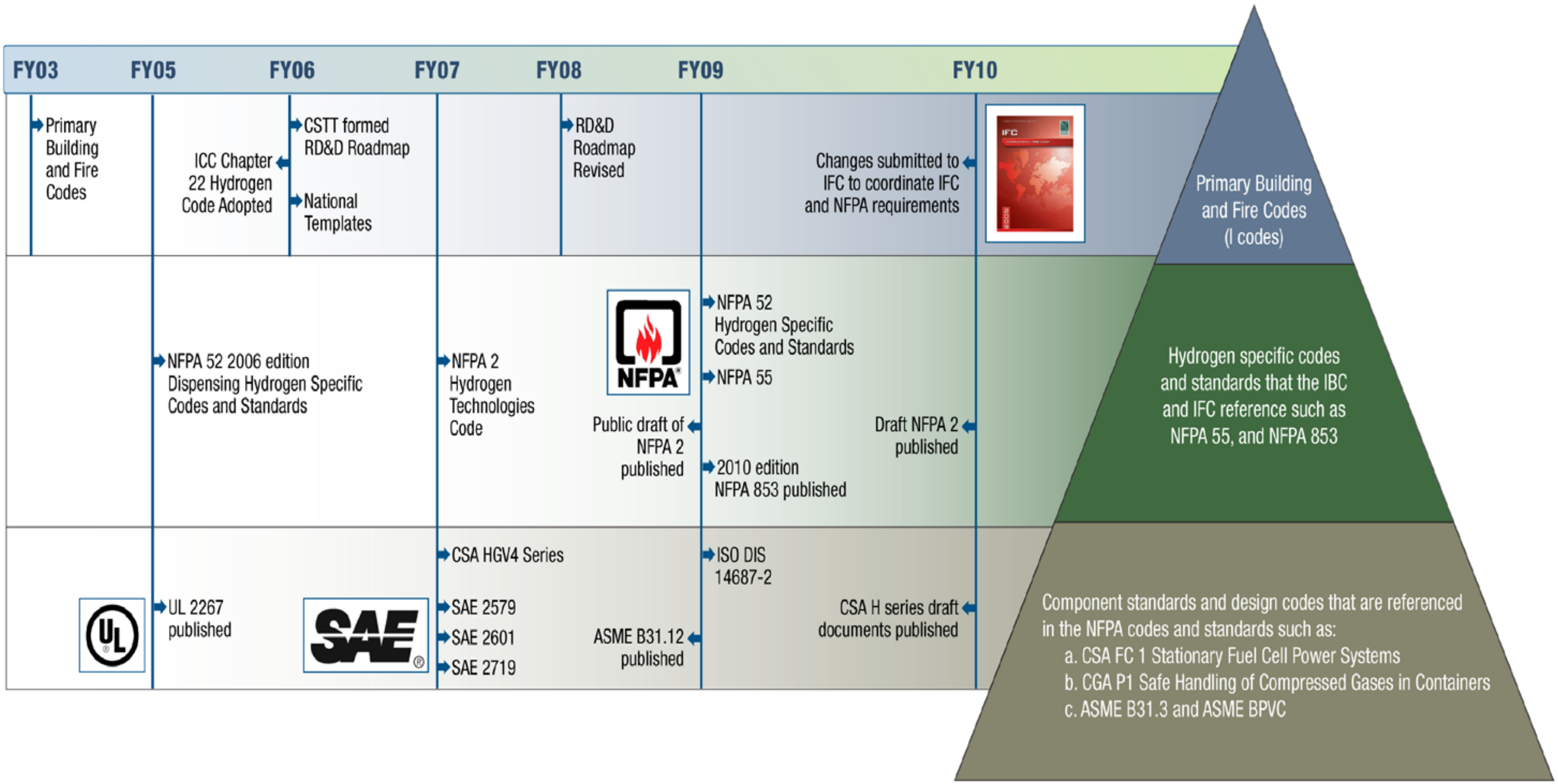
Timeline of Hydrogen Codes and Standards



- *Primary Building and Fire Codes*
- *Hydrogen Specific Codes and Standards*
- *Component Standards and Design Codes*

Progress: Separation Distances

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Quantified the effect of barrier walls to reduce hazards leading to fifty percent distance reduction credit in some cases

- QRA methodology embraced by ISO TC197 WG11, analysis and data provided to support standards language
- Support of NFPA enabling update of bulk gas storage Separation Distances in the 2012 edition of NFPA2

Barrier walls reduce separation distances – experimentally validated simulations to determining allowable heat flux iso-surface for 3-minute employee exposure. (2009 IFC).

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

Progress: Tanks

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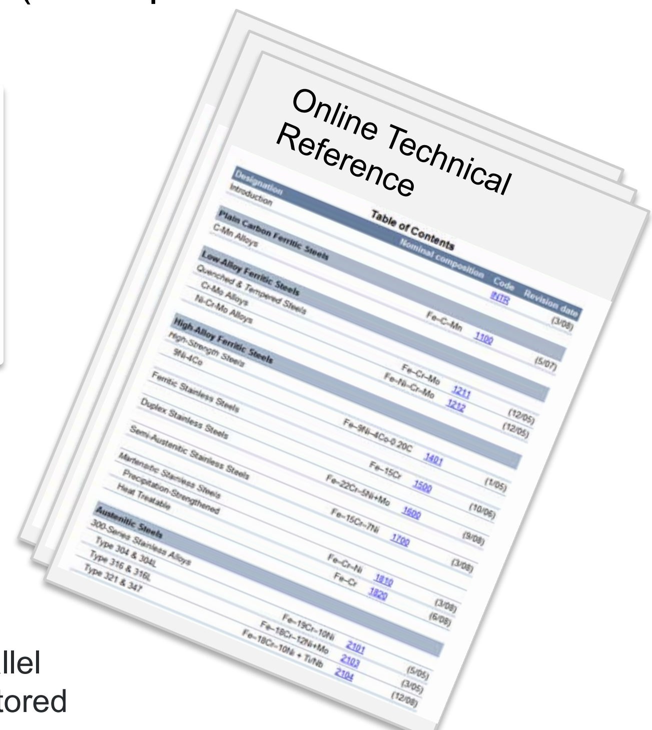
Pressure cycling of steel hydrogen storage tanks exceeded 25,000 cycles.

- Characterized crack initiation and growth in two tank designs that are currently in use (4130 steel)
- Conducted pressure cycling of steel storage tanks with gaseous hydrogen 3.5 to 45 MPa; 5 minute cycle time (2 min pressurization step)

Demonstrated that tanks with engineered defects exceed expected life cycle

Developed accelerated test protocol

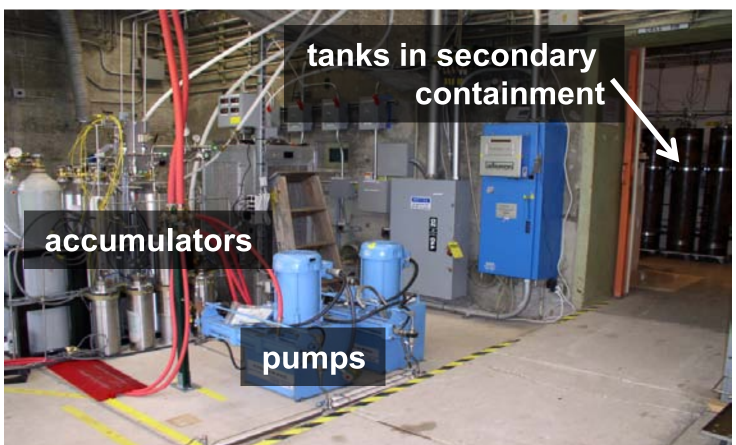
- Closed system
- Periodic pressure profile:
  - ~5 min cycles
- 10 tanks can be cycled in parallel
- Gas purity is periodically monitored



http://www.sandia.gov/matlsTechRef/

Test Matrix

Tank condition	*Objective*	*Tank Design*	*Max # of tanks*
As-manufactured	Baseline Crack initiation	A	4
		B	3
Engineered Defects (various K levels)	Crack initiation	A	4
		B	3
Engineered Defects (precracked)	Validation of Engineering Analysis	A	3
		B	2
Additional testing / Engineered Defects	Effect of pressure	A	1
		B	1



Progress

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International coordination to harmonize high pressure test protocol and qualification requirements

IPHE endorsed the Regulation, Codes and Standards Working Group (RCSWG) to work on harmonizing test protocol laboratory qualifications

- Challenges:
  - Lack of harmonization in testing requirement
- Approach:
  - International workshops
  - International round robin to establish consistent test protocol
  - International exchange program of leading scientists between the U.S. and China

Continued coordination through the UN / Global Technical Regulation (GTR)

http://www1.eere.energy.gov/hydrogenandfuelcells/forum_international.html

Progress: Global Technical Regulation

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Final Approval of GTR: November 2012

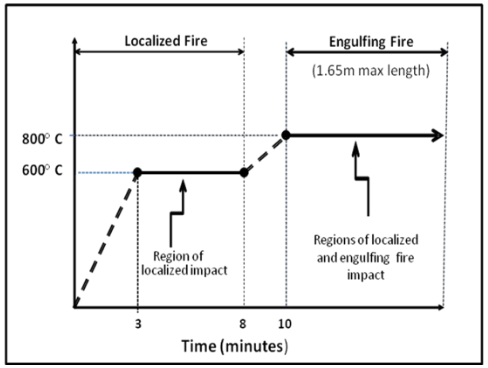
Objective:
Develop performance-based and harmonized international regulations, codes and standards (RCS) critical to fair and open competition in worldwide markets for hydrogen and fuel cell vehicles.

Benefits and Challenges
- Fair and open competition in worldwide markets for hydrogen and fuel cell vehicles.
- Ensure that U.S. (North American) interests and concerns are considered in the development of global RCS.

Approach
- Team with the Department of Transportation.
- Consistent high-level technical representation.
- Technical proposals and scientific data from the automobile industry incorporated into GTR.

Localized Fire Test Example

Preliminary Temperature Profile



Accomplishments
- Significant portions of SAE J2579 Technical Information Report for Fuel Systems in Fuel Cell and other Hydrogen Vehicles have been incorporated into the GTR.
- Technical experts provided extensive input to the GTR.

Progress

Expanded first-responder training

First Responder Education

- Completed upgrade of Web-based *Introduction to Hydrogen Safety for First Responders* – a total of 17,000 visits since January 2007.
- Conducted advanced-level, prop-based training in the state of Washington and California reaching over 300 students from 18 states.

www.hydrogen.energy.gov/firstresponders.html

International Collaborations

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International Partnership for Hydrogen and Fuel Cells in the Economy

Partnership among 17 member countries & the European Commission

- RCSWG is one of two standing committees – Co-Chair by U.S. & EC

International Energy Agency – Hydrogen Implementing Agreement

23 member countries and the European Commission

- Task 19 & Task 31: Hydrogen Safety

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 sponsored by DOE will be held in San Francisco September 12 – 14, 2011

Progress

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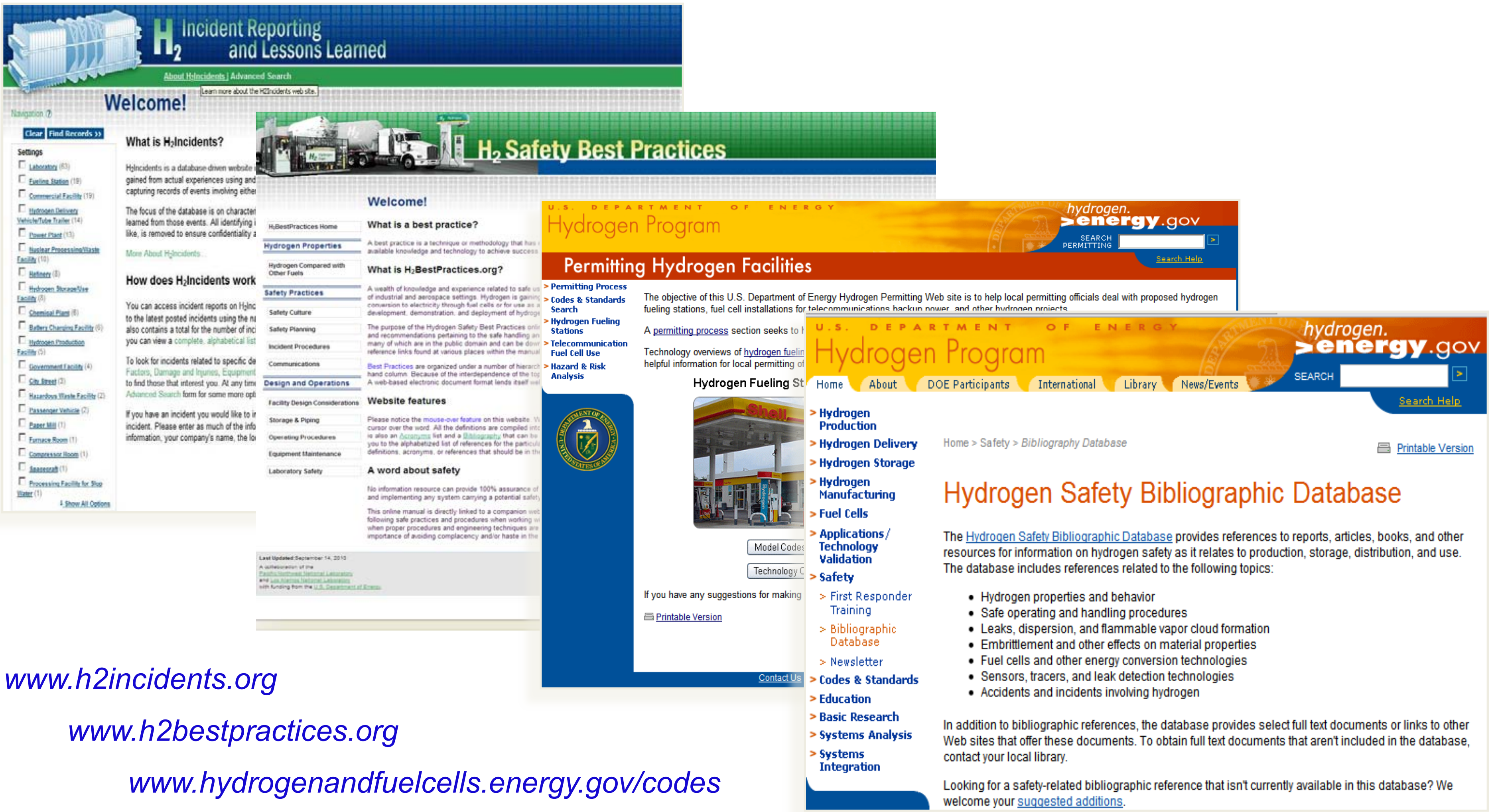
Expanded and Improved Safety Information Tools



www.h2incidents.org

www.h2bestpractices.org

www.hydrogenandfuelcells.energy.gov/codes

www.hydrogen.energy.gov/biblio_database.html

Summary

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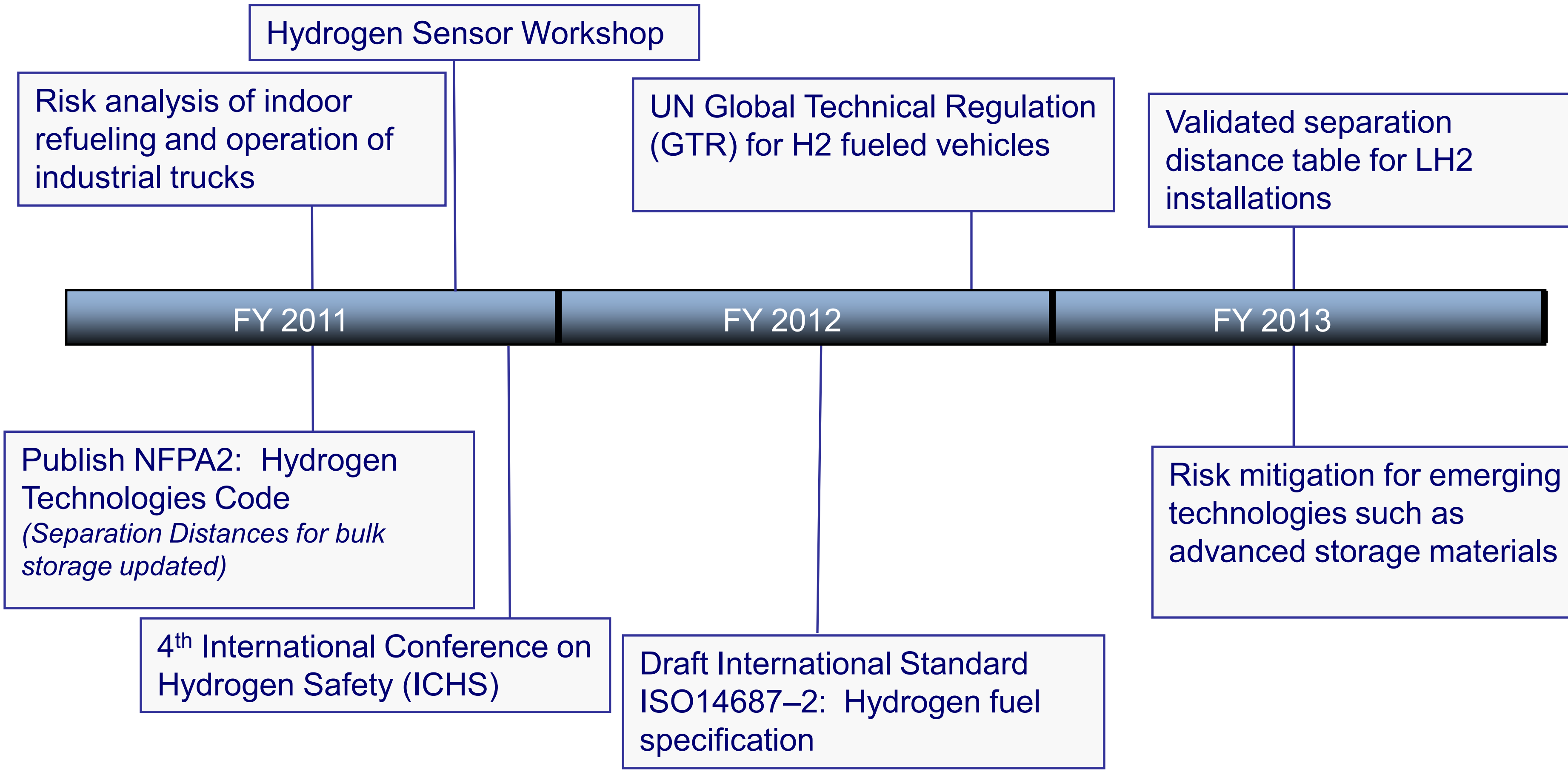
Key Milestones & Future Plans



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.
- Photography and audio and video recording are not permitted.

Reviewer Reminders

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- Deadline for final review form submittal is **May 20th at 5:00 pm EDT.**
- ORISE personnel are available on-site for assistance. A reviewer ready-room is set up in room *The Boardroom* (next to Salon A) and will be open Tuesday – Thursday from 7:30 am to 6:00 pm and Friday from 7:30 am to 2:00 pm.
- Reviewers are invited to a brief feedback session – at 5:45 pm today, in this room.

For More Information

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Safety, Codes and Standards

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Golden Field Office:
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Katie Randolph
Jesse Adams

Technical Support:
Kathleen O'Malley (SRA)
Jim Ohi (Consultant)
Jay Keller (SNL)

EERE Postdoctoral Fellowship Program

U.S. DEPARTMENT OF ENERGY

- Fuel Cell Technologies Program Opportunities Available
  - Conduct applied research at universities, national laboratories, and other research facilities
  - Up to five positions are available in the areas of hydrogen production, hydrogen delivery, hydrogen storage, and fuel cells
    - ❑ Applications are due June 30, 2011
    - ❑ Winners will be announced mid-August
    - ❑ Fellows will begin in mid-November 2011

www.eere.energy.gov/education/postdoctoral_fellowships/

Postdoctoral fellowships in hydrogen and fuel cell research ▸

Participating Organizations

U.S. DEPARTMENT OF ENERGY

Safety, Codes & Standards

LANL

LLNL

NASA

NIST

NREL

PNNL

ORNL

SNL

U.S. Dept. of Commerce

U.S. Dept. of Transportation

Regulatory Logic

Acknowledgements: SCS works with many other international and domestic stakeholders, including auto OEMs, energy providers, governmental agencies, NGOs, CDOs, and SDOs.

Additional Information

Progress

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Materials and Components Compatibility

Technical Reference

Mechanical load-frame used to characterize H2 effects in materials

Objective

- Enable market transformation through development and application of standards for hydrogen components.
  1. Create materials reference guide
  2. Execute materials testing with an emphasis on steel hydrogen storage tanks
  3. Optimize materials and component test methods to reduce cost while maintaining accuracy
- Participate directly in standards development.
  1. Materials testing standards (ASME Article KD-10, SAE and CSA)
  2. Component/system design qualification standards (CSA HPIT1, CHMC1 and SAE J2579)

Benefits and Challenges

- Address need for technical data to revise standards
- Reduce the cost of materials, component and system qualification
- Develop a materials technical reference
- Develop hydrogen storage tank and component standards for portable, stationary and vehicular use

Approach

- Apply expertise and resources in materials compatibility to implement and improve standards for hydrogen components.
- Project Timeline: October 2003 – September 2015 (58% complete)
- Coordination: Standards development organizations (ASME, CSA, SAE), tank manufactures and forklift integrators (FIBA Technologies, Plug Power, Nuvera FC), DOE Pipeline Working Group and HYDROGENIUS

Key Deliverables and Milestones

- Compare cracking threshold to fracture toughness measurements for vessel steels in hydrogen
- Add/update chapters on nickel-based alloys in “Technical Reference”
- Quantify the effects of load cycle frequency on fatigue of steels in high-pressure hydrogen
- Add/update chapters on ferritic steels in “Technical Reference”
- Report on fatigue crack growth and cracking thresholds of SA372 Gr. J steel in hydrogen

Accomplishments

- Provided technical basis for update of SAE J2579 to include design qualification test (C.14) and materials tests and associated acceptance criteria (C.15)
- Enabled revision of ASME KD-10 tank standard - fracture threshold measurements of tank steels in hydrogen
- Completed materials fatigue testing to enable deployment of 100 MPa stationary tanks
- Updated “Technical Reference for Hydrogen Compatibility of Materials” and data used for materials selection in technology design and for standards development

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Quantitative Risk Assessment

Quantitative Risk Assessment helps establish requirements for hydrogen installations

Objective
- Understand the risk associated with hydrogen facilities
- Provide a safe infrastructure for the use of hydrogen through risk management
- Provide risk-informed basis for development of uniform model codes and standards

Benefits and Challenges
- Methods must be developed that accommodate sparse data
- Harmonization of codes and standards requirements allows for international deployment
- Incorporation of risk data helps avoid overly conservative code and standard requirements

Approach
- Use of Quantitative Risk Assessment (QRA) to evaluate risk, identify risk drivers and evaluate mitigation features to establish requirements
- Timeline: October 2003 – September 2015 (60%)
- Coordination: NFPA, ISO, ICC, HIPOC, Air Products

Key Deliverables and Milestones
- Complete risk assessment of indoor fuel cell material handling vehicle operations in warehouses
- Develop a consensus hydrogen ignition probability model for use in QRA
- Support NFPA 2 efforts to develop risk informed separation distance tables for LH2 facilities
- Complete risk evaluation of hydrogen refueling stations that utilize LH2, steam reformers or electroyzers

Accomplishments
- Harmonization of NFPA 55 and ISO risk assessment approach, models and data used to establish separation distances
- Risk reduction potential of barriers utilized to establish reduction factor for separation distances in NFPA-55
- Phase I work has been performed on evaluating the risk associated with indoor refueling
  - Development of approaches, models and data required in QRA
  - Experiments performed to understand phenomena, develop models and bench mark consequence models

Progress

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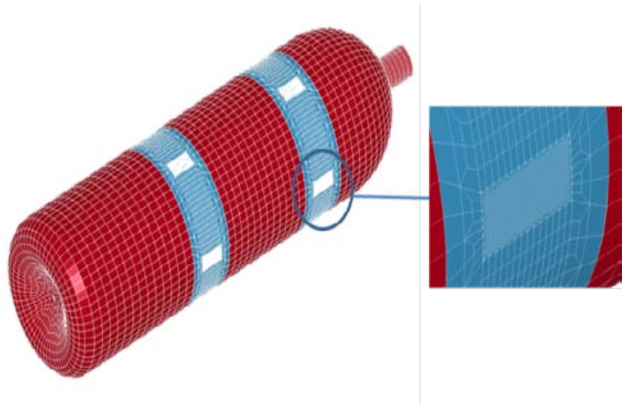
Tank Cycle-Life Testing



Structural Engineering Analysis of Cylinder

Objective

▪Provide technical basis for the development of standards defining the use of steel (type 1) storage tanks with existing defects

1. Engineering Analysis Method: validate fracture mechanics-based design approach in ASME BPVC Sec VIII, Div 3, Article KD-10
2. Performance Evaluation Method: provide data to help determine if time for crack initiation can be reliably credited in design qualification process
3. Quantify failure characteristics

▪Participate directly in standards development such as ASME, CSA HPIT1 working group and SAE J2579

Benefits and Challenges

▪Program provides the technical basis addressing this need within the scope of CSA HPIT1.

▪Hydrogen accelerates fatigue crack growth of existing defects including crack growth under cyclic stress and critical crack propagation.

▪Standards for steel hydrogen tanks that experience a large number of cycles is currently missing (CSA HPIT1).

Approach

▪Perform testing and analysis of hydrogen accelerated fatigue crack growth of existing defects to provide basis for standards development activities

▪Project Timeline: January 2010 – May 2011 (75% complete)

▪Coordination: CSA HPIT1 working group, FCHEA Fork Lift Task Force, Tank Manufactures, Norris Cylinder, Nuvera and Plug Power

Key Deliverables and Milestones

▪Complete cycling of as-manufactured tanks and tanks with engineered flaws until failure

▪Complete benchmark fatigue crack growth testing of 3 heats of 4130X

▪Quantify number of cycles for initiation and growth as well as size and distribution of engineered and “natural” defects

▪Validate structural engineering tools and existing design methodology (in particular ASME VIII.3.KD-10 and leak-before-burst criteria)

▪Communicate results to CSA HPIT1 working group and SAE J2579

Accomplishments

▪As-manufactured tanks have experienced 25,000 cycles as of Feb 2011

▪Fatigue crack growth rates have been measured for each tank material

▪Test matrix defined with input from partners (HPIT1 working group)

▪Infrastructure has been developed for accelerated qualification test method development

Progress

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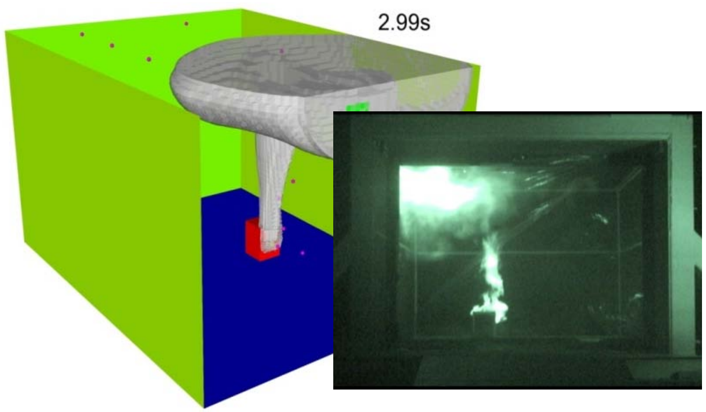
Hydrogen Release Behavior



Simulation and experimental validation of release during indoor refueling

Objective

- Provide a defensible and traceable basis for hydrogen codes and standards
- Provide advocacy and technical support for the codes and standards development process

Benefits and Challenges

- Provide expertise and technical data on hydrogen behavior and risk
- Facilitate global harmonization of RCS
- Address insufficient technical data needed to revise standards
- Reduce large footprint requirements for hydrogen fueling stations
- Facilitate safe deployment of renewable energy technologies

Approach

- Develop and validate models for hydrogen behavior to enable risk-informed decision-making for the codes and standards development process
- Project Timeline: October 2003 – September 2015 (60% complete)
- Coordination: SRI, IEA, ICC, NFPA, ISO, NHA, NIST, CTFCA, NREL

Key Deliverables and Milestones

- Understand ignition and dispersion behavior at appropriate temperature and pressure
- Develop and validate engineering models
- Evaluate risk associated with hydrogen indoor refueling
- Evaluate risk associated with small stationary APUs
- Propose risk mitigation methods and quantify risk reduction - achieved

Accomplishments

- Models validated for hydrogen releases in enclosures:
  - Tunnels
  - Warehouses
- Identified mechanism of spontaneous-ignition due to entrained particulates
- Developed the scientific-basis for separation distances in NFPA 55/2
- Harmonized NFPA and ISO framework for specifying separation distances
- Validated the use of barriers to reduce separation distances

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Hydrogen Safety Training for First Responders

A "rescue" at Sunnyvale (CA) Department of Public Safety

Objective

- Support the successful implementation of hydrogen and fuel cell technologies by providing technically accurate hydrogen safety and emergency response information to first responders.
- Continue to provide a one-day first responder training course utilizing DOE's FCEV prop at offsite first responder training centers (civilian and military).
- Continue to support the web-based awareness-level course.
- Disseminate first-responder hydrogen safety educational materials at appropriate conferences to raise awareness.

Barriers Addressed

- Lack of readily available, objective, and technically accurate information.
- Disconnect between hydrogen information and dissemination networks.
- Lack of educated trainers and training opportunities.
- Lack of hydrogen knowledge by authorities having jurisdiction.
- Lack of hydrogen safety training facilities for emergency responders.

Approach

- Reach first responders via the fuel cell electric vehicle (FCEV) prop-based course, the web-based "Introduction to Hydrogen Safety for First Responders" and outreach to the Fire Department Instructors Conference and Fire Rescue International to raise awareness of hydrogen safety training courses to the target audience.
- Project Timeline: October 2004 – Continuing
- Collaboration: California Fuel Cell Partnership, Hanford Fire Department, and Volpentest Hazardous Materials Management and Emergency Response (HAMMER) Training and Education Center

Key Deliverables and Milestones

- Provide the prop course at Defense Logistics Agency depots and other fire training centers (Summer 2011).
- Continue to update the web-based hydrogen safety course as needed.
- Target outreach opportunities.

Accomplishments

- Trained over 300 students in three FCEV prop-based courses in California in August/September 2010.
  - Rio Hondo College Fire Academy, Santa Fe Springs, CA
  - Orange County Fire Authority, Irvine, CA
  - Sunnyvale Department of Public Safety
- Held three sessions of the prop-based course at the HAMMER facility in 2009 and 2010, training ~100 participants from 18 states.
- Web-based course received 18,000 unique visitors and averages 300-400 unique visits each month from every state and many foreign countries.

Progress

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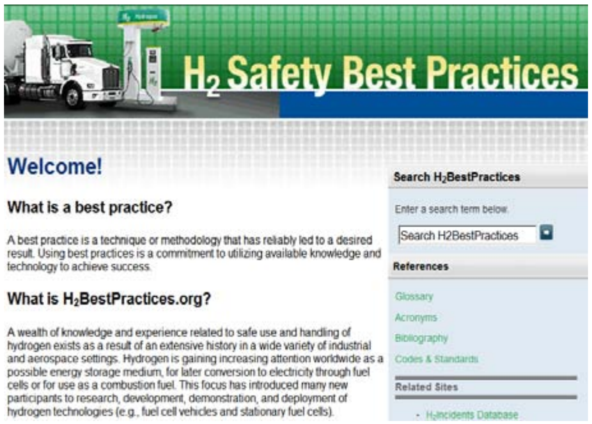
Hydrogen Safety Knowledge Tools



H_2 Safety Best Practices web site (also see H2incidents.org)

Objective

- H2 Safety Best Practices
  Capture vast knowledge base of hydrogen experience and make it publicly available.
- H2 Incident Reporting and Lessons Learned Collect information and share lessons learned from hydrogen incidents and near-misses, with a goal of preventing similar incidents from occurring in the future.

Barriers Addressed

- Limited historical database of incidents
- Proprietary data

Approach

- H2 Safety Best Practices: Best practices are compiled, new Web content is reviewed by the Hydrogen Safety Panel and PNNL experts, and approved material is posted to the Web site.
- H2 Incident Reporting and Lessons Learned: Pursue records and lessons learned for hydrogen incidents and near-miss events to add to the online database.
- Project Timeline: March 2003 – Continuing
- Collaboration: Hydrogen Safety Panel, NASA, LANL, SNL, NREL, IEA Hydrogen Implementing Agreement (HIA) Task 31 and IA HySafe

Key Deliverables and Milestones

- H2 Safety Best Practices
  1. Improve existing and add new content.
  2. Enhance Web site usability.
  3. Encourage use and respond to user questions posted on the Web site.
- H2 Incident Reporting and Lessons Learned
  1. Target to reach > 200 safety event records in FY2011.
  2. Analyze lessons learned from incidents.

Accomplishments

- H2 Safety Best Practices
  1. Enhanced best practices for outdoor storage of hydrogen cylinders.
  2. Added more information on hydrogen properties in collaboration with NASA.
  3. Updated “Hydride Storage and Handling” to cover risks related to large-scale experiments in collaboration with SNL.
- H2 Incident Reporting and Lessons Learned
  1. Currently 195 incidents recorded in the database.
  2. Created new “Lessons Learned Corner” to analyze hydrogen safety themes illustrated by database content.

Progress

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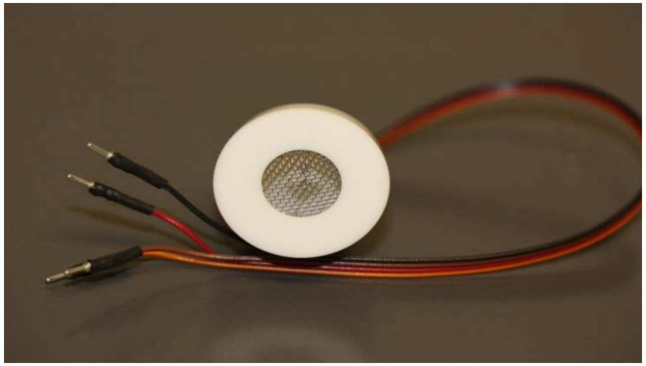
Sensor Testing



Packaged LANL/LLNL Mixed Potential Zirconia-based H_2 Sensor for Independent Testing

Objective:

- Develop a low cost, low power, durable and reliable hydrogen safety sensor for vehicle and infrastructure applications.
- Demonstration of working technology through applications of commercial and reproducible manufacturing methods and rigorous life testing results guided by materials selection, sensor design and electrochemical R&D investigation.
- Disseminate packaged prototypes to DOE laboratories and commercial parties interested in testing and fielding advanced commercial prototypes while transferring technology to industry.

Benefits and Challenges:

- Low cost sensors for hydrogen leakage needed for vehicles and pipelines.
- Potential liability issues and lack of insurability affecting the commercialization of hydrogen technologies.
- Variation in standard practice of hydrogen safety assessments.

Approach:

- Focus on the long-term testing, packaging and manufacturing protocol for the commercialization of hydrogen sensor technology.
- Evaluate alternative measurement and electrode processing methods to further improve sensor stability.
- Coordination: LANL, LLNL and ElectroScience Laboratories with BJR Sensors.

Key Deliverables and Milestones:

- Go for mode of operation and fabrication processes with critical evaluation of mass manufacturing potential.
- Multiple devices fabricated and packaged for 1st round of testing/independent validation at NREL facility.
- Application of BJR Passive Duel Technology (PDT) shows promise with near 100% rejection of cross-interference gas species tested.

Accomplishments

- Developed miniaturized, low power and robust hydrogen sensor prototype conducive to commercialization.
- Developed stable sensor response over time.
- Multiple devices fabricated and packaged showing high-degree of reproducibility device-to-device.
- Incorporation of miniature Resistance Temperature Detectors (RTD) in sensor platform to provide continuous T feedback and control point.
- Developed methods for rejection of cross-sensitivity to common interference gases tested.
- Completed long-term testing of improved electrode devices at LANL and at LLNL on separate devices.
- Completed 1st round of testing packaged H_2 safety sensors at NREL.

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Fuel Quality

Hydrogen Fuel Quality Test Apparatus

Objective:

Determine levels of constituents for the development of an ANSI and international standard for hydrogen fuel quality (ISO TC197 WG12).

Benefits and Challenges:

- Remaining Tests for Fuel Specifications:
  1. Testing critical constituents at reduced levels
  2. Reduce anode loading: .05 mg Pt/cm^2 (DOE 2015 target)
  3. Short term tests: typical vehicle operation (5-10 hours)
  4. Start/stop Fuel Cell operation
  5. Aged studies
- Critical Constituents:
  1. Lower Pt loadings may increase performance losses via surface poisoning and/or within the catalyst layer
  2. Short-term tests may help reduce the build-up of adsorbates and/or cation uptake
  3. Shut down may be to some extent be helpful as a recovering strategy (introduction of air to remove excess hydrogen)
  4. Aged fuel cells may inhibit particle growth and/or ionomer loss (similar to lowering Pt loading)

Approach:

- Help determine levels of constituents and test these critical constituents (NH_3, CO and H_2S) at various conditions (loadings, relative humidity and concentrations) and present data at ISO WG 12 meetings.
- Coordination: University of Hawaii/HNEI, University of Connecticut, University of South Carolina, Clemson University, SRNL, NIST, NREL and ANL

Key Deliverables and Milestones:

- Complete testing of critical constituents at various conditions (loadings, relative humidity and concentrations).

Accomplishments

- H_2S Gore Standard MEA: Slower poisoning onset, but when accumulation occurs these results differ.
- Project produced excellent experimental and modeling results that were adopted by the international community.
- Significant progress on establishing cross contamination effects.
- Data presented at ISO WG 12 Meetings in Berlin, Germany; Seoul, Korea; and San Francisco, CA.

Progress

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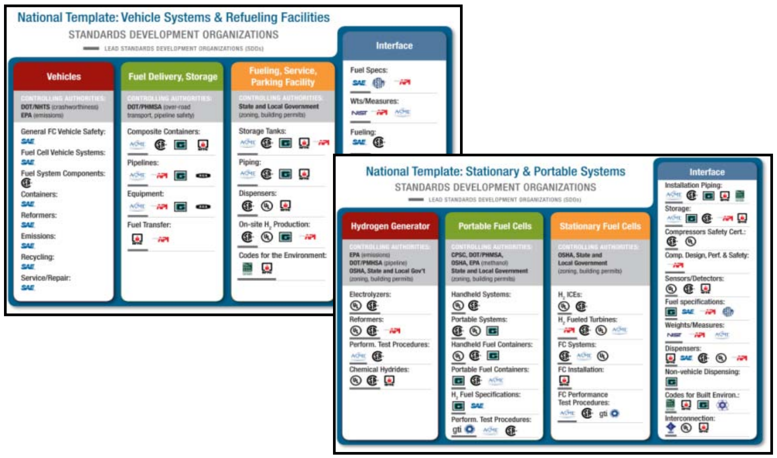
National Template



National Template Web site

Objective:

- Conduct R&D needed to establish sound technical requirements for renewable energy codes and standards with a major emphasis on hydrogen and fuel cell technologies.
- Support code development for the safe use of renewable energy in commercial, residential and transportation applications with a major emphasis on emerging fuel cell technologies.
- Advance renewable energy safety, code development and market transformation issues by collaboration with appropriate stakeholders.
- Facilitate the safe deployment of renewable energy technologies.

Benefits and Challenges:

- Consensus: achieving national agenda on codes and standards.
- Representation: government and industry support and DOE limited role.
- Technology Readiness: jurisdictional issues related to available codes and existing setback distances.

Approach:

- Support codes and standards coordination and development including coordinating involvement in technical committees and coordinating committees.
- Project Timeline: October 2002 – Continuing
- Coordination: California Fuel Cell Partnership (CaFCP), California Air Resource Board (CARB), FCHEA, SNL, LANL, ORNL, ANL, PNNL, NASA, NIST, JRC, SAE, NFPA, CSA America, ICC, CGA, ISO and IEC

Key Deliverables and Milestones:

- Publish Stationary Fuel Cell Application Codes and Standards Gap Analysis
- Direct support of several codes and standards development projects:
  1. NFPA2 Hydrogen Technologies Code
  2. ISO 14687-2 Hydrogen Fuel quality standard
  3. SAE Standards
  4. CSA Component standards

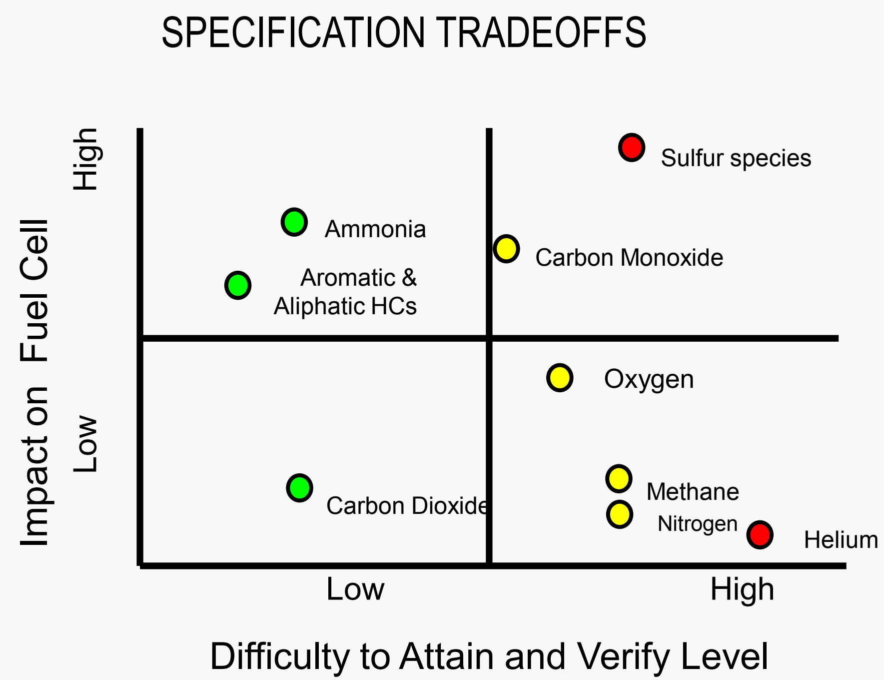
Accomplishments:

- Published Stationary Fuel Cell Application Codes and Standards Gap Analysis (October 2010)
- Direct participation on the following codes and standards committees:
  1. NFPA2 Hydrogen Technologies Code issued December 14, 2010
  2. ISO TS14687-2 Hydrogen Fuel Quality
  3. SAE J2579 Onboard Hydrogen Storage
  4. SAE J2578 General Fuel Cell Vehicle Safety
  5. SAE Fuel Cell Technical Committee
  6. CSA America H4
  7. ISO 20100 Hydrogen Fueling Stations
  8. UL2267 Fuel Cell Powered Forklifts

Progress

- 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