



HYDROGEN
Safety Resources

Overview of the DOE Hydrogen Safety,
Codes and Standards Program Part 2

Hydrogen and Fuel Cells - Emphasizing Safety to Enable Commercialization

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Why is Safety Important

- ▶ Safe practices in the production, storage, distribution and use of hydrogen are essential for deployment of hydrogen and fuel cell technologies. ***A significant incident involving a hydrogen project could negatively impact the public's perception of hydrogen systems as viable, safe, and clean alternatives to conventional energy systems.***
- ▶ Hydrogen CAN be used safely. However, because hydrogen's use as a fuel is still a relatively new endeavor, the proper methods of handling, storage, transport and use are often not well understood across the various communities either participating in or impacted by its demonstration and deployment. ***The resources described in this presentation will continue to play a critical role to help identify issues and inform those tasked with designing, approving, or using systems and facilities, as well as those responding to incidents.***

Hydrogen Safety Resources



HYDROGEN Safety Panel

- ▶ Identify Safety-Related Technical Data Gaps
- ▶ Review Safety Plans and Project Designs
- ▶ Perform Safety Evaluation Site Visits
- ▶ Provide Technical Oversight for Other Program Areas



HYDROGEN Tools

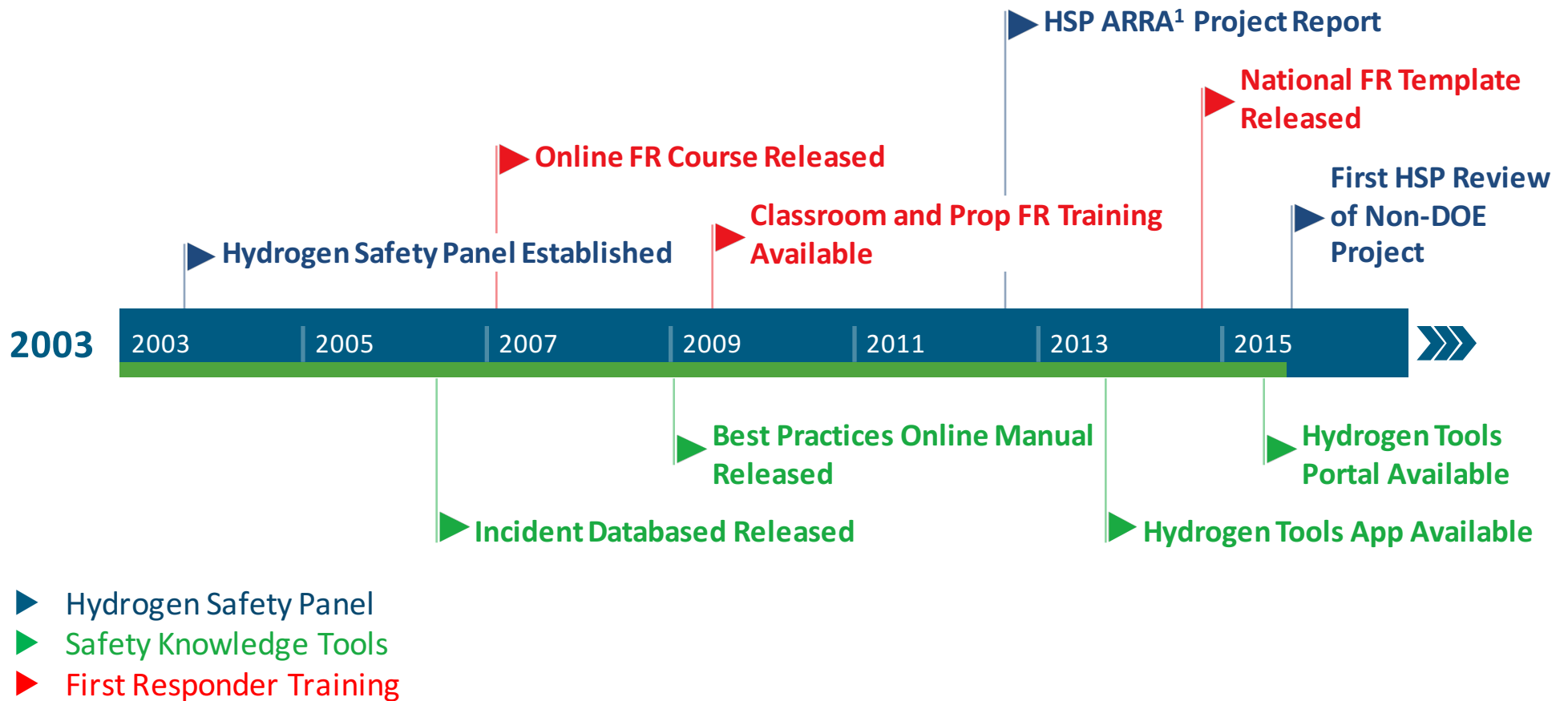
- ▶ Hydrogen Lessons Learned
- ▶ Hydrogen Best Practices
- ▶ Hydrogen Tools (iPad/iPhone mobile application)
- ▶ Hydrogen Tools Web Portal (<http://h2tools.org>)



HYDROGEN Emergency Response Training Resources

- ▶ Online Awareness Training
- ▶ Operations-level Classroom/Hands-on Training
- ▶ National Hydrogen and Fuel Cell Emergency Response Training Resource

Hydrogen Safety Program Timeline



Hydrogen Safety Panel



Hydrogen Safety Panel Mission

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.

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
- making design, construction, and operations personnel aware of relevant issues and best practices that affect safe operation and handling of hydrogen and related systems
- convincing design, construction, and operations personnel to give sufficient priority to safety in their daily, ongoing work

Hydrogen Safety Panel Contributes in Many Ways

The Hydrogen Safety Panel contributes to its objective by:

- ▶ providing safety planning guidance
- ▶ participating in safety reviews
- ▶ reviewing project designs and safety plans
- ▶ sharing safety knowledge and best practices
- ▶ participating in incident investigations



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

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
- ▶ includes committee members from NFPA 2 and 55, and technical committees of ASME, SAE and ISO
- ▶ contributes to peer-reviewed literature on hydrogen safety
- ▶ presents at national and international forums

Hydrogen Safety Panel Accomplishments

- ▶ Reviewed 272 projects (418 reviews) covering vehicle fueling stations, auxiliary power, backup power, combined heat and power, industrial truck fueling, portable power and R&D activities.
- ▶ Recent white papers with recommendations include:
 - Safety of Hydrogen Systems Installed in Outdoor Enclosures
 - Secondary Protection for 70MPa Fueling
- ▶ Supports development/updating of safety knowledge tools on the Hydrogen Tools Portal (h2tools.org): Lessons Learned and Best Safety Practices
- ▶ Conducted 21 Hydrogen Safety Panel meetings since 2003. Panel meetings currently engage a broad cross-section of the hydrogen and fuel cell community.



Example of Learnings from Demonstration Projects

Safety vulnerability analysis needs to comprehensively consider all potential incident scenarios introduced by hydrogen/fuel cell deployment and equipment operations and exposures.

- ▶ A thorough hazards analysis is critical for ensuring safety deployment of hydrogen and fuel cell technologies
- ▶ Many projects did not comprehensively address the potential safety vulnerabilities of all operations regardless of the fuel cell application
- ▶ Hazard analysis was the most frequently cited recommendation but also had the most “no actions”

Recommendations and actions from Panel safety review
(development and deployment projects)

| Category | Recommendations Implemented | In Progress | No Action | Total Recommendations |
|--|-----------------------------|-------------|-----------|-----------------------|
| Safety Vulnerability/ Mitigation Analysis | 23 | 4 | 13 | 40 |
| System/Facility Design Modifications | 11 | 5 | 1 | 17 |
| Equipment/Hardware Installation and O&M | 18 | 7 | 2 | 27 |
| Safety Documentation | 16 | 7 | 0 | 23 |
| Training | 3 | 3 | 0 | 6 |
| Housekeeping | 14 | 6 | 1 | 21 |
| Emergency Response | 9 | 3 | 3 | 15 |
| Total | 94 | 35 | 20 | 149 |

A New Review Approach for Demonstration Projects

Demonstration projects require a new review approach...

Timing for HSP involvement affects the benefit

When HSP review and site visits were provided after the equipment was operational:

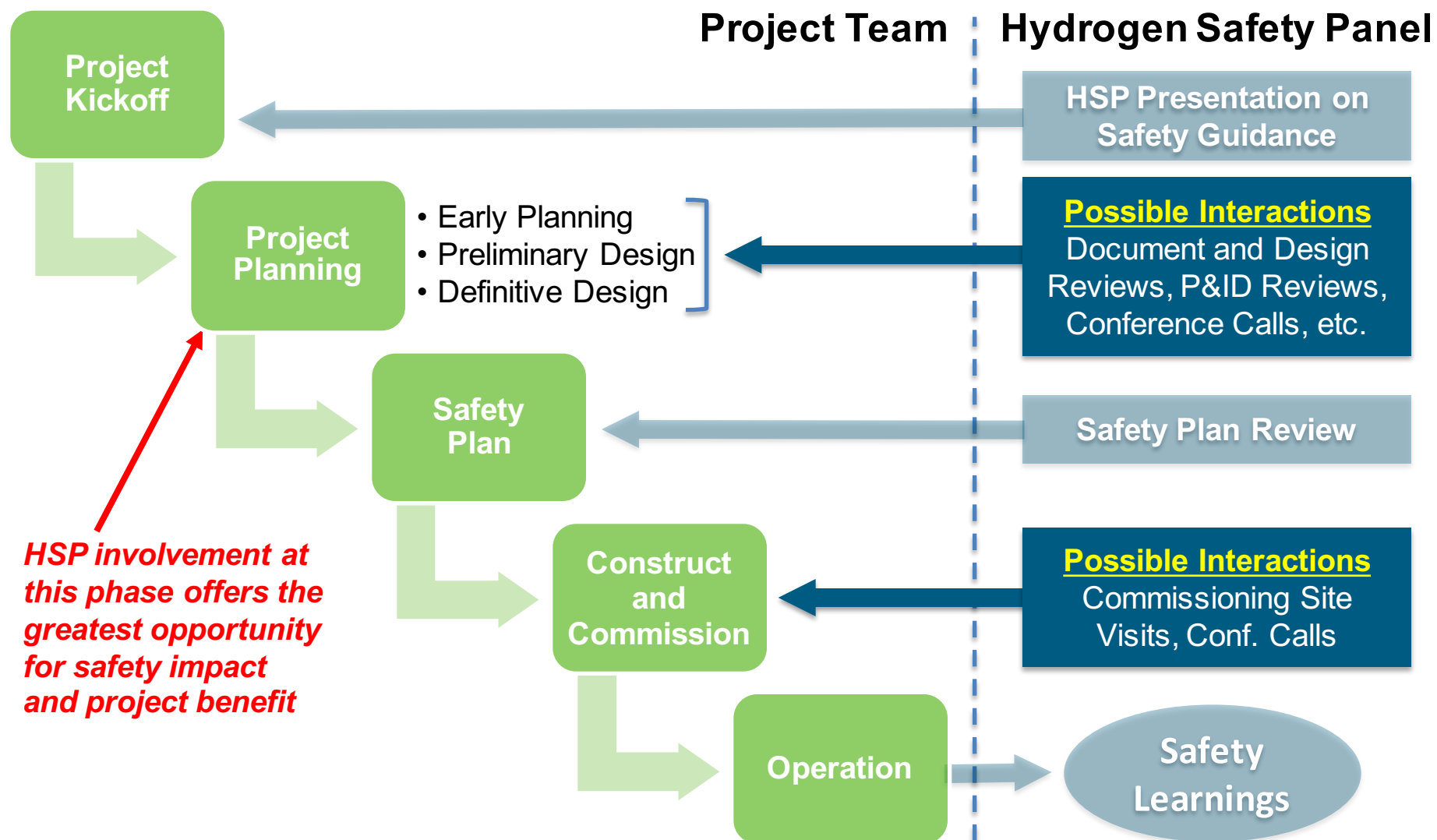
- It is difficult and costly to implement recommendations affecting equipment and configuration
- Projects resist input when it occurs after the completion of design or construction activities

Benefits of early HSP involvement realized in four Hawaii projects:

- Helped the projects understand and evaluate the safety issues and code requirements
- Significant design changes were made based on input from the HSP
- Project management and stakeholders had greater confidence in approving the final configuration

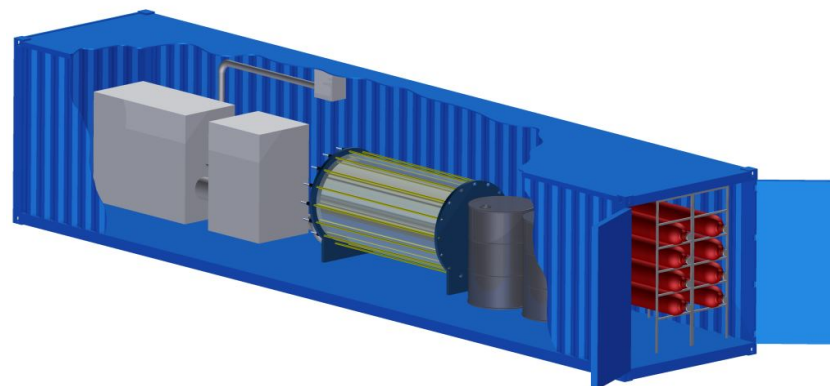
“I believe getting the HSP involved early in the project contributes to a much safer outcome by putting many sets of highly qualified eyes on the project. In fact it would have been useful to get the HSP involved even earlier in the design process - perhaps at the preliminary design review.” Mitch Ewan, HNEI

Maximizing Impact of Panel Review Activities



HSP's Impact on Codes and Standards

- ▶ The Panel's white paper, "Safety of Hydrogen Systems Installed in Outdoor Enclosures," and risk evaluation of enclosures supported changes for the 2016 version of NFPA 2.
- ▶ NFPA 2, 2016 now has prescriptive requirements for Hydrogen Equipment Enclosures¹, including:
 - Ventilation
 - Isolation (gas and fire barrier)
 - Electrical requirements
 - Bonding/grounding
 - Explosion control
 - Detection



¹ A prefabricated area confined by at least three walls and a roof, not routinely occupied or used in a laboratory, *with a total area less than 450 ft² designed to protect hydrogen.*

* Final balloting approved in December 2014

The Certification Challenge

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

Certification presents significant challenges.

- Few systems or equipment that are listed, labeled or certified
- Significant costs since the technology and products are still rapidly changing and each new iteration would require recertification
- When equipment is not listed, the code official must “approve” it before installation

So what criteria do code officials use to approve the equipment?

- The HSP is developing a guide to assist code officials, designers, owners, evaluators and others with the application of requirements pertinent to the design and/or installation of hydrogen equipment as regulated by the model codes

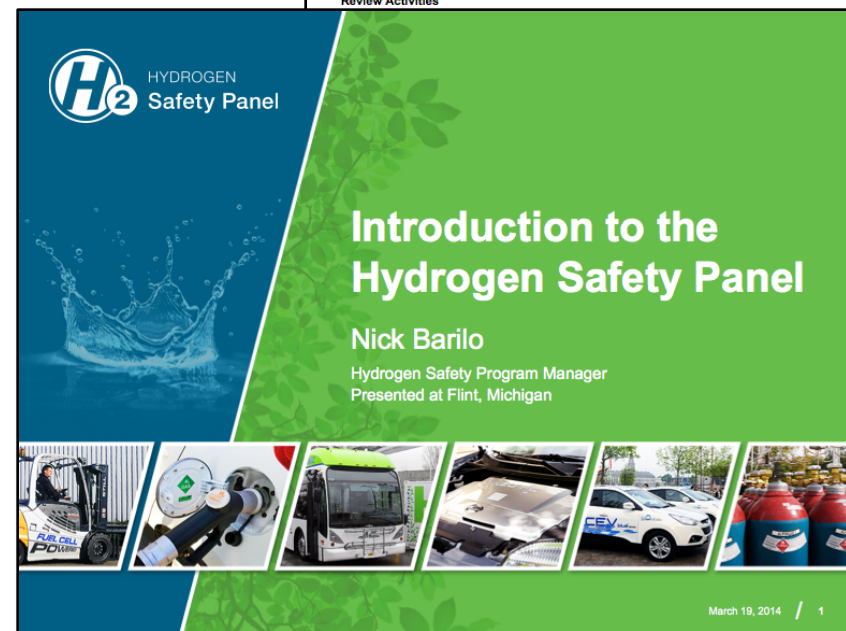
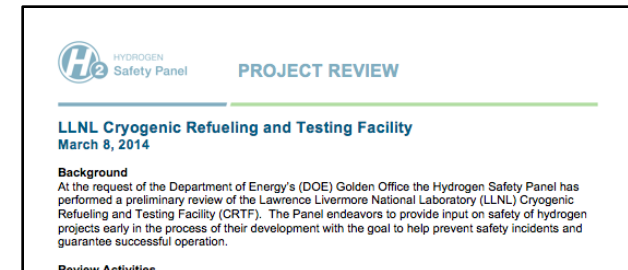


Highlighting the HSP as a Safety Resource



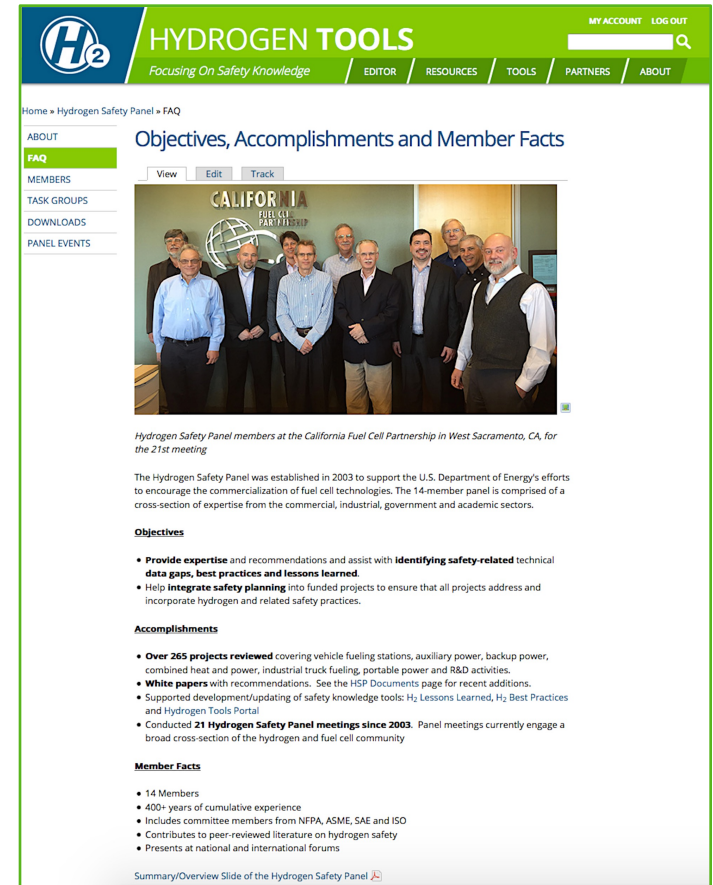
*To enhance the Hydrogen Safety Panel's role as a safety resource for enabling the widespread acceptance of hydrogen, **product branding** is now used:*

- The consistent and appropriate use of branding will strengthen recognition of the HSP and its reputation as a safety resource
- Branding will also validate that information is coming from a reliable and trustworthy source



HSP Support for State Deployment of Infrastructure

- ▶ Assisting the H2USA through focused SCS outreach activities
- ▶ Supporting the California Governor's Office and CA Green Team
 - Included in the CA Hydrogen Station Permitting Guidebook - "this panel can be consulted to review innovative projects and provide feedback and insights to both station developers and AHJs."
- ▶ Drafted safety sections for the Hawaii implementation plan
 - Includes reference to the HSP as a safety resource
- ▶ Working with code officials in Massachusetts to discuss safety issues and assist with infrastructure rollout
- ▶ Completed a safety review of a mobile fuel cell power unit for the California Air Resources Board



The screenshot displays the 'HYDROGEN TOOLS' website. The header includes the H₂ logo, the title 'HYDROGEN TOOLS', and the tagline 'Focusing On Safety Knowledge'. Navigation links for EDITOR, RESOURCES, TOOLS, PARTNERS, and ABOUT are visible. The main content area is titled 'Objectives, Accomplishments and Member Facts' and features a photo of the Hydrogen Safety Panel members at a meeting. Below the photo is a caption: 'Hydrogen Safety Panel members at the California Fuel Cell Partnership in West Sacramento, CA, for the 21st meeting'. The page lists the panel's objectives, accomplishments (including 265 projects reviewed and 21 meetings since 2003), and member facts (14 members with 400+ years of experience).

Establishing public visibility... Hydrogen Safety Panel **website** online March 2015

Maximizing the Impact of the HSP

The Panel is a unique resource and can be a valuable asset for supporting the safe commercial rollout of fuel cell vehicles, stationary applications and the supporting infrastructure.

Can provide support to:

- ▶ Other federal agencies
- ▶ State agencies, code officials and permitting authorities
- ▶ Private industry and commercial installers

By contributing to:

- ▶ Design and document reviews
- ▶ Participation in and/or review of risk assessments
- ▶ Site reviews



“Safety is paramount - its the first question we get asked in California when we go into local communities. If anything, we need to figure out how to expand the Safety Panel's reach. The reviews from the Panel have already shown benefit to the state - its a crucial, trusted 3rd party resource.” – 2015 DOE AMR Reviewer Comment

Sharing Safety Knowledge

Hydrogen Tools

A Transformative Step Towards Hydrogen Adoption

CENTRALIZED LOCATION

organizes current H₂ resources in one robust location—including many proven tools, with plans for adding future content

FOCUSED CONTENT

tailored to the specialized needs of H₂ user groups

RESPONSIVE DESIGN

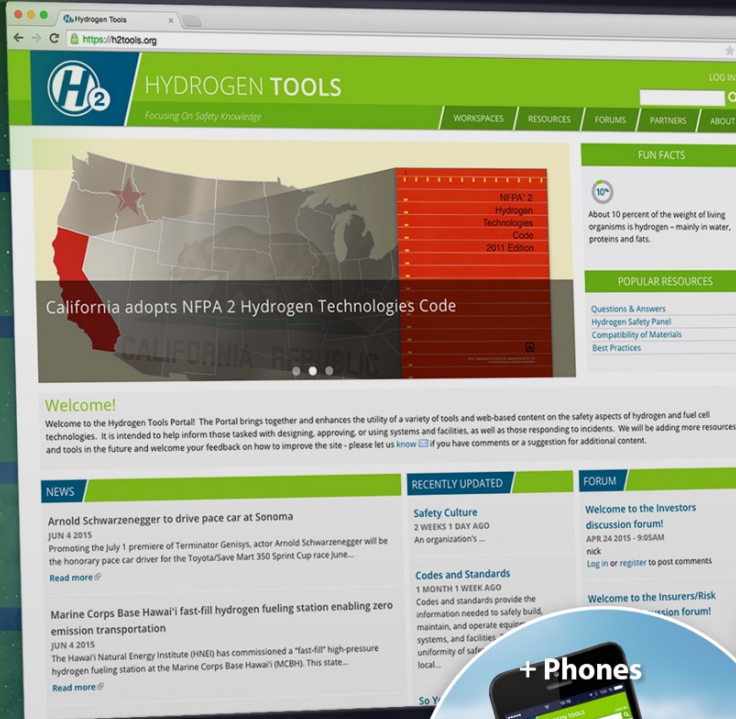
enables H₂ safety work across both desktop and mobile devices

TRUSTED COMMUNITIES

fostered through social networking around H₂ subject matter expertise

EXPANDABLE FORMAT

built with frequently requested future feature sets in mind



+ Tablets



+ Phones



<http://h2tools.org>



> Credible and reliable safety information from a trustworthy source

Consolidating Safety Information and Knowledge

Phase 1
Spring 2015

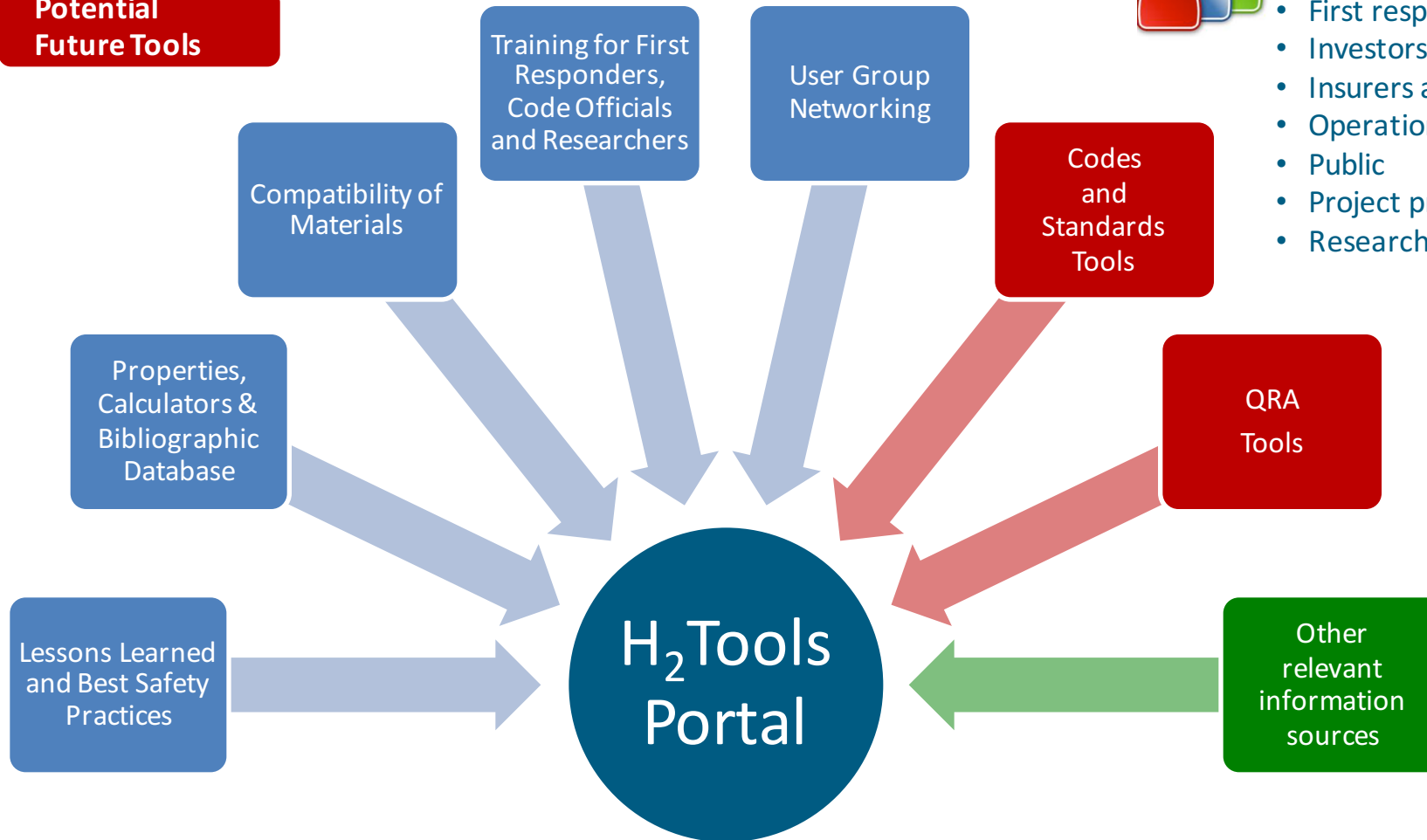
Share your
tools!



User Groups

- AHJ/code officials
- First responders
- Investors
- Insurers and risk managers
- Operations and maintenance
- Public
- Project proponents
- Research and development

Potential
Future Tools



H2tools.org/bestpractices

...Sharing Experience, Applying Best Practices

- Introduction to Hydrogen
 - So you want to know something about hydrogen?
- Hydrogen Properties
 - Hydrogen compared with other fuels
- Safety Practices
 - Safety culture
 - Safety planning
 - Incident procedures
 - Communications
- Design and Operations
 - Facility design considerations
 - Storage and piping
 - Operating procedures
 - Equipment maintenance
 - Laboratory safety
 - Indoor refueling of forklifts

<http://h2tools.org/bestpractices>

HYDROGEN TOOLS
Focusing On Safety Knowledge

Home » Best Practices » Facility Design » Properties Impact Design

Impact of Hydrogen Properties on Facility Design

View Edit Track

An understanding of the properties of hydrogen is critical for the proper design of a facility or workspace. A workspace can be configured to mitigate hazards by understanding and taking advantage of some of the characteristics of hydrogen.

Designers and operators of hydrogen storage facilities must be aware that hydrogen's flammability range is very wide compared to other fuels. Additionally, under optimal combustion conditions (at a 29% hydrogen-to-air volume ratio), the energy required to initiate hydrogen combustion is much lower than that required for other common fuels (e.g., a small spark).

| Property | Hydrogen H ₂ | Methane CH ₄ | Gasoline |
|---|----------------------------|----------------------------|------------|
| Normal boiling point ¹ (NBP) [°C] | -253 | -162 | 37 - 205 |
| Physical state at 25°C, 1 atm | Gas | Gas | Liquid |
| Heating Values ² LHV (kJ/g) HHV (kJ/g) | 120 142 | 50 55.5 | 44.5 48 |
| Flammability limits (vol% in air) | 4.0-75 | 5.3-15 | 1.0-7.6 |
| Molecular weight | 2.02 | 16.0 | ~107 |
| Flame temperature in air ³ [°C] | 2045 | 1875 | 2200 |
| Minimum ignition energy ⁴ (mJ) | 0.02 | 0.29 | 0.24 |
| Quenching distance [mm] | 0.64 | 2.0 | 2.0 |
| Density at NBP (g/L) | 70.8 | 423 | ~700 |
| Vapor specific gravity at 25°C, 1atm (air=1) | 0.070 | 0.54 | 3.7 |

¹The boiling point at 1atm pressure
²Heating values are the energy, per gram of fuel, generated by a combustion reaction. The higher heating value (HHV) is obtained when all of the water formed by combustion is liquid. The lower heating value (LHV) is obtained when all of the water formed by combustion is vapor.
³Experimentally determined flame temperatures are shown in the table. These values do not differ significantly from theoretical adiabatic flame temperatures. See Ref. [3] for discussion.
⁴In air at 1 atm pressure

For any incident involving hydrogen, keep in mind the properties of hydrogen and watch for potential ignition sources that can ignite a hydrogen leak:

- electrical (e.g., static electricity, electric charge from operating equipment)
- mechanical (e.g., impact, friction, metal fracture)
- thermal (e.g., open flame, high-velocity jet heating, hot surfaces, vehicle exhaust)

There should be no grass or shrubs planted near areas where hydrogen potentially may be released to prevent the need for using powered garden tools in the area. According to NFPA 55, both compressed gaseous hydrogen storage vessels and liquid hydrogen storage vessels must be located at least 50 feet from combustible materials.

Mixtures near optimal combustion conditions should be considered prone to spontaneous ignition.

References

Supporting References:
Basic Hydrogen Properties
CGA G-5, Hydrogen
CGA H-4 Terminology Associated with Hydrogen Fuel Technologies
B. Lewis and G. von Elbe, Combustion, Flames and Explosions of Gases, 3rd ed., Academic Press, Orlando, 1987, pg. 717.
Hydrogen Data Book
Babrauskas, Vytenis, "Ignition Handbook" Fire Science Publishers, Issaquah, WA.
J. Hord, Is Hydrogen Safe? National Bureau of Standards (NBS) Technical Note 690, October 1976.
F.J. Edeskuty and W.F. Stewart, Safety in the Handling of Cryogenic Fluids, Plenum Press, New York, 1996, pg. 100.
Glossary | Acronyms | Bibliography | Codes & Standards | Safety Snapshot
NFPA 2, Hydrogen Technologies Code, 2011 Edition

Safety events from "H2incidents.org" illustrate what can go wrong if best practices are not followed.

H2tools.org/lessons

...Capturing the Event, Focusing on Lessons Learned

Each safety event record contains

- Description
- Severity (Was hydrogen released? Was there ignition?)
- Setting
- Equipment
- Characteristics (High pressure? Low temperature?)
- Damage and Injuries
- Probable Cause(s)
- Contributing Factors
- Lessons Learned/Suggestions for Avoidance/Mitigation Steps Taken

<http://h2tools.org/lessons>

Hydrogen Tube Trailer Overturns in Field

Severity: **Incident** Leak: **Yes** Ignition: **Uncertain**

2004

A hydrogen leak occurred when hydrogen tube trailer traveling on a rural roadway left the road, overturned on its side, and resulted in a single hydrogen tube valve being opened or broken. The cause of the accident is unknown. However, it appears to be unrelated to hydrogen (i.e., it is likely that human driving errors caused the accident). The hydrogen tubes contained compressed hydrogen gas at 200 bar (2900 psi). The back end of the tube trailer containing the high pressure hydrogen plumbing and valves contacted the ground and resulted in the valve opening or breaking and losing all the hydrogen from one tube. The tube valve that leaked was located on the bottom tier in the center position. The first firefighter crew to arrive at the accident scene verified that the leakage was limited to one tube valve and that there was no overheating conditions as verified by a thermal imaging device. The second firefighter crew (HAZMAT team) which was sent to recover the hydrogen remaining on the overturned tube trailer, determined that hydrogen recovery at the accident scene was not safe. The hydrogen tube trailer was lifted using lifting straps slung around the trailer near the hydrogen tube anchorage points, since the trailer did not have any fixed lifting points. After the tube trailer was righted, it was transported to the hydrogen supplier, where the hydrogen was removed and reclaimed. No injuries occurred related to the hydrogen leak.

Setting: Hydrogen Delivery Vehicle/Tube Trailer

Equipment: Vehicle & Fueling Systems > Gaseous Hydrogen Delivery Vehicle

Damage and Injuries: Property Damage

Probable Cause: Vehicle Collision

Contributing Factors: Operation Induced Damage

Characteristics: High Pressure (1-100 bar)

When Incident Discovered: During Operations

Lessons Learned:

1. Increased structural protection is needed at the back (manifolds, piping) in case of an accident. Side protection is also needed.
2. A system of designated lifting features is needed on hydrogen cylinders and located at protected points, gravity is more hazardous and less safe.

Supporting Documents:
Figure 1 - Damage to Hydrogen Cylinder Valves from Accident
Figure 2 - Hydrogen Tube Trailer Accident Recovery.jpg

Post date: Monday, April 13, 2009 - 12:23



Tube Trailer Rollover

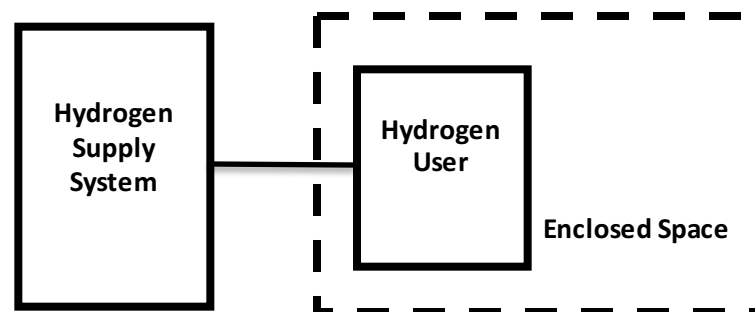
Hydrogen Safety Checklist

...Outdoor Storage, Indoor Dispensing and Use

Hydrogen safety, much like all flammable gas safety, relies on 5 key considerations:

1. Recognize hazards and define mitigation measures **[PLAN]**
2. Ensure system integrity **[KEEP H2 IN THE SYSTEM]**
3. Provide proper ventilation to prevent accumulation **[MANAGE DISCHARGES]**
4. Ensure that leaks are detected and isolated **[DETECT AND MITIGATE]**
5. Train personnel and ensure that hazards and mitigations are understood and that established work instructions are followed **[MANAGE OPERATIONS]**

<http://h2tools.org/hsp/safety-resources>



Hydrogen Safety Considerations Checklist

| | Approach | Examples of Actions |
|--|--|--|
| Plan the Work | Recognize hazards and define mitigation measures | <input type="checkbox"/> Identify risks such as flammability, toxicity, asphyxiates, reactive materials, etc. <input type="checkbox"/> Identify potential hazards from adjacent facilities and nearby activities <input type="checkbox"/> Address common failures of components such as fitting leaks, valve failure positions (open, closed, or lost), valves leakage (through seat or external), instrumentation drifts or failures, control hardware and software failures, and power outages. <input type="checkbox"/> Consider uncommon failures such as a check valve that does not check, relief valve stuck open, block valve stuck open or closed, and piping or equipment rupture. <input type="checkbox"/> Consider excess flow valves/chokes to size of hydrogen leaks <input type="checkbox"/> Define countermeasures to protect people and property. <input type="checkbox"/> Follow applicable codes and standards. |
| | Isolate hazards | <input type="checkbox"/> Store hydrogen outdoors as the preferred approach; store only small quantities indoors in well ventilated areas. <input type="checkbox"/> Provide horizontal separation to prevent spreading hazards to/from other systems (especially safety systems that may be disabled), structures, and combustible materials. <input type="checkbox"/> Avoid hazards caused by overhead trees, piping, power and control wiring, etc. |
| | Provide adequate access and lighting | Provide adequate access for activities including: <ul style="list-style-type: none"> <input type="checkbox"/> Operation, including deliveries <input type="checkbox"/> Maintenance <input type="checkbox"/> Emergency exit and response |
| Keep the Hydrogen in the System | Approach | Examples of Actions |
| | Design systems to withstand worst-case conditions | <input type="checkbox"/> Determine maximum credible pressure considering abnormal operation, mistakes made by operators, etc., then design the system to contain or relieve the pressure. <input type="checkbox"/> Contain: Design or select equipment, piping and instrumentation that are capable of maximum credible pressure using materials compatible with hydrogen service. <input type="checkbox"/> Relieve: Provide relief devices that safely vent the hydrogen to prevent damaging overpressure conditions. <input type="checkbox"/> Perform system pressure tests to verify integrity after initial construction, after maintenance, after bottle replacements, and before deliveries through transfer connections. |
| | Protect systems | <input type="checkbox"/> Design systems to safely contain maximum expected pressure or provide pressure relief devices to protect against burst. <input type="checkbox"/> Mount vessels and bottled gas cylinders securely. <input type="checkbox"/> Consider that systems must operate and be maintained in severe weather and may experience earthquakes and flood water exposures. <input type="checkbox"/> De-mobilize vehicles and carts before delivery transfers or operation. <input type="checkbox"/> Protect against vehicle or accidental impact and vandalism. <input type="checkbox"/> Post warning signs. |
| Size the storage appropriately for the service | <input type="checkbox"/> Avoid excess number of deliveries/change-outs if too small. <input type="checkbox"/> Avoid unnecessary risk of a large release from an oversized system. | |

Introduction to Hydrogen for Code Officials

Provides an overview of hydrogen and fuel cell technologies, discusses how these technologies are used in real-world applications and discusses the codes and standards required for permitting them.

- Hydrogen and fuel cell basics
- Hydrogen and fuel cell applications
- Hydrogen fueling stations
- Fuel cell facilities

Developed and maintained by:



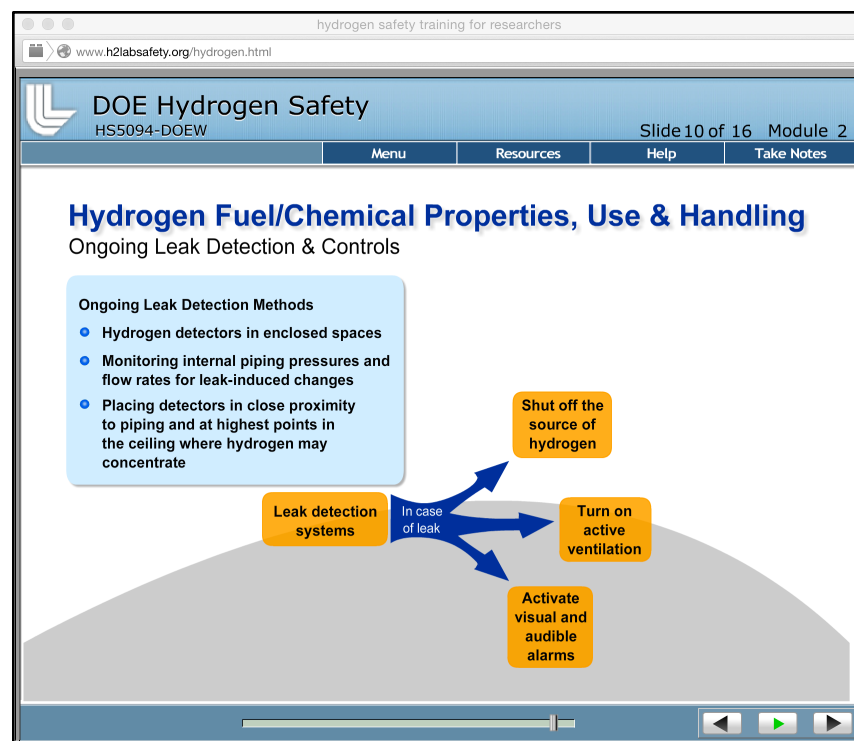
A screenshot of a web-based course page titled "Introduction to Hydrogen for Code Officials". The page has a header with the U.S. Department of Energy Hydrogen Program logo and the URL www.hydrogen.energy.gov. Below the header are navigation tabs for "COURSE MATERIALS", "LIBRARY", and "EXIT". A sub-header contains four checkboxes: "Hydrogen & Fuel Cell Basics", "Hydrogen & Fuel Cell Applications", "Hydrogen Fueling Stations", and "Fuel Cell Facilities". The main content area includes a paragraph about safety analysis for hydrogen fueling stations, a list of safety planning tools (FMEA, What-if analysis, HAZOP, Checklist analysis, Fault tree analysis, Event tree analysis, PRA), and a flowchart showing the stages: Project Considerations, Construction Approval, and Operation Approval. A sidebar on the right provides links to related codes and standards, including "Operation Approvals for Fire Safety and Emergency Planning" and "Safety Planning Guidance for Hydrogen Projects document (PDF 157 KB)". A "Download Adobe Reader" link is at the bottom of the sidebar. The footer of the page shows "Slide 2 of 27" and navigation arrows.

<http://h2tools.org/content/training-materials>

Hydrogen Safety Training for Researchers

- **Objectives:** Provide basic hydrogen safety training through an interactive online course
- Laboratory researchers and technical personnel handling hydrogen need basic information on pressure, cryogenics, flammability, asphyxiation, and other risks and precautions for using hydrogen.
- **Six Modules** are included in the course, with a quiz at the end of each module.
 - Course introduction and overview
 - Basic handling precautions for hydrogen
 - Safety issues related to pressure systems
 - Safety issues related to cryogenic systems
 - Overview of emergency response considerations for hydrogen incidents
 - High-Level overview of the codes and standards that apply to hydrogen applications

*Developed and
maintained by:*



Sample Screenshot

Class is available at <https://h2tools.org/content/training-materials>

First Responder Hydrogen Safety Training

► National Goal

- Support the successful implementation of hydrogen and fuel cell technologies by providing technically accurate hydrogen safety and emergency response information to first responders

► Integrated Activities

- Online, awareness-level training
(<http://hydrogen.pnl.gov/FirstResponders/>)
- Classroom and hands-on operations-level training
- National training resource (enabling trainers)
(<http://h2tools.org/fr/nt>)



A properly trained first responder community is critical to the successful introduction of hydrogen fuel cell applications and their transformation in how we use energy.

What Others Are Saying About These Safety Resources

Feedback from the 2015 DOE Annual Merit Review

- ▶ “Safety is paramount - its the first question we get asked in California when we go into local communities. If anything, **we need to figure out how to expand the Safety Panel's reach**. The reviews from the Panel have already shown benefit to the state - its a crucial, trusted 3rd party resource.”
- ▶ “HSP – excellent – still **need to get this talent used more broadly**”
- ▶ “**Component listing is** critical as well - the plan to level the playing field by showing AHJs and Station Developers how they can establish comfort that station systems will perform is **incredibly timely and important. It's a big, unanswered question** in California.”
- ▶ “Listed equipment – **Development of a guide** to assist AHJ’s to “approve” installations which are not “listed” **will be a great asset in the early stages of development** until the community gets hardware listed.”
- ▶ “The new H2tools website is an example of successful communication effort, is well structured and of utility for users with different goals and level of competences.”

Thank You for Your Attention!

The authors also 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), and the California Fuel Cell Partnership for their support of this work.

For Additional Information...

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OR VISIT:

<http://h2tools.org>

for more Hydrogen Safety related news and the latest resources

