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Hydrogen Safety Knowledge Tools

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Overview

Timeline

- Project start: March 2003
- Continuing

Budget

- FY09 Funding: $300K for both **Best Practices** and **Incident Reporting**
- FY10 Funding: $200K for both **Best Practices** and **Incident Reporting**

Barriers

- Limited Historical Database
- Proprietary Data

Partners

- **Best Practices** – Hydrogen Safety Panel, NASA, and SNL
- **Incident Reporting** – Hydrogen Safety Panel, NASA, and IEA Hydrogen Implementing Agreement Task 19 (Hydrogen Safety)

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Relevance --- Objectives

H2 Safety Best Practices (H2BestPractices.org)

Capture vast knowledge base of hydrogen experience and make it publicly available. DOE Hydrogen Program MYPP says, “This living document provides guidance for ensuring safety in DOE hydrogen projects, while serving as a model for all hydrogen projects and applications.”

H2 Incident Reporting and Lessons Learned (H2Incidents.org)

Collect information and share lessons learned from hydrogen incidents and near-misses, with a goal of preventing similar incidents from occurring in the future.

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Relevance --- Goals

- H2 Safety Best Practices
  - **Update Hydrogen Safety Best Practices Online Manual (9/30/10)**
    - Improve existing content
    - Add new content
- H2 Incident Reporting and Lessons Learned
  - **Achieve Target of 200 Records in Database (9/30/10)**
    - Currently 170 records
    - 15 more in progress
  - **Analyze Lessons Learned from Incidents (3/31/10)**
    - Created new quarterly feature on website called “Lessons Learned Corner “
    - Published first installment in March 2010

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Approach
H2 Safety Best Practices

Best practice = a technique or methodology that utilizes available knowledge and technology to achieve success

- Best practices are compiled from learnings and observations from Hydrogen Safety Panel site visits, safety plan reviews and other work, and available reference materials tailored specifically to working with hydrogen.
- Proposed new content is discussed at Panel meetings.
- PNNL staff create draft strawman materials.
- Panel members and PNNL subject matter experts review the drafts and provide comments.
- PNNL staff revise drafts based on reviewers' comments and then publish materials on website.
- Respond quickly to user questions posted on website.

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H_2 Safety Best Practices

Welcome!

H_2BestPractices Home

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 methodology that has reliably led to a desired result. Using best practices is a commitment to utilizing available knowledge and technology to achieve success.

What is H_2BestPractices.org?

A wealth of knowledge and experience related to safe use and handling of hydrogen exists as a result of an extensive history in a wide variety of industrial and aerospace settings. Hydrogen is gaining increasing attention worldwide as a possible energy storage medium, for later conversion to electricity through fuel cells or for use as a combustion fuel. This focus has introduced many new participants to research, development, demonstration, and deployment of hydrogen technologies (e.g., fuel cell vehicles and stationary fuel cells).

The purpose of the Hydrogen Safety Best Practices online manual is to share the benefits of extensive experience by providing suggestions and recommendations pertaining to the safe handling and use of hydrogen. Best Practices have been compiled from a variety of resources, many of which are in the public domain and can be downloaded directly from the References section. Many others can be obtained via reference links found at various places within the manual.

Best Practices are organized under a number of hierarchical categories in this online manual, beginning with those displayed down the left-hand column. Because of the interdependence of the topical areas, however, individual pages are often accessible via multiple internal links. A web-based electronic document format lends itself well to this type of overlapping content.

Website features

Please notice the mouse-over feature on this website. When a word in the text appears in blue font, you can see its definition by placing your cursor over the word. All the definitions are compiled into a Glossary that can be accessed from the References section of every page. There is also an Acronyms list and a Bibliography that can be accessed from every page. When you click on the link to the Bibliography, it will take you to the alphabetized list of references for the particular section from which you accessed it. Please contact us if you notice any definitions, acronyms, or references that should be in these lists but aren't.

A word about safety

No information resource can provide 100% assurance of safety. Personnel with applicable expertise should always be consulted in designing and implementing any system carrying a potential safety risk.

This online manual is directly linked to a companion website, H2Incidents.org, to provide unambiguous illustration of the importance of following safe practices and procedures when working with and around hydrogen. Like virtually all energy forms, hydrogen can be used safely when proper procedures and engineering techniques are followed, but its use still involves a degree of risk that must be respected. The importance of avoiding complacency and/or haste in the safe conduct and performance of projects involving hydrogen cannot be overstated.

Search H_2BestPractices

Enter a search term below.

Search H2BestPractices

References

- Glossary
- Acronyms
- Bibliography
- Codes & Standards

Related Sites

- H_2Incidents Database
- NHA Hydrogen and Fuel Cell Safety
- DOE Hydrogen Program
  - Hydrogen Safety Bibliographic Database

Contact Us

h2bestpractices@pnl.gov

Last Updated: February 12, 2010

A collaboration of the Pacific Northwest National Laboratory and Los Alamos National Laboratory with funding from the U.S. Department of Energy.

Technical Accomplishments
H2 Safety Best Practices

- Enhanced best practices for outdoor storage of hydrogen cylinders (under Laboratory Safety/Laboratory Design)
- Made "Management of Change" more visible and added links to it from three places on the site
- Added more information on "Hydrogen Properties" (hydrogen combustion and liquid hydrogen expansion) with help from NASA
- Updated "Hydride Storage and Handling" to cover risks related to large-scale experiments with help from SNL
- Added about 50 links to safety event records in Hydrogen Incident Reporting and Lessons Learned database

Safety Culture
- Institutional Commitment
- Training
- Formalized Procedures
  - Management of Change
- Worker Participation
- Lessons Learned

MOC = the process used to review all proposed changes to equipment, procedures, materials, personnel, and process operations before they are Implemented to determine their effects on safety vulnerabilities

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Proposed Future Work
H2 Safety Best Practices

- Add new content
  - A section for technicians and young engineers with no hydrogen experience that is practical and concise, formatted as simple bulleted “DO’s” and “DON’Ts”, and contains lots of photos and graphics
  - Indoor refueling of hydrogen forklifts
  - Brainstorm with the Panel to identify additional content areas (possibly working safely with chemical hydrides [analogous to existing section on metal hydrides] or nanomaterials)
- Enhance website utility.
  - Continue to link content to safety event records in H2Incidents.org.
  - Add more photos, graphics, and videos.
- Encourage use and respond quickly to user questions posted on the website.

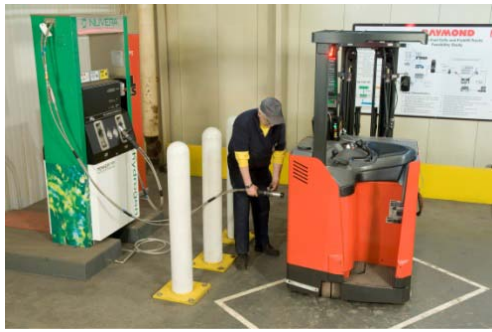

Photo: Nuvera

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Collaborations
H2 Safety Best Practices
Since 2009 AMR

- Hydrogen Safety Panel
  - Addison Bain
  - Dave Farese
  - Don Frikken
  - Glenn Scheffler
- NASA White Sands Test Facility
  - Steve Woods
  - Miguel Maes
- SNL
  - Dan Dedrick

Thanks to my PNNL colleagues: Nick Barilo, Kathleen Quick, and Steve Weiner

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Approach
H2 Incident Reporting and Lessons Learned

Purpose: Facilitate sharing of lessons learned from hydrogen incidents to help avoid similar future incidents, without attribution to organization, location, or date of occurrence

- Success requires that people use the database and not fear negative consequences from reporting incidents. We encourage all DOE projects to submit incidents and near-misses with lessons learned.
- Pursue addition of new records by actively seeking news reports for hydrogen incidents and searching existing databases for hydrogen events.
- Contact private-sector companies who experience hydrogen incidents and near-misses to solicit permission to publish records.
- Establish and maintain a mechanism for online submissions of records.
- Add links to H2BestPractices.org to emphasize safe practices for working with hydrogen.
- Provide expert review of all incidents and lessons learned by Hydrogen Safety Panel and PNNL subject matter experts.

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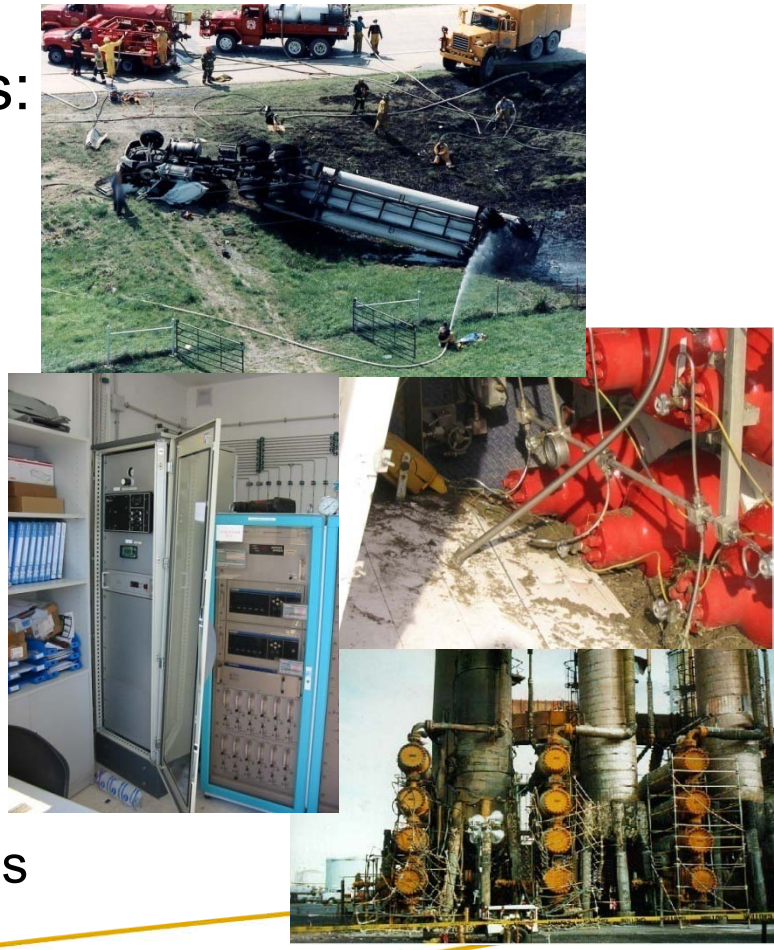
Approach
H2 Incident Reporting and Lessons Learned

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
- Contributing Factors
- Lessons Learned and Mitigation Steps
- *And some records include photos*



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H_2 Incident Reporting and Lessons Learned

About H_2Incidents | Advanced Search

Navigation

Welcome!

Clear | Find Records >>

Settings

- [ ] Laboratory (61)
- [ ] Commercial Facility (19)
- [ ] Fueling Station (18)
- [ ] Hydrogen Delivery Vehicle/Tube Trailer (14)

Show All Options

Equipment

- [ ] Piping/Fittings/Valves (79)
- [ ] Hydrogen Storage Equipment (34)
- [ ] Vehicle & Fueling Systems (31)
- [ ] Safety Systems (24)

Show All Options

Damage and Injuries

- [ ] Property Damage (81)
- [ ] None (74)
- [ ] Minor Injury (21)
- [ ] Lost Time Injury (12)

Show All Options

Probable Causes

- [ ] Equipment Failure (75)
- [ ] Human Error (22)
- [ ] Design Flaw (20)
- [ ] Failure to Follow Standard Operating Procedures (19)

Show All Options

Contributing Factors

- [ ] Human Error (46)
- [ ] Situational Awareness (41)
- [ ] Equipment Failure (40)
- [ ] Change in Procedures, Equipment, or Materials (33)

Show All Options

Clear | Find Records >>

What is H_2Incidents?

H_2Incidents is a database-driven website intended to facilitate the sharing of lessons learned and other relevant information gained from actual experiences using and working with hydrogen. The database also serves as a voluntary reporting tool for capturing records of events involving either hydrogen or hydrogen-related technologies.

The focus of the database is on characterization of hydrogen-related incidents and near-misses, and ensuing lessons learned from those events. All identifying information, including names of companies or organizations, locations, and the like, is removed to ensure confidentiality and to encourage the unconstrained future reporting of events as they occur.

More About H_2Incidents...

Submit an Incident

Latest Reports

Tube Trailer Leak through Over-Pressure-Protection Rupture Disk

Hydrogen Gas Leak from Compressed Gas Cylinder

TOTAL EVENTS REPORTED: 170 (SHOW ALL)

New! Lessons Learned Corner

Management of Change

LESSONS LEARNED ARCHIVES

How does H_2Incidents work?

You can access incident reports on H_2Incidents in a number of different ways. Here on the home page, you can go directly to the latest posted incidents using the navigation in the box to the right labeled "Latest Reports." The bottom of this box also contains a total for the number of incident reports in the system. By clicking the "show all" text next to this number, you can view a complete, alphabetical list of incidents.

To look for incidents related to specific details, you can use the left navigation. The five main headings—Contributing Factors, Damage and Injuries, Equipment, Probable Causes, Settings—will help you drill through the collection of incidents to find those that interest you. At any time, you can also use the Search box along the top of the page, or use the Advanced Search form for some more options as you search the database.

If you have an incident you would like to include in the H_2Incidents database, please visit the Submit an Incident page. This page will ask for a wide range of information on your incident. Please enter as much of the information as possible. In order to protect your and your employer's identities, information that may distinguish an incident (your contact information, your company's name, the location of the incident, etc.) will not be displayed in the incident reports on H_2Incidents.

Technical Accomplishments
H2 Incident Reporting and Lessons Learned

- Added 35 new incident records since 2009 AMR from DOE projects, private-sector firms, and members of IEA HIA Task 19
- Currently 170 records in database, with 15 more in progress
- Collaborated with DOE projects, private-sector firms, and contributing organizations in other countries to prepare and submit records of incidents and near-misses with lessons learned
- Obtained incident alerts from DOE, NHA, and Google Alerts for hydrogen and fuel cell vehicles
- Identified additional incident databases to potentially draw from (e.g., National Response Center)
- Created new “Lessons Learned Corner” to analyze hydrogen safety themes illustrated by database content

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Technical Accomplishments
H2 Incident Reporting and Lessons Learned

- Approach to last 35 incidents has been more rigorous and detailed --- much more time spent interacting with incident “owners” to extract maximum value in lessons learned from their perspectives
- Setting: laboratory (8), fueling station (7), hydrogen storage/use facility (5), power plant (3), refinery (3), tube trailer (3), other…
- Probable cause: equipment failure (11), human error (6), failure to follow SOPs (5), deficiency in procedures (4), design flaw (4), inadequate venting design (4), incomplete O&M procedures (4), inadequate equipment (3), inadequate maintenance (3), material incompatibility (3)
- Lessons learned are quite detailed for most of the 35 incidents.
- 15 of them have photos or more detailed descriptions attached.

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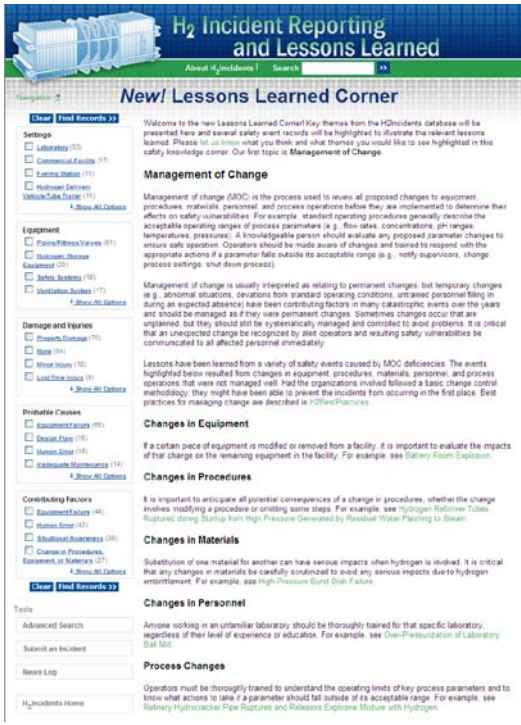
Technical Accomplishments
H2 Incident Reporting and Lessons Learned

- New "Lessons Learned Corner" created
  - Publish quarterly
  - Share content on hydrogen safety themes
  - Illustrate with safety event records
  - First theme = "Management of Change"
- Search features streamlined and clarified
  - Removed "Google Search" function from top of page
  - Clarified "Advanced Search" function
- Homepage layout made more user-friendly
  - Reduced number of incidents in Latest Reports box
  - Added blue "Submit an Incident" button at top of page to provide easier access to H2Incidents Submission Form



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Proposed Future Work
H2 Incident Reporting and Lessons Learned

- Increase number of records and lessons learned in database.
- Identify additional sources of hydrogen safety event information (e.g., other databases).
- Add links from incident records to best practices that should have been used to avoid incidents.
- Investigate options for graphics software to enhance display of database contents.
- Continue to encourage both DOE projects and private-sector organizations to voluntarily submit records of incidents and near-misses to the website.

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Collaborations
H2 Incident Reporting and Lessons Learned

Since 2009 AMR

- Organizations that "own" the incidents and near-misses added to the database
- Hydrogen Safety Panel
  - Dave Farese
  - Richard Kallman
- NASA White Sands Test Facility
  - Steve Woods
- IEA Hydrogen Implementing Agreement Task 19 (Hydrogen Safety)
  - Canada, France, Germany, Italy, Japan, the Netherlands, Switzerland, and the United Kingdom

Thanks to my PNNL colleagues: Eric Berglin, Kathleen Quick, and Steve Weiner

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Summary

- **H2 Safety Best Practices**
  - New content is being added and existing content is being improved.
  - Best practices are being linked to hydrogen incidents that illustrate the hazards of not working safely with hydrogen.

- **H2 Incident Reporting and Lessons Learned**
  - Database currently contains 170 records.
  - New Lessons Learned Corner added to analyze lessons from incidents that illustrate key hydrogen safety themes.
  - Lessons learned are being linked to best practices that would have helped avoid the incidents from occurring in the first place.

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