Using Hydrogen Safety Best Practices and Learning from Safety Events

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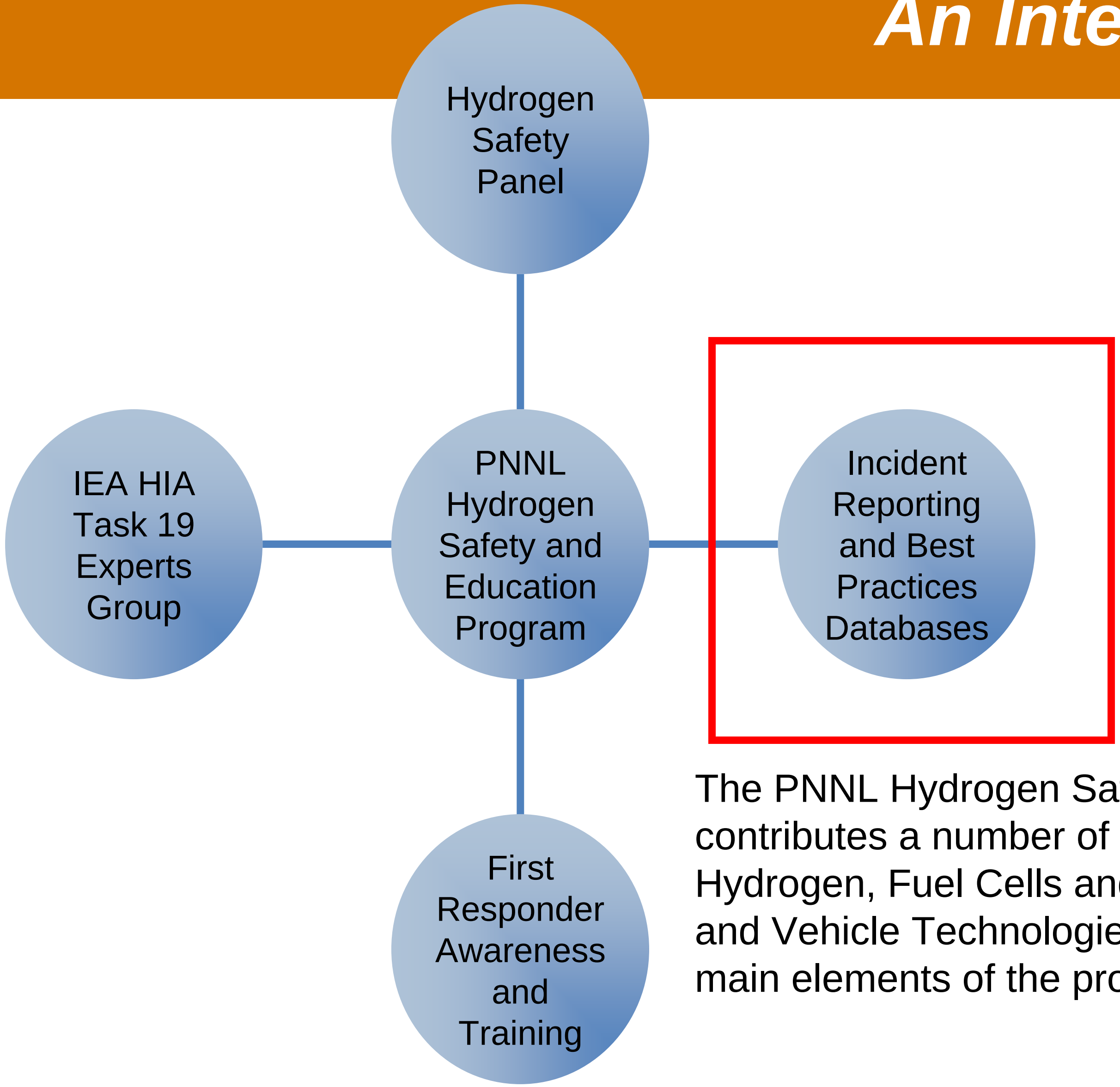
International Conference on Hydrogen Safety

"A best practice can be defined as the means used to accomplish a task or perform some action that is based upon knowledge learned and experience gained, e.g., lessons learned from safety events…

In the end, the database underscores the importance of establishing, conducting and maintaining safe practices while providing a mechanism for sharing safety knowledge and learning from the experience of others."

"Incident Reporting: Learning from Experience"
San Sebastian 2007

PNNL Hydrogen Safety and Education Program
An Integrated Approach



The PNNL Hydrogen Safety and Education Program contributes a number of important activities to the Hydrogen, Fuel Cells and Infrastructure Technologies, and Vehicle Technologies Program Offices. The current main elements of the program are shown here.

H_2 Safety Best Practices

H2BestPractices.org

Welcome!

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.

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

Search H_2BestPractices

Enter a search term below.

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

Hydrogen Safety Best Practices

"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."

- The challenge is to apply this broad definition to hydrogen-specific practices in an easy-to-use format that capitalizes on (without duplicating) a wealth of knowledge and experience.

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Principles for Development and Design

- Make knowledge base available to those working with hydrogen and related systems including those just starting to work with hydrogen.
- Utilize experience and learnings from the Hydrogen Safety Panel work and other practices.
- Ensure that at each point of updating/adding technical content, the tool is useable and useful.
- Collaborate with other national laboratories (LANL, SNL and NREL), other government agencies (NASA) and IEA HIA Tasks 19 and 22.

Content
Safety Practices

- Safety Practices
  - Safety culture

    Characteristics and attitudes in organizations and individuals that establishes, as an overriding priority, that safety issues receive the attention warranted by their significance

  - **Safety planning**

    Identify hazards, evaluate risks by considering likelihoods and consequences, and mitigate those risks **(*****See "Safety Planning Guidance for Hydrogen Projects"*****)**

  - Incident procedures

    Ensure the safety of personnel and the public and protect equipment

  - Communications

    Documentation and bulletins, labeling, warning placards, workplace safety and emergency response

Content
Design and Operations

- Design and Operations
  - Facility design considerations

    Ventilation, electrical classification, piping layout and design, safety interlock systems
  - Storage and piping systems

    Compressed gas and cryogenic liquid: storage vessels, piping systems, fittings and joints, valves
  - Operating procedures

    Operation of a system or conduct of an experiment: steps, operating limits, authorizations, PPE, safety systems

Content
Design and Operations (continued)

- Design and Operations (continued)
  - **Equipment maintenance and integrity**

    Inspection, testing and other maintenance; management of change (MOC)
  - Laboratory safety

    Laboratory design and operations

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Learning from Safety Events
Applying Best Practices

- H2BestPractices.org content provides 128 links to relevant safety event records for which the following are examples:
  - Installation and commissioning of compressed gas systems
    - http://h2bestpractices.org/lab_safety/lab_operation/general_ops.asp
    - http://h2incidents.org/incident.asp?inc=49
  - Invisible hydrogen fires
    - http://h2bestpractices.org/lab_safety/lab_operation/detect_flame.asp
    - http://h2incidents.org/incident.asp?inc=149
  - Hydride storage and handling
    - http://h2bestpractices.org/lab_safety/lab_operation/hydride.asp
    - http://h2incidents.org/incident.asp?inc=25

Installation and Commissioning of Compressed Gas Systems

- The safety event

  A primary valve was opened on a laboratory's 1500-psi hydrogen gas line. Failure occurred at a fitting on the switching manifold, releasing a small amount of hydrogen gas.

- The learning

  Formal management review and revision of procedures help clarify the roles and responsibilities for compressed gas systems, further assuring users that the proper reviews and testing have been completed. Lessons learned also emphasize the importance of visual inspection, in this case, to ensure that ferrules are in place and correctly positioned.

Invisible Hydrogen Fires

- The safety event

  A technician was welding a cable suspended over a stainless steel hydrogen instrument line. During the welding process, two holes were accidentally burned through the hydrogen tubing. The operator heard a hissing sound and closed the valve, but the hydrogen had already ignited and it burned his hand while he was feeling for a leak.

- The learning

  If a known leak is present, ignition should always be presumed. An alternative to performing hot work or relocating the hot work should have been considered. If such work was necessary, it should have been performed only after the gas supply was verified closed (along with a lock and tag). Also, if this latter option was chosen, then the system should be checked for leaks prior to turning the gas back on.

Hydride Storage and Handling

- The safety event

  A researcher was working with a sample of less than one gram of aluminum deuteride synthesized from lithium aluminum deuteride and aluminum chloride in diethyl ether. The sample-containing ampoule had previously been placed under vacuum and had been isolated from the atmosphere. To seal for shipment, the ampoule is slowly rotated under heat provided by a torch. However, in this instance, a bubble formed at the point where the heat was applied and a hole formed in the ampoule, providing a route for air to enter the ampoule. Within approximately 30 seconds, the ampoule "exploded" and the researcher suffered cuts from the glass shards that sprayed outward.

Hydride Storage and Handling (continued)

- The learnings
  - Metal hydride materials of a composition that is not well characterized should be handled with procedures that assume a "worst case" for that class of materials, intermediates or precursors.
  - Laboratory procedures should be in written form and should be adopted only after performing a safety vulnerability analysis and adopting appropriate risk mitigation steps. In this case, the method used to seal samples that are highly reactive upon exposure to air is not recommended.
  - Working with small amounts of material does not necessarily provide assurance of safety.

Another Safety Knowledge Tool
H2 Safety *SNAPSHOT*

- A one-page topical safety bulletin e-published in April 2009
- The approach
  - Hydrogen Safety Panel task group selects topics
  - Utilize guest expert authors
  - Use "snapshot@pnl.gov" to solicit comments and suggestions

http://hydrogen.energy.gov/safety.html

H_2 SAFETY *Snapshot*

Vol. 1, Issue 1, Apr. 2009

H_2 Safety Snapshot is a quarterly bulletin that highlights safety as an important element when working with hydrogen and hydrogen systems. This inaugural issue discusses several safety tools related to the safe use and handling of hydrogen. We envision that H_2 Safety Snapshot will promote our continued success in the safe operation of DOE hydrogen projects.

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Link Up with Hydrogen

Sharing Best Practices
www.h2bestpractices.org

Reporting Lessons Learned
www.h2incidents.org

Hydrogen Safety Bibliographic Database
www.hydrogen.energy.gov/biblio_database.html

DOE Program
www.hydrogen.energy.gov

CAPTURING a Wealth of Knowledge

Sharing Best Practices – an online manual and website that share the extensive experience of the safe handling and use of hydrogen in a wide variety of applications. 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, which contains a bibliography, glossary, and acronyms. Best practices are organized in hierarchical categories, including multiple topics under Safety Practices, Design, and Operations. New content has been recently added to cover key topics with regard to laboratory safety. A search capability is provided along with links to related websites of interest.

Visit www.h2bestpractices.org or contact us at h2bestpractices@pnl.gov.

LEARNING Lessons from Experience

Reporting Lessons Learned – a database-driven website intended to facilitate sharing lessons learned and other relevant information gained from actual experiences using and working with hydrogen. The database serves as a voluntary reporting tool for capturing records of events involving hydrogen or hydrogen-related technologies. The focus is on the characterization of hydrogen-related incidents and near-misses as well as ensuing lessons learned. All identifying information (names of organizations, workers, and locations) is removed for confidentiality and to encourage unconstrained reporting of events. Selected safety event records are linked to content in the companion Best Practices manual/website to illustrate the importance of safe practices. A search capability is provided along with an easy-to-use online submission form to enable sharing experiences with others.

Visit www.h2incidents.org or contact us at h2incidents@pnl.gov.

SEARCHING the Literature

The Hydrogen Safety Bibliographic Database – references to reports, articles, books, and other resources on hydrogen safety as it relates to hydrogen production, storage, distribution, and use. In addition to bibliographic references, the database provides select full-text documents or links to other websites that offer these documents.

Visit www.hydrogen.energy.gov/biblio_database.html or contact us at hydrogen_biblio_database@nrel.gov.

PNNL-SA-63909

Topic suggestions? Comments?
Contact us at snapshot@pnl.gov

A safety knowledge tool from U.S. Department of Energy | Pacific Northwest National Laboratory

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Concluding Thoughts

- Being conscious of the need to use safe practices is a necessary first step…
- Online safety knowledge tools can provide a mechanism for sharing, discussing and learning from the experience of others.
- It is hoped that international collaboration will be encouraged by such dialogue to enhance these and other safety knowledge tools.

Acknowledging…

- U.S. Department of Energy
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