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## Web-based resources enhance hydrogen safety knowledge

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### ARTICLE INFO

#### Article history:

Received 22 March 2012

Received in revised form

11 June 2012

Accepted 6 July 2012

Available online 2 August 2012

#### Keywords:

Hydrogen safety

Incidents

Best practices

Safety training

Codes and standards

### ABSTRACT

The U.S. Department of Energy's Fuel Cell Technologies Program addresses key technical challenges and institutional barriers facing the development and deployment of hydrogen and fuel cell technologies with the goal of decreasing dependence on oil, reducing carbon emissions and enabling reliable power generation. The Safety, Codes & Standards program area seeks to develop and implement the practices and procedures that will ensure safety in the operation, handling and use of hydrogen and hydrogen systems for all projects and utilize these practices and lessons learned to promote the safe use of hydrogen. Enabling the development of codes and standards for the safe use of hydrogen in energy applications and facilitating the development and harmonization of international codes and standards are integral to this work.

Web-based resources play a key role in reaching, educating and informing stakeholders whose contributions will help enable the deployment of new hydrogen and fuel cell technologies. This paper surveys eight web-based tools, each targeted to a specific stakeholder audience, that are integral resources for information on hydrogen-related safety, codes and standards work in the Fuel Cell Technologies Program.

- Hydrogen Incident Reporting and Lessons Learned (<http://h2incidents.org>)
- Hydrogen Safety Best Practices (<http://h2bestpractices.org>)
- Hydrogen Safety Bibliographic Database ([http://www.hydrogen.energy.gov/biblio\\_database.html](http://www.hydrogen.energy.gov/biblio_database.html))
- Introduction to Hydrogen Safety for First Responders (<http://www.hydrogen.energy.gov/firstresponders.html>)
- Introduction to Hydrogen for Code Officials ([http://www.hydrogen.energy.gov/training/code\\_official\\_training/](http://www.hydrogen.energy.gov/training/code_official_training/))
- Permitting Hydrogen Facilities (<http://www.hydrogen.energy.gov/permitting/>)
- Safety Training for Researchers (<http://www.h2labsafety.org/>)
- Technical Reference for Hydrogen Compatibility of Materials (<http://www.sandia.gov/matsTechRef/>)

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The development and use of each safety knowledge tool is described.  
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## 1. Introduction

The U.S. Department of Energy's (DOE) Fuel Cell Technologies Program addresses key technical challenges and institutional barriers facing the development and deployment of hydrogen and fuel cell technologies with the goal of decreasing dependence on oil, reducing carbon emissions and enabling reliable power generation. The Safety, Codes & Standards (SC&S) program area seeks to develop and implement the practices and procedures that will ensure safe operation, handling and use of hydrogen and hydrogen systems for all projects and utilize these practices and lessons learned to promote the safe use of hydrogen. Enabling the development of codes and standards for the safe use of hydrogen in energy applications and facilitating the development and harmonization of international codes and standards are integral to this work.

Web-based resources play a key role in reaching, educating and informing stakeholders whose contributions will help enable the deployment of new hydrogen and fuel cell technologies. This paper surveys eight web-based tools, each targeted to a specific stakeholder audience, that are integral resources for information on hydrogen-related safety, codes and standards work in the Fuel Cell Technologies Program. The development and use of each safety knowledge tool is described.

## 2. Hydrogen incident reporting and lessons learned

This database-driven website (<http://h2incidents.org>), first developed in 2006 [1], facilitates the sharing of lessons learned and other information gained from actual experiences using and working with hydrogen. The site is focused on characterizing hydrogen-related incidents and near-misses and the ensuing lessons learned. The site is also a voluntary reporting tool for capturing records of safety events involving either hydrogen or hydrogen-related technologies and currently contains 206 safety event records. All identifying information

(location, organization and so on) is removed to ensure confidentiality and to encourage unconstrained reporting of events.

Table 1 lists the information captured for each safety event in the database.

The website's Lessons Learned Corner (LLC) is a quarterly posting designed to share insights gleaned from the safety events in the database. The LLC is organized around specific themes and illustrated with actual safety events from the database [2]. Previous LLC postings, summarized in Table 2, are archived for user reference.

"H2Incidents.org" enables those who work with hydrogen to share lessons learned from safety events at their facilities, with the goal of preventing similar events in the future. The target audience is anyone who works with or around hydrogen, in all types of settings (e.g., laboratories, fueling stations, commercial facilities, electric power plants, hydrogen delivery vehicles) and also includes those involved in the development of hydrogen-related codes and standards. Users can browse a list of all incidents in the database and review specific incidents. Users can also submit incident records, knowing that their identities will be protected.

User inquiries suggest that the hydrogen community is being well-served by this resource. The Nuclear Regulatory Commission requested permission to use several records of power plant incidents in their safety training program. Similarly, an insurance company requested permission to reprint an incident for use in their customer intranet. A company in the oil and gas industry requested permission to use the database structure and interface to redesign their own lessons learned database.

### 2.1. International collaborations demonstrate value of lessons learned

In 2010, the Pacific Northwest National Laboratory (PNNL) collaborated with the member countries of the International Energy Agency (IEA) Hydrogen Implementing Agreement (HIA) Task 19 (Canada, France, Germany, Italy, Japan, the Netherlands, Norway, Switzerland, the U.K. and the U.S.). Each country submitted at least one safety event to H2Incidents.org to show their support for freely sharing lessons learned with colleagues around the world [3].

**Table 1 – Information parameters for each safety event record.**

- Description
- Severity (Was hydrogen released? Was there ignition?)
- Setting
- Equipment
- Characteristics (high-pressure compressed gas? cryogenic liquid?)
- Damage and injuries
- Probable cause(s)
- Contributing factors
- Lessons learned/suggestions for avoidance/mitigation steps taken

**Table 2 – Archived postings for the lessons learned corner.**

- Ventilation of facilities where hydrogen is used
- Hydrogen compatibility of materials
- Learning from burst disk failures
- Adequate ventilation of battery charging facilities
- Hydrogen use in anaerobic chambers
- The importance of purging hydrogen piping and equipment
- Working with reactive metal-hydride materials in the laboratory
- Management of change

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