What Can We Learn from Hydrogen Safety Event Databases?

Webinar Moderator:
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Safety, Codes and Standards

September 10, 2013
Overview
Fuel Cells – An Emerging Global Industry

- Clean Energy Patent Growth Index\(^1\) shows growth in all clean energy technology patents
- More than 1,000 fuel cell patents issued in 2012

Interest in fuel cells and hydrogen is global, with more than $1 billion in public investment in RD&D annually. The world’s leading automakers have committed to develop FCEVs.

**Major Auto Manufacturers’ Activities and Plans for FCEVs**

- **General Motors**
  - >120 vehicles deployed since 2007 in Project Driveway
  - 2012: Technology readiness goal for FC powertrain

- **Toyota**
  - 2010-2013: U.S. demo fleet of 100 vehicles
  - “FCHV-adv” can achieve 431-mile range & 68 mpgge
  - 2015: Commercialize cars at <$100K
  - Clarity FCX named “World Green Car of the Year”;
    EPA certified 72mpgge; leasing up to 200 vehicles

- **Honda**
  - Plans for tens of thousands of FCEVs/year in 2015–2017 and hundreds of thousands a few years after
  - Partnership with Linde to develop fueling stations.
  - Moved up commercialization plans to 2014

- **Daimler**
  - Plans for tens of thousands of FCEVs/year in 2015–2017 and hundreds of thousands a few years after
  - Partnership with Linde to develop fueling stations.
  - Moved up commercialization plans to 2014

- **Hyundai-Kia**
  - 2012-2013: 2000 FCEVs/year
  - 2015: 10,000 FCEVs/year
  - “Borrego” FCEV has achieved >340-mile range.

- **Volkswagen**
  - Expanded demo fleet to 24 FCEVs in CA
  - Recently reconfirmed commitment to FCEVs

- **SAIC (China)**
  - SAIC Motor Company is planning 20-30 prototypes in 2013 and >1,000 FCEVs in 2015.
  - Commercial FCEVs planned for 2016. FCEVs are key part of “Nissan Green Program.” Announced strategic partnership with Daimler on FCEVs.

- **BMW**
  - Fielding a fleet of “F-Cell” vehicles in the U.S. 40 currently leased with another 20 on the way.

**Market Growth & Potential**

Fuel cell markets continue to grow

- ~30,000 units shipped in 2012 (~35% increase)
- 48% increase in global MWs shipped

Independent analyses show global markets could mature in the next 10–20 years, producing revenues of:

- $14 – $31 billion/year for stationary power
- $11 billion/year for portable power
- $18 – $97 billion/year for transportation

**Fuel Cell Systems Shipped by Application, World Markets: 2008-2012**


Sources: Navigant Research, DOE Fuel Cells Market Report
Safety Information Portal

- Information Portal will serve as a central point for access to the hydrogen safety lessons learned and best practices information.

- IPHE will consolidate information into a single, global, open-source, searchable information resource.

Webinars

- Regular IPHE webinars will serve as another pathway to share information while utilizing the resources, knowledge and experience of IPHE members and partners.

- Webinars will cover topics of interest to the global hydrogen and fuel cell community.
  - Safety information sharing
  - H2 resource availability analysis (IEA HIA\(^2\) Task 30) results
  - Status of infrastructure deployments
  - Policy Examples to Promote H2 and FCs

- Two webinars per year

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\(^1\)IPHE – *International Partnership for Hydrogen and Fuel Cells in the Economy*

\(^2\)IEA HIA – *International Energy Agency Hydrogen Implementing Agreement*
Webinar Objective: To Share U.S. and E.U. information as it pertains to Hydrogen Safety and Best Practices, Lessons Learned and Available Databases

- Each speaker up to 15 minutes for formal remarks
  - We will entertain panel discussion questions at the end of the formal presentations for 20 minutes
  - Webinar is being recorded and will be posted approximately 10 days after the webinar. This will be through the U.S. DOE Fuel Cell Technologies Office homepage.

www1.eere.energy.gov/hydrogenandfuelcells/webinar_archives_2013.html
Example – H2 Information Sharing

- Safety Information helps guide R&D.
- It is critical to collect and disseminate relevant information.

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Total Incidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piping/Fitting/Valves</td>
<td>102</td>
</tr>
<tr>
<td>Hydrogen Storage</td>
<td>49</td>
</tr>
<tr>
<td>Vehicle &amp; Fueling System</td>
<td>40</td>
</tr>
<tr>
<td>Safety Systems</td>
<td>25</td>
</tr>
<tr>
<td>Ventilation System</td>
<td>22</td>
</tr>
<tr>
<td>Laboratory Equipment</td>
<td>19</td>
</tr>
<tr>
<td>Pressure Relief Devices</td>
<td>16</td>
</tr>
<tr>
<td>Motive Power Systems</td>
<td>15</td>
</tr>
<tr>
<td>Heating Equipment</td>
<td>14</td>
</tr>
<tr>
<td>Electrical Equipment</td>
<td>14</td>
</tr>
<tr>
<td>Process Equipment</td>
<td>14</td>
</tr>
<tr>
<td>Batteries and Related Equipment</td>
<td>13</td>
</tr>
</tbody>
</table>

Examples:
- Piping (36)
- Valve (36)
- Flexible Tubing (8)
- Gasket (6)
- Bolts (6)

Database web address – www.h2incidents.org

Cross–Search Categories:
- Settings
- Damage and Injuries
- Probable Causes
- Contributing Factors
What Can We Learn from Hydrogen Safety Event Databases?

H2Incidents.org

STEVEN C. WEINER
Battelle Washington Office
Washington, DC
“Hydrogen and fuel cell safety event information can serve as a rich and valuable resource if it is systematically collected, analyzed and used to enhance hydrogen safety knowledge. The sharing of lessons learned from safety events can serve to help prevent similar events from happening in the future…”

What is H2Incidents.org?

- Database-driven website to facilitate the sharing of lessons learned and other relevant information gained from actual experiences using and working with hydrogen.

- Focus on characterization of hydrogen-related incidents and near-misses, and ensuing lessons learned from those events.

Welcome!

What is H2Incidents?

This database is supported by the U.S. Department of Energy. The safety event records have been contributed by a variety of global sources, including industrial, government and academic facilities.

H2Incidents 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 ensuring 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 H2Incidents...

How does H2Incidents work?
H2Incidents.org History

- Launched in 2006 to store information and analysis of hydrogen-related safety events including describing the event, its setting and equipment, its characteristics, causes and contributing factors
  - 210 Safety event records to date
  - Voluntary reporting tool for capturing records of events involving hydrogen or hydrogen-related technologies.

Key Attributes
- Search Incidents
- Enter Incidents
- New Lessons Learned

The road to “H2incidents.org” began in Pisa....
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

Lessons learned content enhanced by links to “H2best practices.org”
Search capabilities allow the user to seek information of interest.
Both incidents and near-miss records are sought

Encourage self-submittal through an easy-to-use online form

Identify potential records through other means, e.g. media reports and other databases

Work with “incident owners” and other submitters

- Discuss, encourage and reach agreement for the submittal of a safety event record
- Discuss, clarify and edit description, information and lessons learned.
- Ensure anonymity in the safety event record itself
- Obtain organizational approval for posting

Provide expert review of safety event records by the Hydrogen Safety Panel and other subject matter experts.
Hydrogen leak detection
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
Safety event links illustrate what can go wrong if best practices are not followed.
A recent event that is relevant to the focus on deployment of hydrogen and fuel cell technologies

Root causes for PRD failure
- Incompatible materials
- Improper assembly
- Over-hardening of inner assembly materials

But there is usually something else one can learn from the incident
- Timely communication during emergency events
- Training of personnel focused on improving response time
- Effective communication between employees, first responders and suppliers
HYDROGEN TOOLS
…available now for your mobile devices!

- First mobile app targeted for AHJs, end-users and other stakeholders
  - Integrates H\textsubscript{2}incidents.org, H\textsubscript{2}bestpractices.org and other resources into a single, searchable iPad and iPhone application
  - Features include safety planning guidance and checklists

Announced by the U.S. Department of Energy
September 2013
“...Informed analysis of leaks, fires and explosions, and equipment failure and ignition data derived from these safety events can facilitate the development of risk assessment models and help technical experts identify gaps in applicable codes and standards that can be addressed by a variety of means.”

Concluding Thoughts

- Safety knowledge tools such as “H2incidents.org” provide a powerful resource for conveying data, information and knowledge.
- Content must be current, relevant to the community being served and valuable to the user.
- Prompt and timely responses to user feedback and inquiries to h2incidents@pnnl.gov are important.
- Progress is being made but there is more to be done!
Acknowledging…

- Fuel Cell Technologies Office (Sunita Satyapal, Director) and Staff, U.S. Department of Energy’s Office of Energy Efficiency and Renewable Energy
- All those who have contributed safety event information, knowledge and lessons learned to our database
- International Conference on Hydrogen Safety
Contacts

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Related References


HIAD
The EUROPEAN HYDROGEN INCIDENT & ACCIDENT DATABASE

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pietro.moretto@ec.europa.eu & daniele.baraldi@jrc.nl
Typical (vehicle) safety research cycle

**Review accident data:**
1. To identify problems
2. To assess success of implemented changes

**Perform research to understand problem:**
1. Detailed accident analysis
2. Laboratory experiments

**Develop test procedures to implement changes**

**Introduce procedures into legislative and/or consumer testing**

Modified from TRL presentation
Safety research cycle for low carbon vehicles

Review accident data:
1. To identify problems
2. To assess success of implemented changes

Introduce procedures into legislative and / or consumer testing

Perform research to understand profile:
1. Detailed accident analysis
2. Laboratory experiments

Develop test procedures to implement changes

HIAD ambition is filling this gap for hydrogen technologies

Limited accident data

Few vehicles available for research

Modified from TRL presentation
What is HIAD?

HIAD aims to be an repository of any accidental even related to hydrogen technology

- Originally designed to be a multi-task tool:
  - Open platform for lessons learned and risk communication
  - Data source of information to assist risk assessment approaches

- Fully operational with about 250 events published
HIAD history

HIAD was originally developed in the European Network of Excellence for Hydrogen Safety (**HySafe** 2004-2009).

After the end of HySafe, the International Association for Hydrogen Safety (**IA-HySafe**) became the focal point for all hydrogen safety related issues. HIAD was further developed with an analysis module.

HIAD is maintained, updated and funded by the **Joint Research Centre**, and is available at [https://odin.jrc.ec.europa.eu/](https://odin.jrc.ec.europa.eu/).
HIAD Structure – 4 modules

**DEM – Data Entry Module:** Users can register as “event provider” and insert/update events directly on the database

**DRM – Data Retrieval Module:** Allows the user to access hydrogen events recorded on HIAD

**DAM – Data Analysis Module:** Is a tool for conducting online simple analyses of the data recorded into the database

**MAP:** a GIF based tool which links events to their geographical distribution
Event structure

**Pre-event conditions:** Date/time of event, Weather conditions, Geographical location, applications, Operation phase or mode.

**Nature of event:** Systems and components affected or involved, Chain of events, Causal relations, Relevant safety systems and emergency response, Release, fire and explosion specifications/details.

**Consequences of event:** Fatalities and injuries, Property, environment and economical loss and damage.

**Post-event actions:** Clean-up and restoration, Legal/legislation initiatives, Lessons learned, Investments made.

**References:** Hyperlinks/references to files and documents, web-sites, etc., Specification of attachments, e.g. maps, drawings, photos, etc.
DEM = Data Entry Module Inputs

Users can enter events into HIAD in two ways:

- Users can e-mail the event to JRC who can insert it on behalf of the users
- Alternatively users can register as “event provider” and insert/update events directly on the database, using the DEM.

Only fields describing the dynamics of the event are mandatory. All other fields are not mandatory and the event can be introduce as a completely anonymous event without any information on location, company, etc.
Each event undergoes a QA process.

An event is published (visible) in HIAD only after QA process.
**DAM = Data Analysis Module**

How to analyse:

In this module you can search for event versions based on up to 5 database information fields. The search result can be presented as a plain list or in a cross table based on 2 database fields.

*Note: Not all combinations of search fields and cross table fields will give a reasonable output.*

Step 1: Select and submit search fields and cross table fields.

Step 2: Add search values and criteria.

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**Step 1:**

<table>
<thead>
<tr>
<th>Event</th>
<th>Other sets: Tech. Info &amp; People</th>
<th>Other &amp; Postevents</th>
<th>Subevent Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>City</td>
<td><strong>Tech info</strong></td>
<td>Application</td>
<td></td>
</tr>
<tr>
<td>Country</td>
<td></td>
<td>Application chain</td>
<td></td>
</tr>
<tr>
<td>Street</td>
<td></td>
<td>Application stage</td>
<td></td>
</tr>
<tr>
<td>State</td>
<td></td>
<td>Storage medium</td>
<td></td>
</tr>
<tr>
<td>Year</td>
<td></td>
<td>Storage quantity</td>
<td></td>
</tr>
<tr>
<td>Systems involved</td>
<td></td>
<td>Actual pressure (in storage medium)</td>
<td></td>
</tr>
<tr>
<td>Principal event</td>
<td></td>
<td>Design pressure (of storage medium)</td>
<td></td>
</tr>
<tr>
<td>Event nature summary</td>
<td></td>
<td>Type of location</td>
<td></td>
</tr>
<tr>
<td>Subevent type</td>
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<td>Location description</td>
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</tr>
<tr>
<td>Emergency action</td>
<td></td>
<td>Potential ignition source</td>
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<tr>
<td>Emergency evaluation</td>
<td></td>
<td>Surroundings</td>
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<td>Event scenario</td>
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<td></td>
<td>Operations phase</td>
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<td>Pre event summary</td>
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<td>Scenario author</td>
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<tr>
<td>Year</td>
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<td></td>
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<tr>
<td>Date</td>
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</tr>
<tr>
<td>Scenario analysis type</td>
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<tr>
<td>Established Frequency (scenario)</td>
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</tr>
<tr>
<td>Scenario reference</td>
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<tr>
<td>Scenario comments</td>
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<tr>
<td>Event weather</td>
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<tr>
<td>Season of the year</td>
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<td></td>
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</tr>
<tr>
<td>Weather type</td>
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<tr>
<td>Wind direction</td>
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</tr>
<tr>
<td>People Injuries</td>
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<tr>
<td>Persons affected onsite</td>
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</tr>
<tr>
<td>Persons affected rescued</td>
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<tr>
<td>Persons affected offline</td>
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<tr>
<td>Persons at risk onsite</td>
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<tr>
<td>Persons at risk offline</td>
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<td></td>
<td></td>
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<tr>
<td>Total number of affected persons</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total number of injured persons</td>
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<tr>
<td>Total number of fatalities</td>
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<tr>
<td>Injury comments</td>
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</tbody>
</table>
Data Analysis example: total number of involved people

Events 1985-2008: total number of involved people.

<table>
<thead>
<tr>
<th>Year - Principal event</th>
<th>Burst of tank</th>
<th>Explosion</th>
<th>Fire</th>
<th>Fire - hydrogen</th>
<th>Pipe rupture</th>
<th>Release of hydrogen</th>
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<td>3</td>
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<tr>
<td>Total</td>
<td>0</td>
<td>607</td>
<td>117</td>
<td>35</td>
<td>0</td>
<td>76</td>
<td>835</td>
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</tbody>
</table>

- Explosion
- Fire
- Fire - hydrogen
- Release of hydrogen

14% Explosion
4% Fire
9% Fire - hydrogen
73% Release of hydrogen
The screen shows you the HIAD events as they are scattered over the globe. Only events where the city or town is known are displayed. Events where only the country/continent is known are not displayed. impression.
Lesson learned and improvement actions

A database such as HIAD is an essential reference and qualitative/quantitative tool for

- A structured dissemination of information
- An optimisation of safety for an emerging technology.

It will increase importance and expand usage with increasing technology deployment.

To this purpose, the experience with HIAD of the past years has generated improvement needs...
Lesson learned

**Requirement 1 - commitment to reporting:**
First responders or facility owners do not have as a duty a HIAD input.
Therefore a commitment to reporting also to HIAD should be required by licensing bodies. A 'distributed', European-wide network of data providers should be in place.

**Requirement 2 - availability of accurate event reports:**
Event description providers tend to input a minimal number of information, and many fields remain empty.
Local journal articles almost never provide data with the required quality and resolution.
Therefore final internal accident reports should be made available for HIAD input (a very good example: the Emeryville accident report).
Improvement actions so far

1. Since 2013 all the European FCH JU projects, and especially the Demo projects are committed to report safety related events in HIAD

2. The US and the European databases ‘speak’ to each others, and a small exchange of events has started

A similar commitment is wished also from commercial installations
Improvement actions to come

**Improve end-user usefullness**
HIAD has been written for expert operators, not for end users; the level of details of the data expected/required must take into account the average availability of data.

**Solution**: restructuring of HIAD interface is planned for the coming 2 years

**Improve quality assurance service**
A broader and permanently available, quality assurance group is required, also for the interaction with the event provider.

**Solution**: not available at the moment; joining forces between databases could be a way forward.
References


Thank You

hydrogenandfuelcells.energy.gov