EC-JRC contribution to IEA-H2 Task 31 and the new version of the Hydrogen Incident Accident Database (HIAD)

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EC-JRC contribution to IAE-HIA Task 31
Filling of hydrogen tanks

Experiments and simulations of hydrogen fast filling scenarios

Analysis of temperature distribution in hydrogen tanks during filling (-40°C < $T_{\text{design}}$ < 85°C)

Goals: to provide inputs for Regulations Codes and Standards for safer hydrogen technologies
Filling of hydrogen tanks

Gas tanks Testing Facility (GasTeF)

- EU reference laboratory on safety and performance assessment of high-pressure hydrogen (and natural gas) storage tanks
- Fast filling, cyclic and permeation testing
Filling of hydrogen tanks: validation
CFD simulations of accident scenarios

Numerical simulations of accidents scenarios related to hydrogen technologies for safety analysis

Estimates of accident consequences due to pressure and thermal loads of hydrogen explosions

Goals: to provide inputs for Regulations Codes and Standards for safer hydrogen technologies
CFD validation for hydrogen jet release

Notional-nozzle approaches:
- Birch 1984
- Birch 1987
- Ewan and Moody 1986
- Schefer et al. 2007
- Harstad 2006

Evaluation of notional nozzle approaches for CFD simulations of free-shear under-expanded hydrogen jets

Red: $\kappa$-$\varepsilon$ model; Green: SST model; Blue: BSl model.
HD35-37: 53 bar; 1 mm diameter nozzle
Testing of H2 sensor performances

H2 sensing technologies:
• Catalytic
• Electrochemical
• Thermal conductivity
• Semiconducting metal oxide/SnO2
• MOS (Field Effect Transistors)
• Optical
• Acoustic
• Mechanical

Market survey (2010)
57 off-the-shelf sensors

Example of results for catalytic and thermal conductivity sensors

Strong collaboration with NREL with a number of joint publications on sensor testing.
Collaboration with NREL and University of Quebec a Trois Rivieres on MEMS sensors.
HIAD: Hydrogen Incident and Accident Database

- Development of HIAD, a database for hydrogen incidents and accidents.

- Collaboration between JRC and the Pacific Northwest National Laboratory:
  - exchange of some safety records between HIAD/JRC and H2incidentts.org/PNNL,
  - A joint topical session on safety event databases with online demonstrations of both HIAD and H2incidentts.org at the 4th International Conference on Hydrogen Safety (ICHS) in San Francisco, 2011.
HIAD: Hydrogen Incident and Accident Database
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 has been maintained, updated and funded by the Joint Research Centre of the European Commission.
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
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

Develop test procedures to implement changes

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

HIAD ambition was filling this gap for hydrogen technologies

Limited accident data

Few vehicles available for research
HIAD: goals

Collaborative and communicative web-based information platform: repository of data defining events related, directly or indirectly, to hydrogen safety.

• to assist all stakeholders in better understanding hydrogen-related undesired events
• to keep the industry updated with recent hydrogen events → Encourage and facilitate industry partners to share experience
• to serve as an important data source for risk assessment of hydrogen applications
• to provide **safety lessons learned**

The collection of data is characterized by a significant degree of details and information about recorded events:
• physical consequences
• Application chain
• causes
• ...
Lesson learned and improvement actions (2012-2013)

• The experience with HIAD of the past years has revealed shortcoming and generated improvement needs...

• HIAD goal to become a tool for QRA was too ambitious, due to the limited statistics of the various accidents

• After the end of NoE HySafe has not been supported financially
  ➢ the pool of quality reviewers not available anymore
  ➢ the link to possible event providers disappeared
Lesson learned and improvement actions

Requirement 1: commitment to reporting
• Facility owners or project coordinators do not have as a duty a HIAD input.
  → a commitment to report 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.
  → full accident reports by internal investigators, local authority and/or first responders should be made available for HIAD input
Lesson learned and improvement actions (cont'd)

Requirement 3: Improve end user usefulness

HIAD has been written for expert operators, not for end users, which imply a somehow cumbersome interface:
→ the level of details of the data required must be balanced with the average availability of data
   → a simplification of HIAD users interface is critical

HIAD structure:
→ Too many fields could never be filled
→ The level of details required for a full event description was so high to scare event providers, and caused misreporting.
   → a simplification of HIAD structure and event description is critical
The new HIAD

• The upgrade work on HIAD, started in June 2016

• The new database has a significantly simplified structure

→ resulting in a more streamlined user interface
HIAD refurbishment

• The front-end and back-end of the database were completely redesigned
• Simplified version (easy-to-use)

• New web-based template for data collection (reduced number of entries)

• Focus on lesson learned

• The Data Analysis Module has been abandoned
New HIAD versions

HIAD FP7
2003-2006
NoE HySafe and JRC

FCHJU HIAD
2016
EC-JRC inputs from FCH-JU Projects

HIAD 2.0
2017
Free access database
Database access

HIAD FP7
- H2 events
- Registration and log-in

HIAD 2.0
- H2 events
- New H2 public available events
- Free access

FCHJU-HAID
- Project events
- Restricted only FCHJU
FCHJU-HIAD data collection process

1. Data collection
2. Data processing
3. Validated events
4. Event analysis
5. Reporting
6. Dissemination

Participants:
- EC-JRC
- HSP
- FCHJU

Flow:
- FCHJU Projects → Data collection → Data processing → Validated events → Event analysis → Reporting → Dissemination
- HSP feedback loop
FCHJU-HIAD data collection

FCHJU-HIAD Event Report Form

Fields marked with * are mandatory

Pages
- Intro
- Provider information
- General information
- Initial situation
- Application
- Consequences
- Causes for the event
- Corrective actions
- Lessons learned
- References

HIAD 2.0 event report form

Welcome to the entry page of the FCHJU Hydrogen Incident and Accident Database (FCHJU-HAID).

FCHJU-HAID is a repository of data defining events related, directly or indirectly, to hydrogen safety. It is designed as a multi-tasking tool: an open communication platform suitable for providing safety lessons learnt and risk communication as well as a potential data source for risk assessment.

The database is a collaborative and communicative web-based information platform, aimed at promoting both the safety performance of existing hydrogen technologies and safety actions after events involving hydrogen. The main purpose of FCHJU-HAID is to assist all stakeholders in better understanding hydrogen-related undesired events, to serve as an important data source for risk assessment of hydrogen applications. In order to achieve those objectives, the collection of data is characterized by a significant degree of details and information about recorded events (e.g. causes, releases, fires, explosions, consequences).

To ensure a sufficent level of quality for all collected data into FCHJU-HAID, each event submitted by means of this form will be subjected to a quality assurance process.

The database has been developed in the year 2003-2005 by the NoE HySafe. Since then, it is hosted and operated by the European Commission Joint Research Centre (JRC). In 2016-17, JRC issued FCHJU-HAID, optimized for inputs from the FCH JU Projects.

Next  Save as Draft
HIAD 2.0 – Home page

HIAD

The Hydrogen Incidents and Accidents Database, is an international open communication platform collecting systematic data on hydrogen-related undesired events (incidents or accidents).

DATA RETRIEVAL

The data retrieval module allows you to select and view HIAD events.

DATA ENTRY

The data retrieval module allows you to enter and manage your events in HIAD. This option is only available to registered users. If you are interested in submitting HIAD events, please submit a request from your My Profile page.

Disclaimer

JRC Petten and the ODIN site administrator cannot be held responsible for the validity or integrity of the data that you will view on this site, regardless of the original source of this data. However, only acknowledged experts are allowed to enter data. They are held responsible for the data quality and have to validate the data before final release. An additional check is performed by JRC Petten experts.

Login: Not logged in yet
Event classification (definition):

- **Non-hydrogen system initiating event**: event not directly caused by the hydrogen system (e.g. sudden, unintended damage to hydrogen vehicles, installations or plants caused by impact, high voltage, failure of conventional components, etc.)

- **Hydrogen system initiating event**: event triggered directly by system containing hydrogen (e.g. rupture of hydrogen pipe, valve, tank)

- **False positive**: emergency alarm or procedure triggered in the absence of any actual problem; a hydrogen sensor giving a false alarm, for instance, falls in this category
DRM Database structures

Physical consequences:

- Jet fire and explosions
- No hydrogen release
- Unignited hydrogen release
DRM Database structures

Application stage:
several subcategories such as:
• hydrogen production
• hydrogen transport and distribution
• hydrogen refueling station
• road vehicles
• …
DRM Database structures

Advance selection criteria page
HIAD 2.0 – example of event

Event details

<table>
<thead>
<tr>
<th>ID</th>
<th>382</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provider</td>
<td>HIAD support</td>
</tr>
<tr>
<td>Event</td>
<td>Near the end of the process of filling a gaseous hydrogen tube trailer at a liquid hydrogen transfer filling station, a safety pressure-relief device (PRD) rupture disc on one of the tube trailers burst and vented hydrogen gas. The PRD vent tube directed gas to the top of the trailer where the hydrogen vented and ignited, blowing a flame straight up in the air. The operator, filling the tube trailer, heard a loud explosion from the sudden release of hydrogen gas and saw flames immediately. The operator closed the main fill valve on the tube trailer, stopping the hydrogen fill, however, the ten cylinders on the tube trailer were almost full (2500 psig/173 bar). The tube trailer involved in this incident was one of two tube trailers being filled simultaneously and was second in a line up of five tube trailers parked adjacent to one another at this location.</td>
</tr>
<tr>
<td>Full description</td>
<td>Design failure/defect</td>
</tr>
<tr>
<td>Country</td>
<td>UNITED STATES</td>
</tr>
<tr>
<td>Date</td>
<td>02-JAN-09</td>
</tr>
<tr>
<td>Cause</td>
<td>Equipment failure. The hydrogen tube trailer involved in this incident was doing its first fill after requalification, where all the PRDs had just been replaced. The PRD rupture disc designed for 5500 psig (384 bar) failed at about 1000 psig (69 bar) below rated pressure. The hydrogen tube trailer was grounded per procedure during the filling operation. Subsequent follow-up examination of the PRD rupture disc lot by the PRD manufacturer found that all of the lot conformed to specification.</td>
</tr>
<tr>
<td>Cause comments</td>
<td>1. Specific response drills/exercises need to be conducted yearly. In this case, all safety systems worked as they were designed and outside emergency responders were not needed. 2. Performing other tasks while filling hydrogen tube trailers, such as mechanical work, should be avoided. Most premature failures of hydrogen tube trailer PRD burst discs occur during the fill process. 3. Grounding, as was done in the incident, should always be done during hydrogen filling. However, even when the fill vessel is grounded, it is not unusual for a hydrogen release to immediately ignite. 4. The facility safety deluge water system should be checked periodically for coverage. In this case, a water cannon was a little off target from the last time it was operated and has now been repositioned and stabilized to ensure that it does not move in the future. 5. Emergency responders assumed that adjacent tube trailers were heating up from single-cylinder vent flare as a 300°F (149°C) reading was obtained with a thermal device. This slightly delayed the closing of the cylinder isolation valves on the tube trailer. After-incident investigation found no paint discoloration or burn, so the...</td>
</tr>
</tbody>
</table>

European Commission
HIAD 2.0 – next step

Database ready to be used: https://odin.jrc.ec.europa.eu/odin/index.jsp

Your feedback are very important!

Share among colleagues

Populate the database with events (using the ad hoc event report form)
Stay in touch

**JRC Science Hub:** www.ec.europa.eu/jrc

**Twitter:** @EU_ScienceHub

**LinkedIn:** european-commission-joint-research-centre

**YouTube:** JRC Audiovisuals

**Vimeo:** Science@EC
References

