Achievements of the EC Network of Excellence “HySafe”

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et al (…150 colleagues)

3rd ICHS, 16 September 2009, Ajaccio, Corse, France
Networks of Excellence (NoE)?

NoE HySafe Objectives

• strengthen and focus, **integrate** fragmented research on hydrogen safety
  → competitive scientific and industrial community
• Promoting **public awareness and trust** in hydrogen technologies
• development of an excellent safety culture

General Goal
Contribute to a **safe transition** to a **sustainable development** in Europe by facilitating the **safe introduction of hydrogen** technologies / applications
NoE HySafe - Integration of the EU Hydrogen Safety Research

Consortium
● 23 partners from 12 European countries
  + Kurchatov Institute, Russia + University of Calgary, Canada
● 13 research institutes, 7 industry partners, 5 universities
● ~150 scientists actively involved

Budget Total ~ 14 M€ ; EC grant ~ 7 M€

Time frame: 03/2004 – 02/2009

Key integration result:
“International Association for Hydrogen Safety - HySafe”
(Non profit, self-funded, Belgium based)
Cluster Research Activities
Related to Integration of Experimental Facilities

MISTRA

cylindrical steel vessel
originally designed as $1/10^6$ in linear scale of Pressurized Water Reactor containment
studies of H2 (simulated by He) release and distribution in a confined geometry.

Free online catalogue
(Here just 6 out of > 100)

GexCon 168 m$^3$ open geometry with internal obstructions
explosion vessel
large scale (168 m$^3$)
studies on explosions in open, congested geometries

A1 Vessel
cylindrical vessel
full or large scale
studies on turbulent combustion and detonations, vented explosions, hydrogen distribution, integrity of mechanical structures under high pressure load
Cluster Activities
Integration Workshops „Experiments“

Objectives
- to become more acquainted with the partners’ experimental activities
- to share knowledge in the field of experimental work
- to support jointly planned and performed experiments

Achievements
- Eight 2-3 day workshops (2005-2008, biannual)
- Topics: practical aspects of experiments, measurement techniques, data acquisition and safety
- Technical facility tours
- Initiation of joint internal studies
Internal Project “InsHyde”
addressing the priorities

• Investigation of realistic non-catastrophic releases in (partially) confined areas
• Determination of permeation and release limits
• Systematic assessment of mitigation (including detection) measures (sensors + venting + recombiner...)
• Simulations and experiments for critical releases
• Deriving „Recommendations“, → see deliverable D113
• Proposing a dedicated EC project “HyGarage” (lead NCSRD)
“InsHyde” – Experimental Program

Distribution and integral explosion tests

- Stainless steel skeleton
- Replaceable wall modules
- Commercial tilting door in the front side (not completely sealed)
- Technical access door in the back
- Laser-based measurements possible
- Sound speed measurements:
  - Concentration
  - Gas velocity

Test cell at FZK

Garage facility at CEA

Confinement

Injection

BOS visualization

xi = 5.76 m
yi = 2.96 m
zi = 2.42 m
Vi = 40.92 m³
“InsHyde” – Permeation Survey on Existing Allowable Rates

- Draft UN ECE regulation (EIHP draft & possibly the basis of the EU Regulation) and superseded versions of draft ISO/DIS 15869:
  - For Type 4 containers, the steady state permeation rate < 1.0 NmL/hr/L internal vol.
  - The test is conducted at ambient temperature and nominal working pressure.

- ISO/DIS 15869.2 & .3:
  - For Type 4 containers, the steady state permeation rate < 2.0 NmL/hr/L water capacity at 35 MPa, and 2.8 NmL/hr/L water capacity at 70 MPa.
  - The test is conducted at ambient temperature and nominal working pressure.

- SAE J2579, Jan. 2008:
  - The steady state hydrogen discharge rate due to leakage and permeation from the hydrogen storage system shall not > 75 NmL/min at 85°C and nominal working pressure for a standard passenger vehicle.
  - The rate may be increased in proportion to the enclosure volume for large vehicles.
HyTunnel - Experimental Layout

Objective:
Critical conditions for FA and DDT in semi-confined gas mixture layer

Expected data: Dependence of critical $\sigma^*$ and $\lambda^*$ on gas layer height $\delta$

- $I$ – ignition point;
- $P, I$ – pressure and light gauges.
- $L = 12$ m – A1 length;
- $D = 3.5$ m – A1 diameter;
- $V = 100$ m$^3$ (+30 m$^3$) – total volume;
- $BR = 0.6$ (0.3) by obstacle laden grid

$C_{H_2}$ – hydrogen concentration;
$\delta$ – layer thickness
Some results -

of the experimental program

Hydrogen stratified layer experiments completed by FZK:

- Summary included in HyTunnel Deliverable D62
- Full report in deliverable D87
- 10 experiments conducted

<table>
<thead>
<tr>
<th>Layer height $\delta$ [m]</th>
<th>Small scale</th>
<th>Large scale</th>
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</thead>
<tbody>
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<tr>
<td>0.15</td>
<td>slow Deflagration</td>
<td>slow Deflagration</td>
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<tr>
<td>0.30</td>
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<td>0.60</td>
<td>Detonation</td>
<td>(fast Deflagration)</td>
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Paper 241
> 250 hydrogen specific event stories

Hydrogen Incidents & Accidents Database (HIAD)

Accident Database HIAD
Collecting experience

Over the last few months JRC and DNV have been working on HIAD application. As you know, the previous-version of the Data Entry Module (DEM) - only Graphical User Interface (GUI) - was available for comments the last few months. The developed carried out has mainly been related to integrating a new...
Education and Training Offers
Academic and industry level

PGCert Hydrogen Safety Engineering

Introduction
The Postgraduate Certificate programme in Hydrogen Safety Engineering offered at the University of Ulster is the only such programme in the UK and worldwide, giving graduates the opportunity to specialise in a new field. The programme comprises of two 30 CATS point modules, namely, one on "Principles of Hydrogen Safety" and one on "Applied Hydrogen Safety".

The topical content of the modules complies with the International Curriculum on Hydrogen Safety: http://www.hysafe.org/index.php?ID=68. There is a growing need for specialists in hydrogen safety engineering. Graduates with a PGCert in Hydrogen Safety Engineering will be suitably qualified for employment opportunities at various industrial corporations, government bodies, research organisations, and educational institutions.

Quick Facts
Course Name
PGCert Hydrogen Safety Engineering
Faculty
Engineering
Course Code(s)
PGCert: CS14P1
Duration
PGCert: One year (two semesters)

for details see www.hysafe.net/PGC
Dissemination via the unique conference
<table>
<thead>
<tr>
<th>No</th>
<th>Title</th>
<th>WP</th>
<th>Lead</th>
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<tbody>
<tr>
<td>D9</td>
<td>Report on compiled facility descriptions</td>
<td>WP2</td>
<td>FZJ</td>
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<tr>
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<td>Report on Specification and definition of the HySafe - Hydrogen incident and accident database cont</td>
<td>WP5</td>
<td>DNV</td>
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<td>D23</td>
<td>Status report on compilation of results of SBEPs</td>
<td>WP3</td>
<td>UPM</td>
</tr>
<tr>
<td>D24</td>
<td>Report on phenomena / scenario ranking</td>
<td>WP4</td>
<td>CEA</td>
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<td>Report on CFD models in the simulations of the problems related to H2 safety.</td>
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<td>FZK</td>
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<td>Summary on HySafe Risk Assessment methodologies/approaches including and priorities</td>
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<td>DNV</td>
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<td>Website presentation of the facilities</td>
<td>WP2</td>
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<tr>
<td>D34</td>
<td>Report on available information including existing standards for bonfire tests of H2 tank structures</td>
<td>WP9</td>
<td>BAM</td>
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<td>D41</td>
<td>Database of Literature on Hydrogen Safety</td>
<td>WP1</td>
<td>INERIS</td>
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<td>D44</td>
<td>Report describing established definitions and classifications of incidences and accidents</td>
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<td>DNV</td>
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<td>Second Status report on code validation and applicability based on the results of SBEPs</td>
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<td>INERIS</td>
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<tr>
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<td>Report on HZ methodology for H2 including calculation examples</td>
<td>WP12</td>
<td>NH</td>
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<td>D66</td>
<td>Report on CFD code validation (SBEP)</td>
<td>WP6</td>
<td>GEXCON</td>
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<td>D75</td>
<td>List of Basic Test Problems</td>
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<td>FZK</td>
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<td>The 1st &quot;HySafe Hydrogen Accident Statistical Report&quot;</td>
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<td>FZK</td>
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<tr>
<td>D84</td>
<td>Report on internal safety distances</td>
<td>WP12</td>
<td>DNV</td>
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Final Integration

A huge majority (21 / 24) NoE partners founded the International Association HySafe (see www.hysafe.net/IAHySafe)

International focus of Hydrogen Safety Research

- Research Coordination
- International Conference on Hydrogen Safety ICHS
- Education and Training
- Biennial Report on Hydrogen Safety BRHS
- Hydrogen Incidence and accident database HIAD
External Relations
Focussing further

E&T
HySAFEST
HyFire
HyCourse
RC&S
CEN/CENELEC
ISO/IEC

R&D
HyApproval
HyPer
HYTHEC
NATURALHY
StorHy
HyWays

Guide
Inform
Partner

Co-ordinate
Membership
Authorities

Industry

...and you?

IEA HIA
Task 19

JTI + JRC + EHA

US DOE + NHA

HYCAN
Further Information

www.hysafe.net

www.hysafe.info
Support

NoE HySafe is co-funded by the European Commission within the 6th Framework Programme (2002-2006); Contract n°: SES6-CT-2004-502630.

The network is contributing to the implementation of the Key Action "Integrating and strengthening the ERA" within the Energy, Environment and Sustainable Development.

Thanks to all HySafe colleagues…

… and thank you for your attention.