

Wasserstofftechnik – Forschung für Sicherheit (und Transport)

1. Sicherheit von Wasserstoff
2. Integration / Koordination internationaler
Sicherheitsforschung mit „HySafe“
3. Ausbildungsangebote

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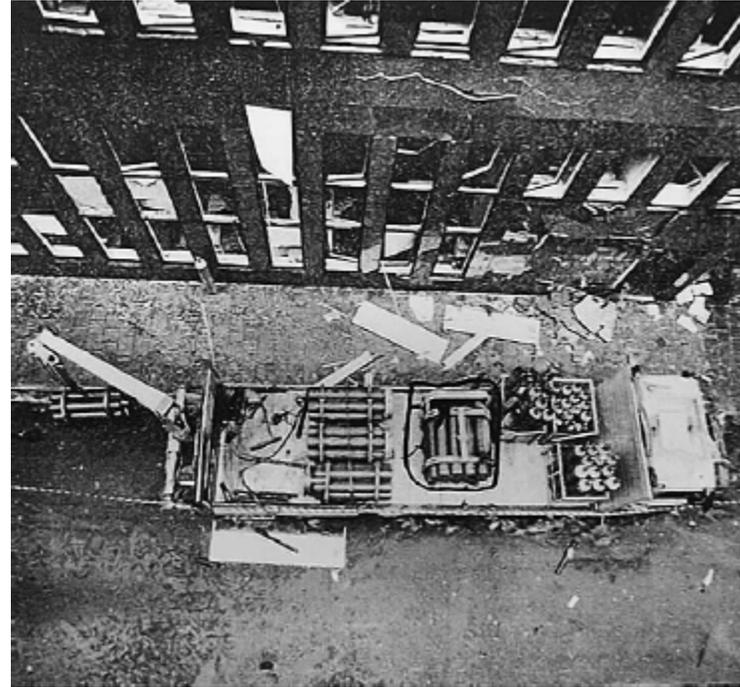
UNFÄLLE MIT WASSERSTOFF

Norwegen 1984



Detonation von ~5 kg,
2 Tote, Zerstörung
des gesamten
Industriegebäudes

Stockholm 1984



H₂-Quelle 180 Nm³
16 Verletzte, beschädigte
Fahrzeuge u. Gebäude
im Umkreis von 90 m

Köln 2005

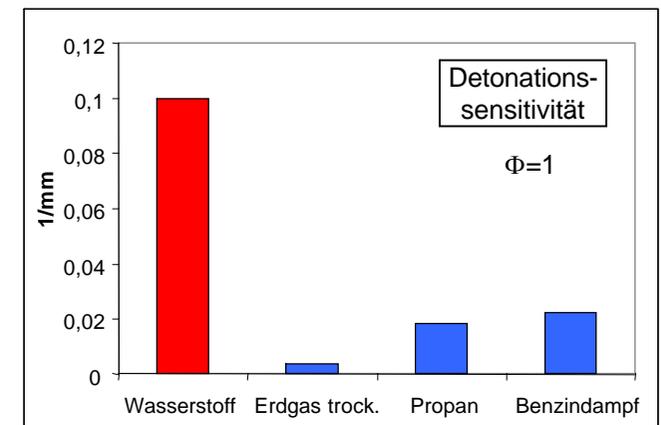
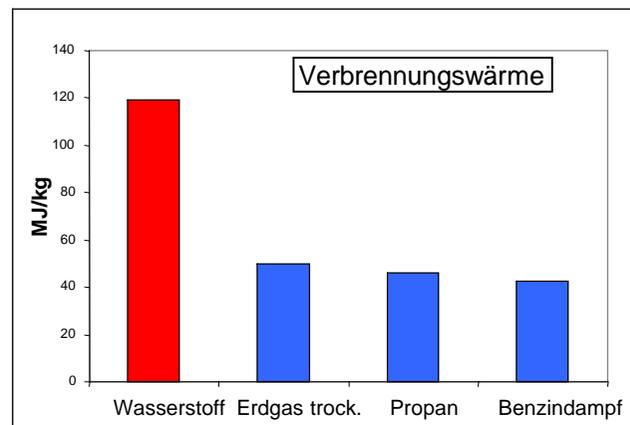
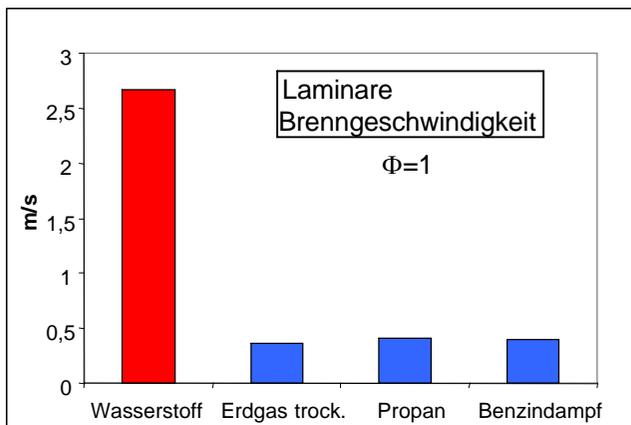
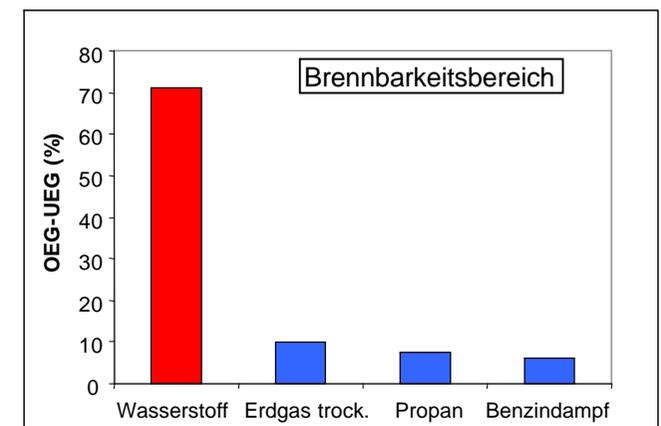
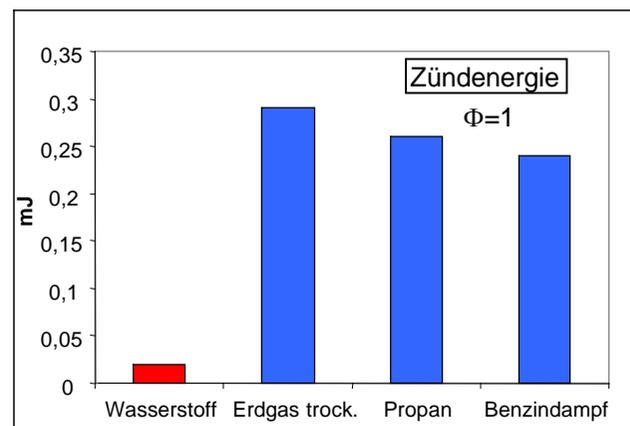
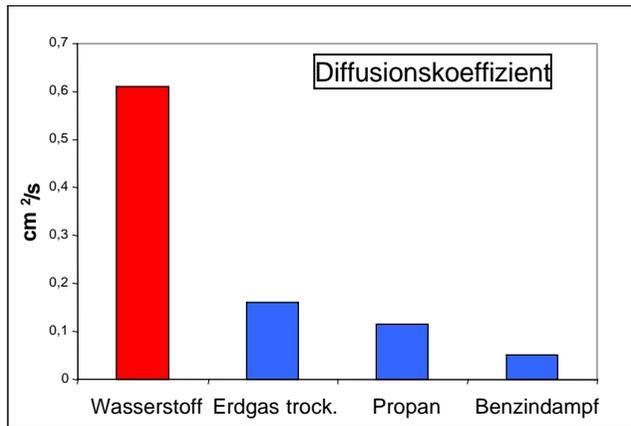
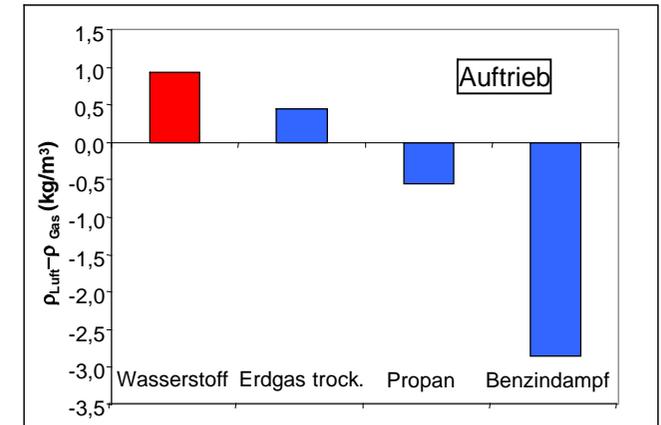
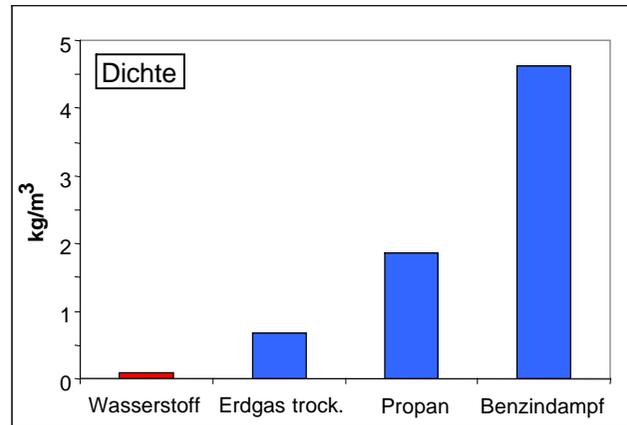


Was wäre wenn...?

SICHERHEITSRELEVANTE EIGENSCHAFTEN GH_2

Sicherheitsrelevante Eigenschaften von

- Wasserstoff
- Erdgas trocken
- Propan
- Benzindampf



SPEZIFISCHE GEFAHREN MIT LH₂



- **-253°C** → Kaltverbrennungen, Erfrierungen,
Materialdegeneration (Tiefkaltversprödung NDTT)
- **780 x Volumenzunahme** beim Verdampfen → Erstickung
- **Pool kann durch Kryopumpeneffekt LO₂ einlagern** →
Spontanzündungen möglich

Grösste Unfalldatenbank HySafe/HIAD

ie

Hydrogen Incidents & Accidents Database (HIAD)



> 170 H2 spezifische Fälle

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HySafe - Hydrogen Incident and Accident Database (HIAD)

Welcome to the H.I.A.D. BETA version!!!!



Courtesy of Holmefjord:
Livorno Hydrogen Refuelling Station



Courtesy of Gerd Petra Haugom:
Beijing Hydrogen Refuelling Station



Courtesy of Gerd Petra Haugom:
Beijing Hydrogen Refuelling Station

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) - onl Graphical User Interface (GUI) - was available for comments the last few months. The developed carried out has mainly been related to integrating a new

Done

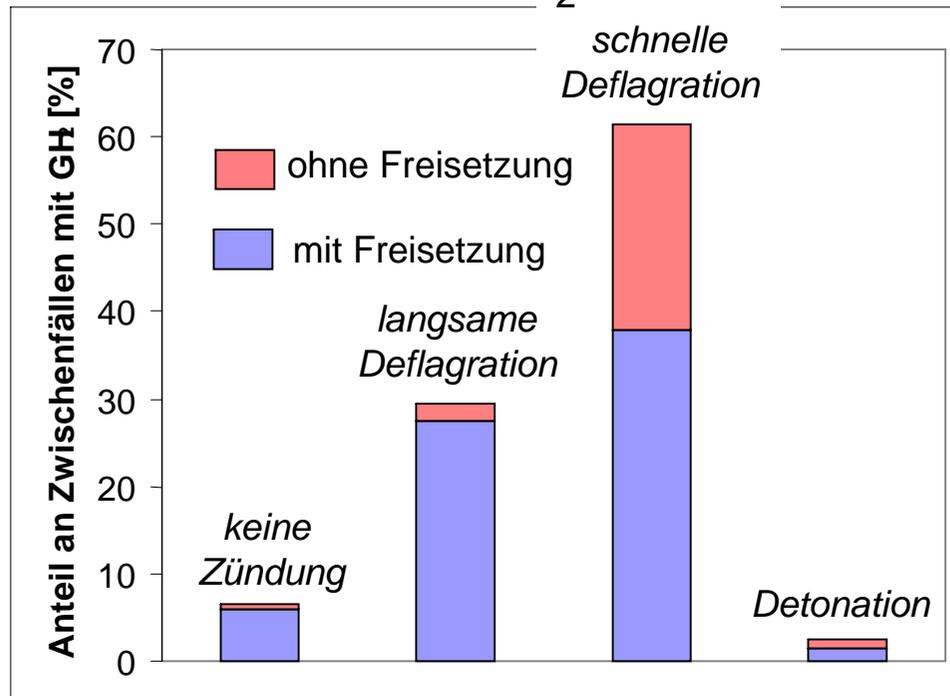
Internet

ZWISCHENFÄLLE MIT WASSERSTOFF: FOLGEN

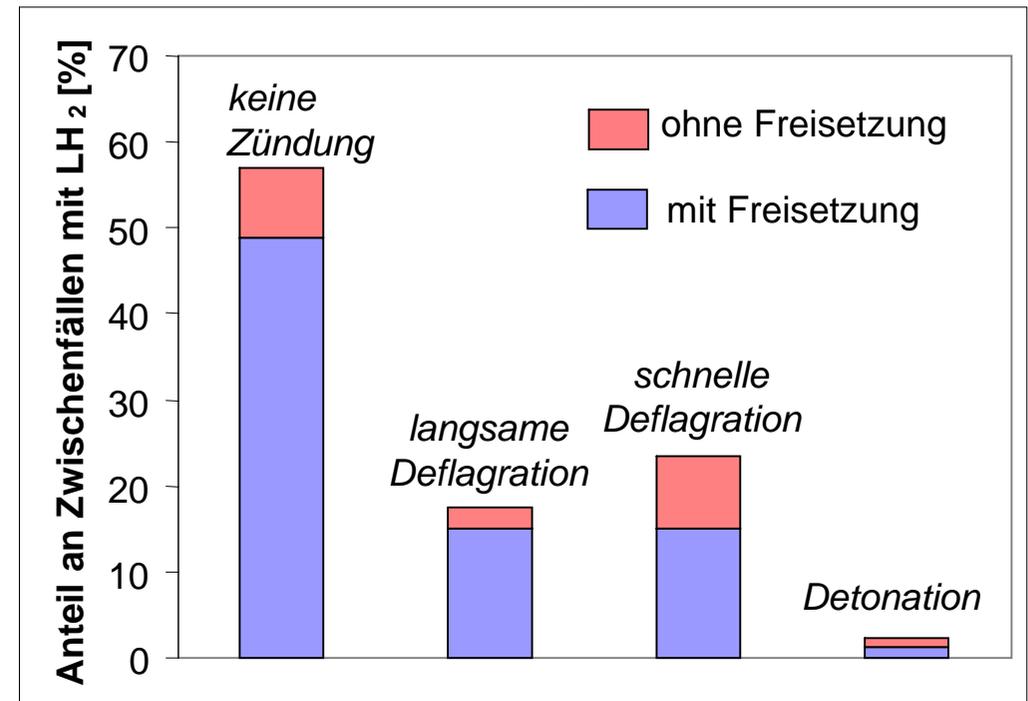
Störfällen werden unterschieden in:

- ohne Freisetzung (Wasserstoff verbleibt in Speicherbehälter oder Prozessanlage)
- mit Freisetzung, (Wasserstoff wird in Umgebung freigesetzt, oder in für Menschen zugängliche Räume)

GH_2

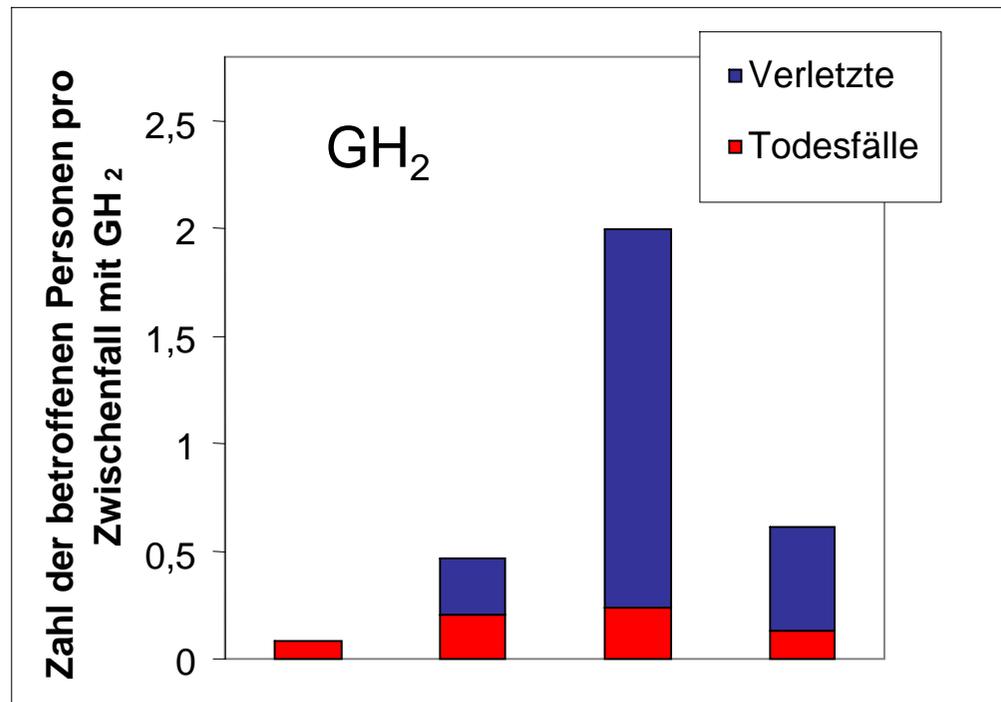


LH_2

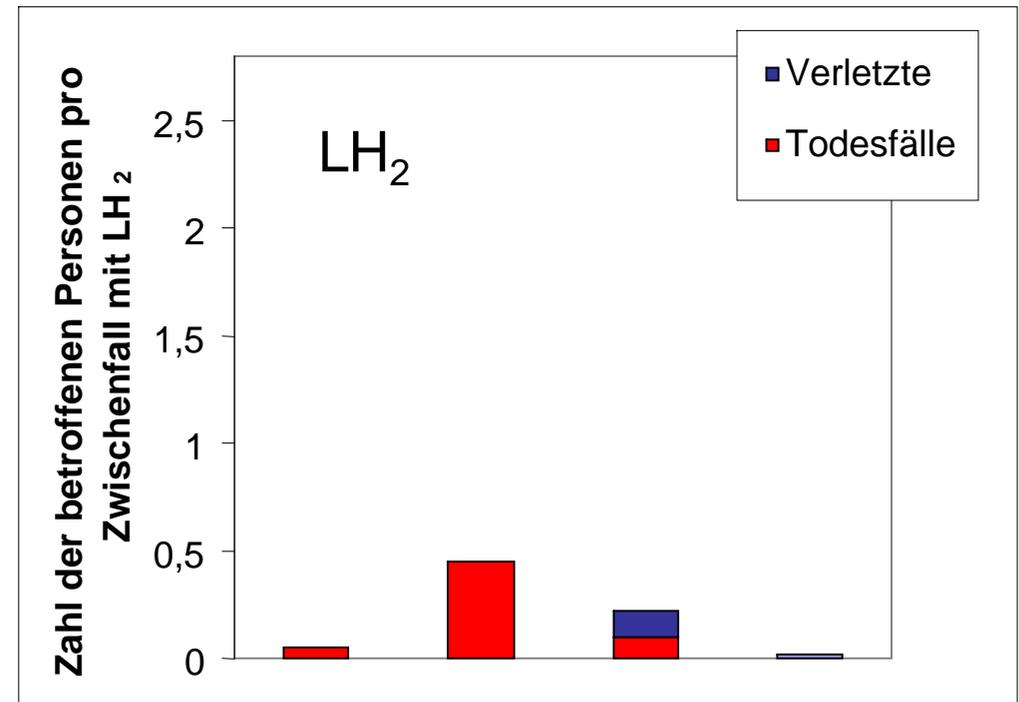


- Zwischenfälle mit GH_2 führen überwiegend zur Zündung und schnellen Deflagrationen
- Zwischenfälle mit LH_2 zünden wesentlich seltener als solche mit GH_2 (Gemischbildung)

ZWISCHENFÄLLE MIT WASSERSTOFF: PERSONENSCHÄDEN



Freisetzung ohne Zündung Freisetzung und Feuer Freisetzung und Explosion Keine Freisetzung



Freisetzung ohne Zündung Freisetzung und Feuer Freisetzung und Explosion Keine Freisetzung

- Wesentlich weniger Verletzte mit LH_2 als mit GH_2 , aber vergleichbare Anzahl an Todesopfern
- Fazit: Es treten alle Verbrennungsregimes auf, Konsequenzen hängen von vielen verschiedenen Einflussparametern ab, systematische Analyse notwendig

Integration der EU Forschung über das NoE HySafe

Consortium

- 24 partners from 12 European countries incl. Russia (Kurchatov Institute) and one Canadian partner (University of Calgary)
- 13 public research organisations, 7 industrial partners, 5 universities
- ~150 scientists involved



Budget

Total > 13 M€ with a EC grant of max. 7 M€

Time schedule

network/project start: 03/2004

subsidised max. duration: 5 years

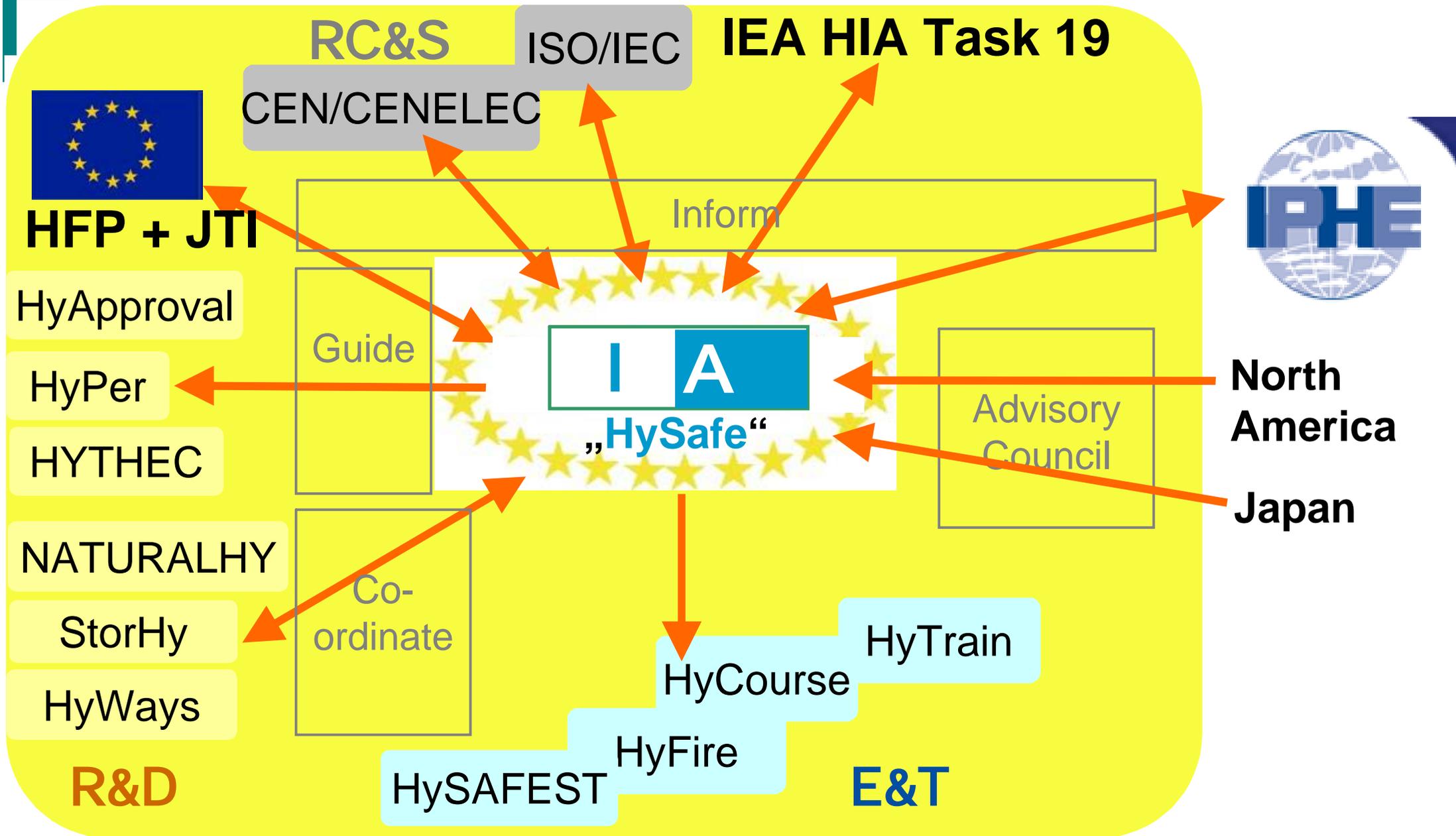
→ 02/2009 activities transferred to the
International Association “HySafe”

HySafe Consortium



- | | |
|--|-----|
| Forschungszentrum Karlsruhe GmbH | DE |
| L'Air Liquide | FR |
| Federal Inst for Materials Research and Testing | DE |
| BMW Forschung und Technik GmbH | DE |
| Building Research Establishment Ltd | UK |
| Commissariat à l'Energie Atomique | FR |
| Det Norske Veritas AS | NO |
| Fraunhofer-Gesellschaft ICT | DE |
| Forschungszentrum Jülich GmbH | DE |
| GexCon AS | NO |
| The UKs Health and Safety Laboratory | UK |
| Foundation INASMET | ES |
| Inst Nat de l'Environm industriel et des RISques | FR |
| European Commission - JRC - Inst for Energy | NL |
| National Center for Scientific Research Demokritos | EL |
| Norsk Hydro ASA | NO |
| Risø National Laboratory | DK |
| TNO | NL |
| University of Calgary | CA |
| University of Pisa | IT |
| Universidad Politécnica de Madrid | ES |
| University of Ulster | UK |
| VOLVO Technology Corporation | SE |
| Warsaw University of Technology | PL |
| Russian Research Centre Kurchatov Institute | RUS |

Internationale Einbettung von HySafe



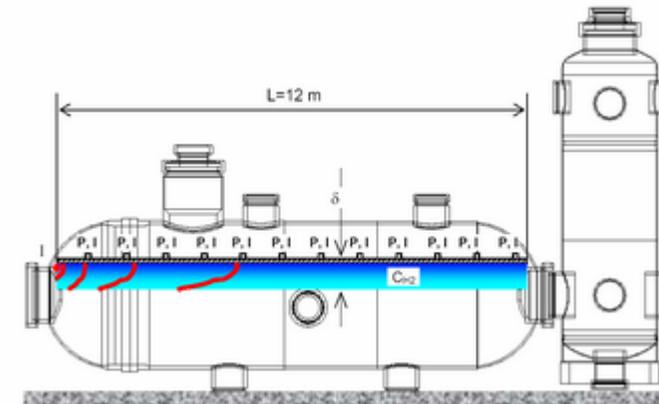
Research Headlines

➤ (Partially) Confined Releases ➤ Mitigation

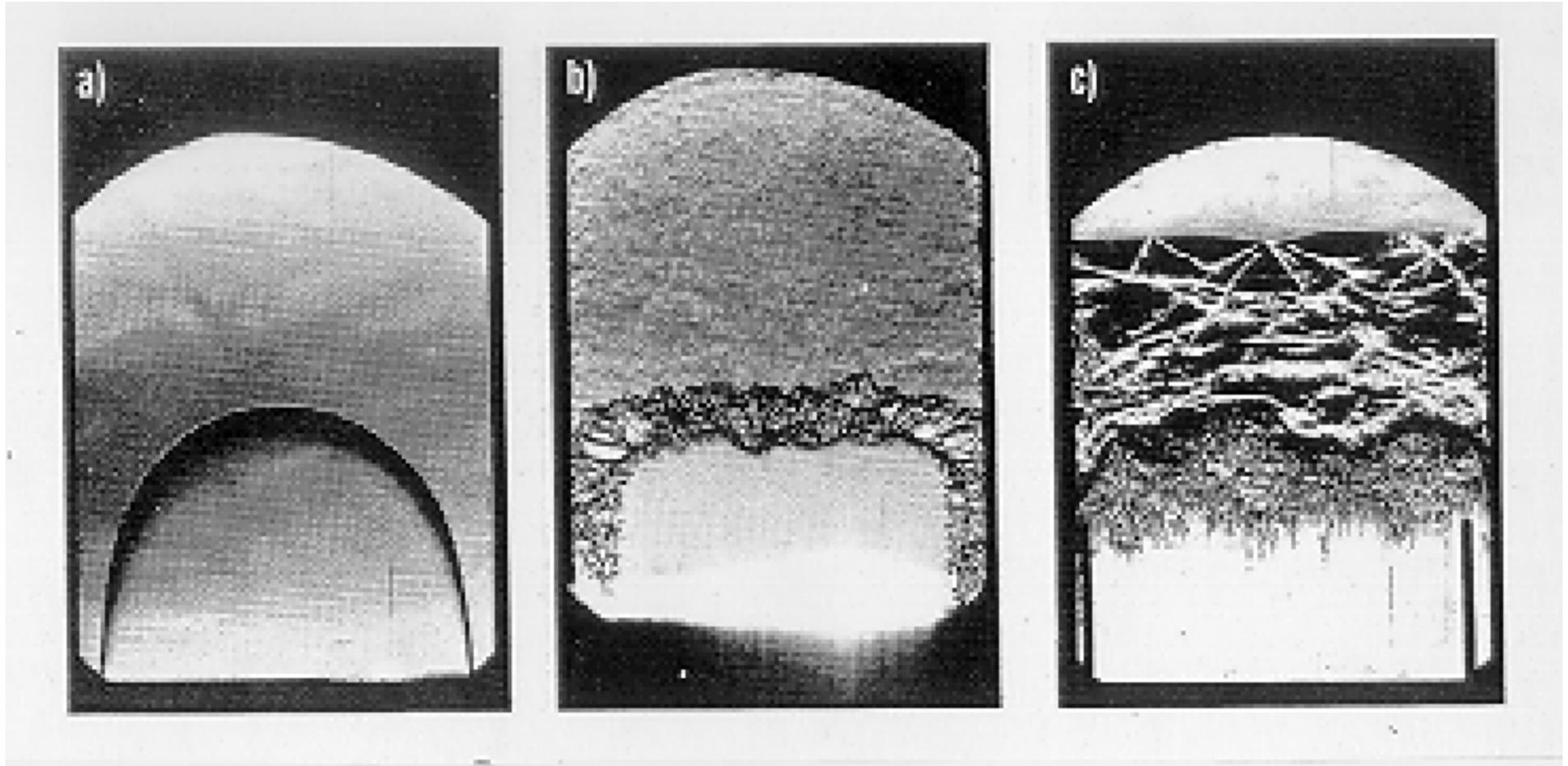
determined by

- initial PIRT study
- expert questionnaire
- state-of-the-art survey

communicate the network's working topics,
orientate the work on intermediate time
scale (proposals for experiments,
benchmarking, Internal Projects ...)



VERBRENNUNGSREGIMES VON H₂-LUFT GEMISCHEN

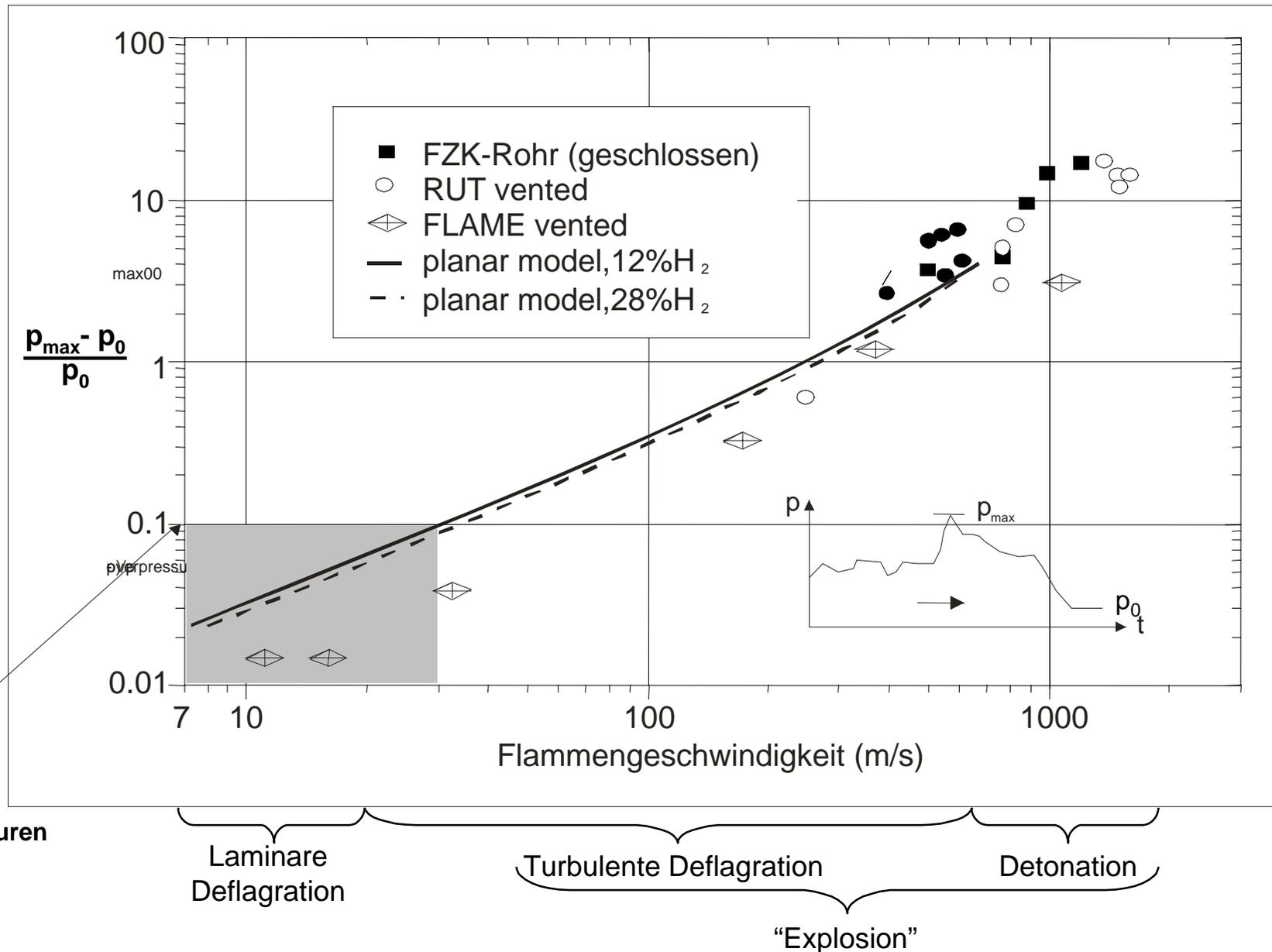


Laminare Flamme
 $v \approx 1 \text{ m/s}$, $Ma \ll 1$

Turbulente Flamme
 $v \approx 300 \text{ m/s}$, $Ma \approx 1$

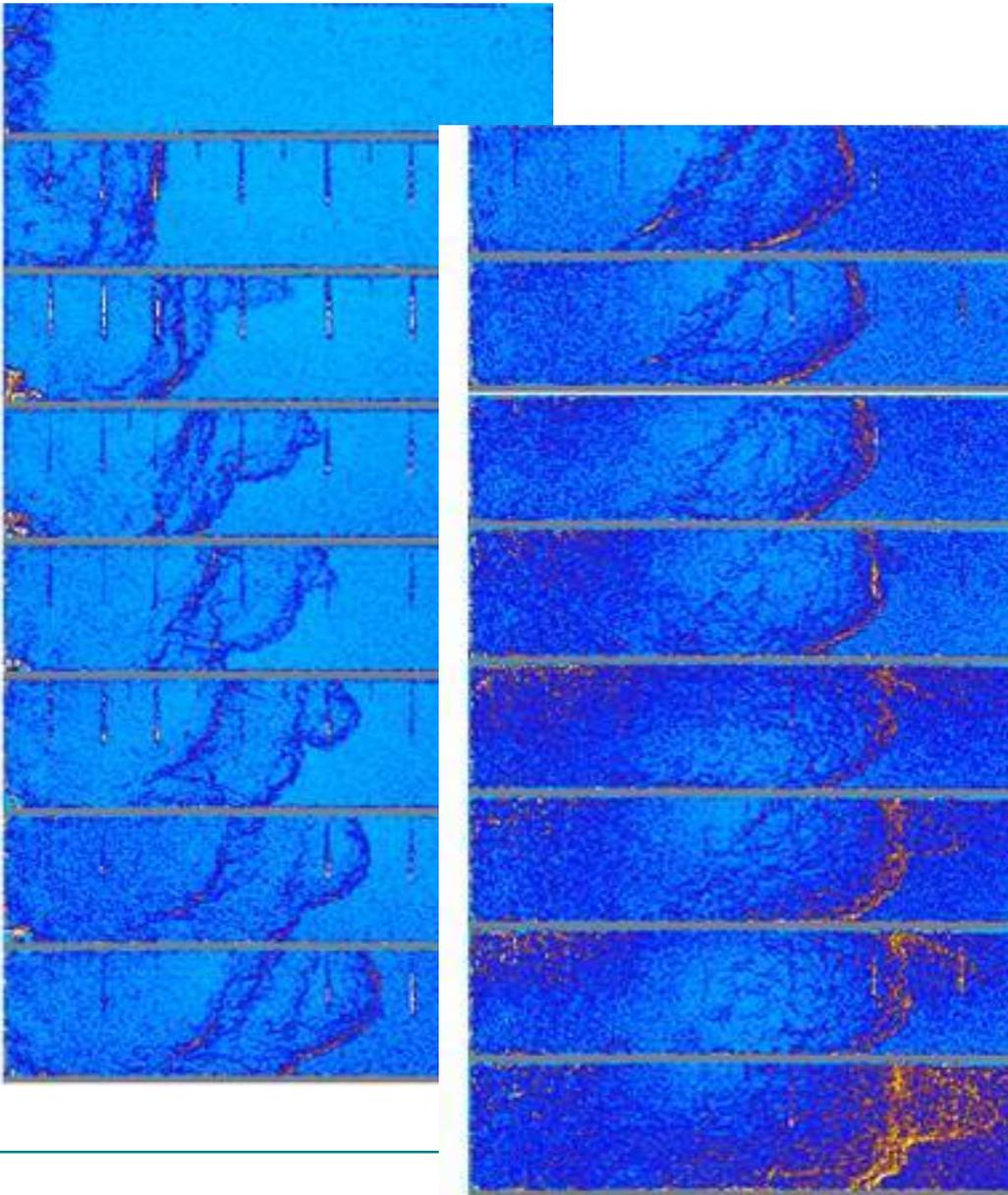
(Quasi-) Detonation
 $v > 1000 \text{ m/s}$, $Ma > 1$

ÜBERDRÜCKE VON H₂ – LUFT - FLAMMEN

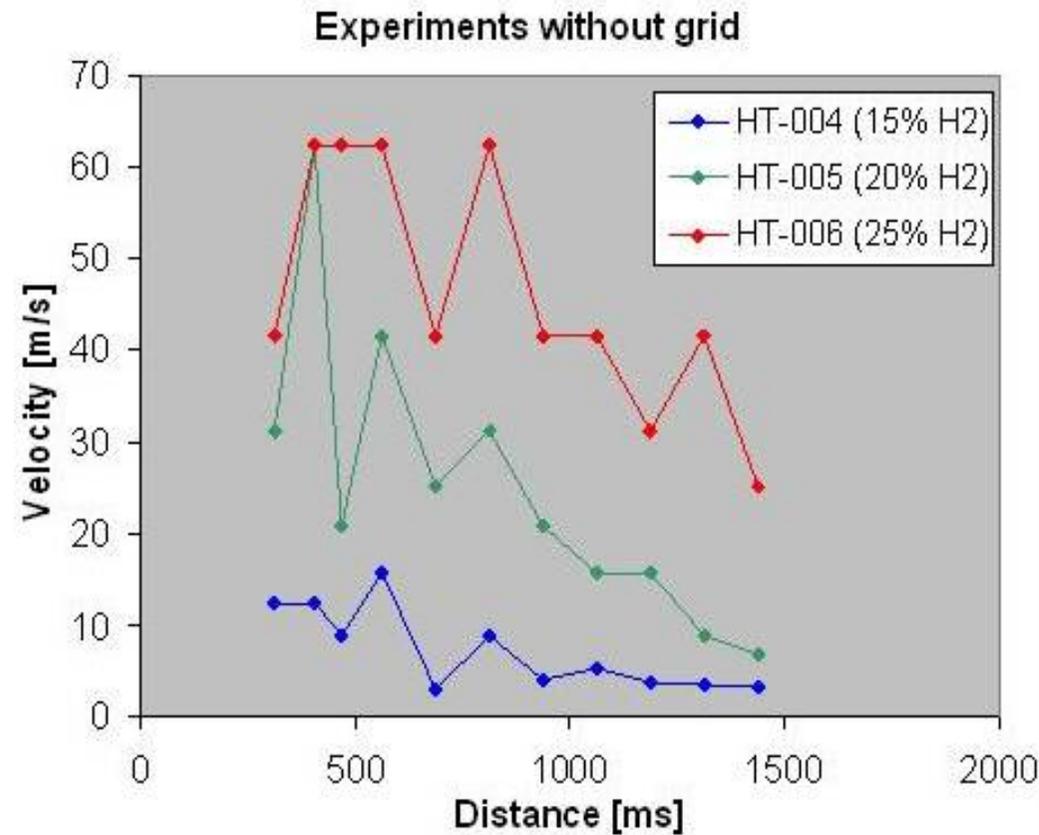


“HyTunnel” – Pretests Results

BOS 15 % H₂/air w/o obstacles



Flame velocity vs. distance



“HyTunnel” – Experimente

Large scale facility (5.7 x 1.6 x 0.6 m)

- effective venting ratio $\alpha = 0.46$ (layer thickness $\delta = 0.15$ m)

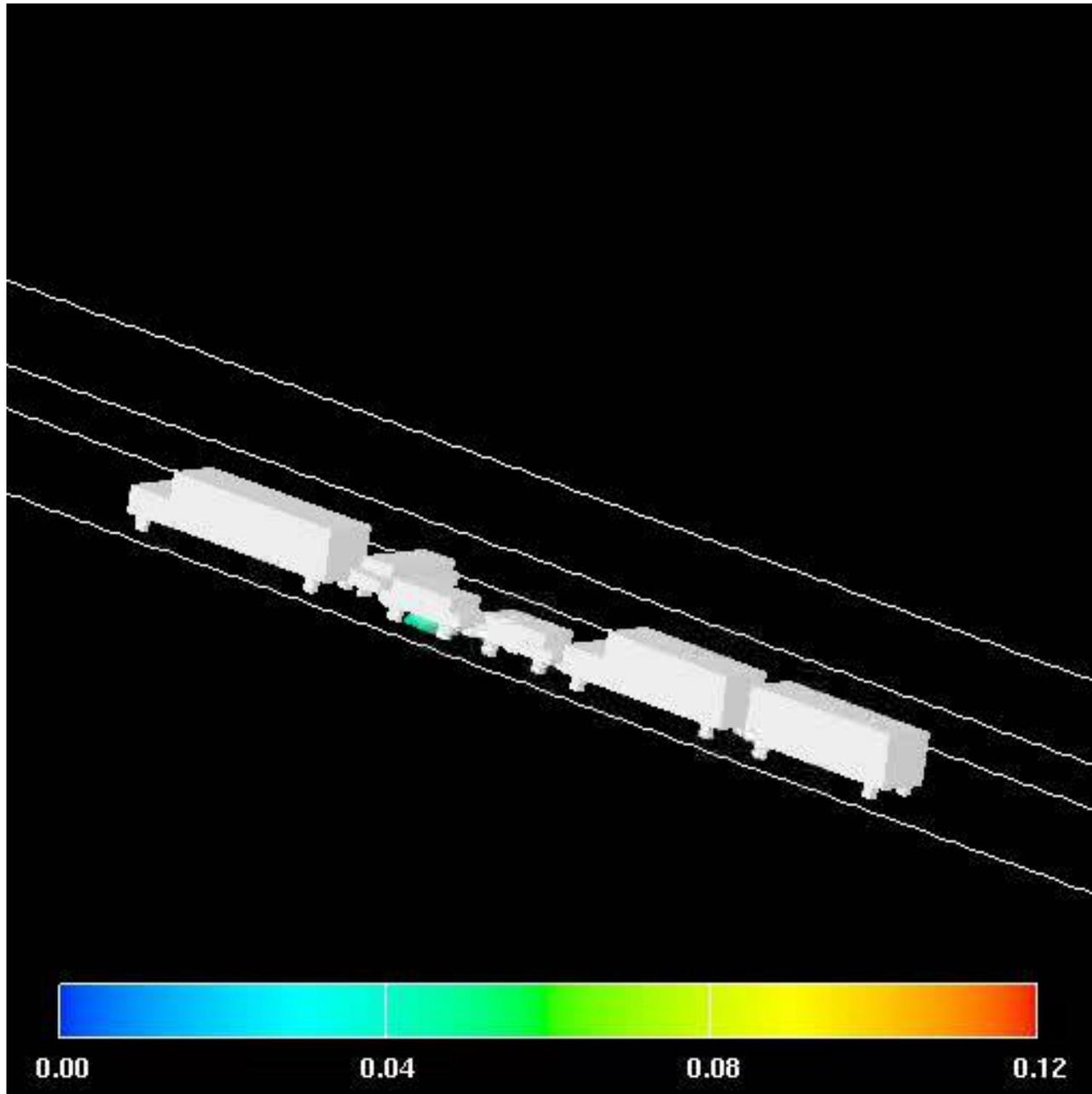
Diagonal view



Film opening



Tunnel-Simulation

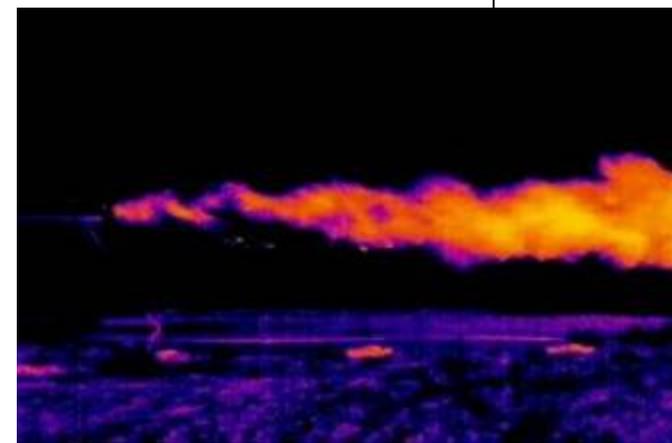


Zündfähige Wolke bei
Freisetzung von 5 kg LH2

WP18.4 “HyNano” – Zielsetzung

Fundamental understanding the safety issues regarding nano-scaled solid-state hydrogen storage materials/systems through:

- (i) development of standard testing techniques to quantitatively evaluate both materials and systems,**
- (ii) understand the fundamental science of environmental reactivity of hydrides and**
- (iii) develop methods and systems to mitigate the risks to acceptable levels.**



nano-structured alanate blown out of a heat exchanger tube at 10 bar and 120 °C (frames of a high speed video (left) and of a infrared video (right) at the same instant)

Wasserstoff-Tankstellen

(Optionales Video)

A simulation contributions to the EC project HyApproval „Handbook for the safe installation/operation of a HRS“ (details on <http://www.hyapproval.org>)

Schulungsmaterial

<http://www.ehammertraining.us/energy/hydrogen/controller.cfm>

Introduction to Hydrogen Safety for First Responders

U.S. Department of Energy
Hydrogen Program
www.hydrogen.energy.gov

COURSE MATERIALS LIBRARY EXIT

Hydrogen Basics Transport & Storage Hydrogen Vehicles Hydrogen Dispensing Stationary Facilities Codes & Standards Emergency Response Summary

Hydrogen Storage for Transport

INCREASE YOUR H₂IQ
www.hydrogen.energy.gov

Tube trailers transport bulk quantities of hydrogen gas, while cargo tanks carry bulk liquid hydrogen. Placards and/or other markings are required on bulk shipments to help first responders recognize the material and respond appropriately in the event of an emergency. Information about those markings is included in the



Liquid Cargo Tanks
Photo: Air Products and Chemicals, Inc.



Tube Trailers
Photo: Praxair, Inc.



Hydrogen Cylinders
Image: Airgas, Inc.

Slide 3 of 4

University of ULSTER
Progress in Hydrogen Safety
International short course series

Hydrogen and fuel cell technologies: Safety issues

29 September - 3 October 2008, Belfast, UK



Early booking recommended for all courses!

Further courses in 2008/2009 series

Hydrogen regulation, codes and standards
January 2009

Safety of hydrogen fuelled vehicles
April 2009

The hydrogen and fuel cell infrastructure
June 2009

Supported by



Forschungszentrum Karlsruhe
in der Helmholtz-Gemeinschaft

Invitation to the 3rd Int. Conf. on Hydrogen Safety September 16-18th, 2009 Ajaccio, Corse, France



Contact: ICHS@hysafe.org

INTERNATIONAL CONFERENCE ON HYDROGEN SAFETY