Latest Advances in Hydrogen Safety R&D

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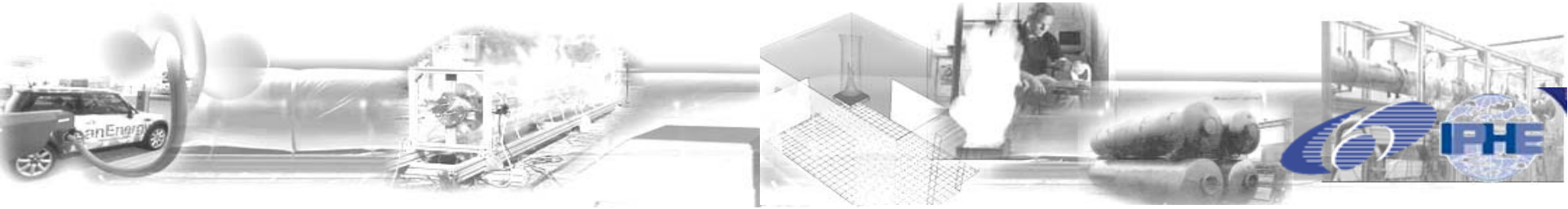
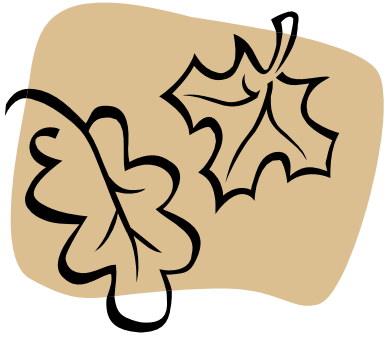
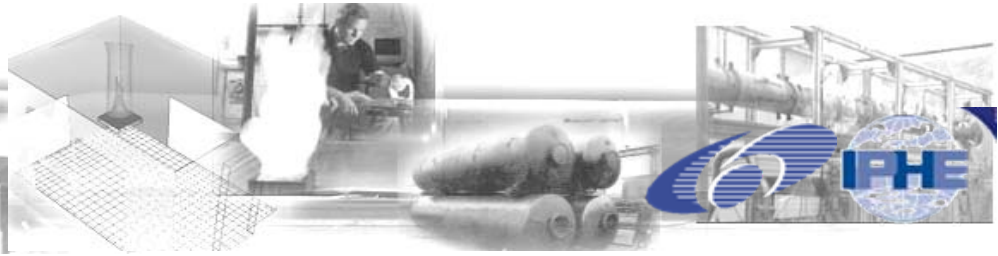
3rd ICHS, 17 September 2009, Ajaccio, Corse, France



Looking back (a little further)





H2 Safety Research Needs

Article "How safe is Hydrogen?" by J. Hord: pp 615 Symposium Papers of the "Hydrogen for Energy Distribution„, Lyon, France, July 24-28, **1978!**

- Provide analyses and experimental data to determine vapor cloud dispersion characteristics (near-field and far-field) resulting from large liquid spills.
- Fires: Assess thermal radiation effects and the effects of water vapor absorption.
- Evaluate existing fire control techniques: dry chemicals, foams, etc. as found useful in controlling LNG fires.
- Experimentally determine vaporization rates for large pools of liquid hydrogen (surface and material effects).
- Correlate analytical studies with experimental studies to determine liquid spreading rates, resulting from large liquid spills.
- Determine practical lower flammable limit for the propagation of open air explosions (8%+ H2-in-air?).
- Experimentally verify detonation in open air detonable clouds. (Evaluate strong initiator and the possibility of transition from deflagration to detonation in the absence of turbulence inducers).

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- Confinement: (What constitutes sufficient confinement to sustain a detonation or higher order explosion?). Determine the effects of weak walls, elastic curtains, etc. on the transition to detionation, relief of deflagrations, etc.
- Model and study the effects of piping complex and turbulence-inducing appurtenances, for example, subdivisions, trees, buildings, etc. on transition to detonation
- Evaluate the effects of various liquid spill quantities, spill-and-surrounding configurations, atmospheric conditions, ignition energy, and ignition time delays on resultant blast hazards.
- Perform systematic studies of the ignition energy of potential ignition sources in order to classify practical ignition sources as weak or strong initiators.
- Establish appropriate flame-arrester criteria and design/develop reliable flame-arresters
- Evaluate odorants and illuminants for improved leakage and flame detection
- Systematically evaluate and catalog the hydrogen embrittlement (material compatibility) characteristics of practical containment materials.

Knowledge gaps listed in the

IEA HIA Task 19 Subtask A report

- Spontaneous ignition
- Protective Barriers
- Wall effects

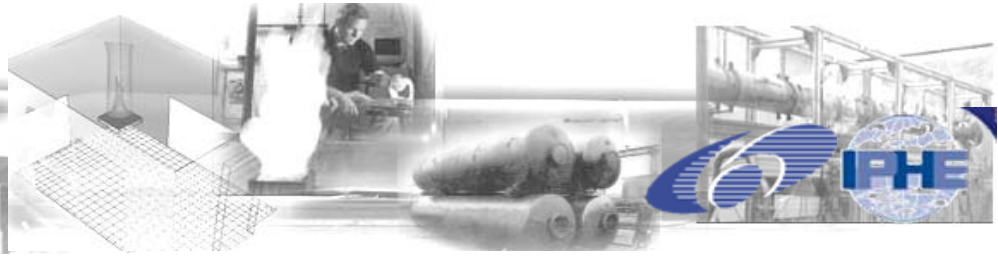
HySafe final report

- Properties and behaviour of cold hydrogen from liquid releases
- Release strategies related to accidental scenarios, i.e. scientifically grounded requirements to location of and operational parameters for pressure relief devices
- Further the understanding of ignition phenomena to allow suitable modelling
- Impinging and wall attached jets and jet fires with the associated heat transfer to set conditions for safe blowdown

Knowledge gaps listed in the HySafe final report

- Transitional combustion phenomena in realistic conditions (low temperatures, congestion, non-uniform mixtures...) and the impact on mitigation measures, for example flame acceleration and deflagration-detonation-transition in the presence of water sprays
- Formulation of requirements for permitting the use of hydrogen vehicles (cars and commercial vehicles) in confined spaces
- Increase the understanding of hydrogen behaviour in confined spaces, with focus on vehicle applications and indoor use of portable hydrogen technologies
- Develop further appropriate safety engineering methodology like a reference quantitative risk assessment methodology and apply it to garage, tunnel scenarios etc
- Development of a reliable reference simulation tool for combustion open to the research community

Subjective list of recently addressed / solved issues



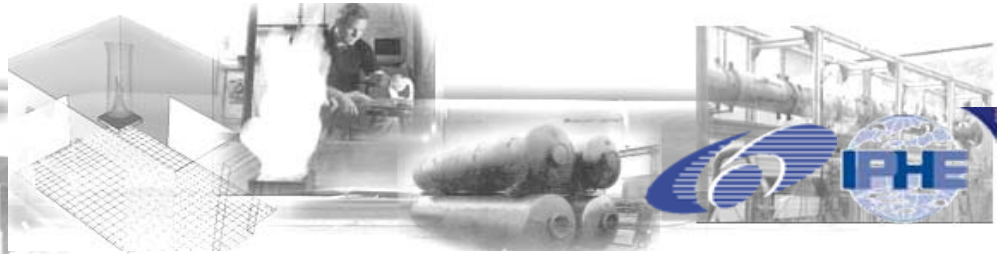
Release and mixing

Permeation

- first modelling of permeation release scenarios with CFD

Jets

- extension of integral models to buoyancy and low temperature regimes based on new experimental data (239)
- Modelling of the expansion zone
- Evaluation of notional nozzle models (see Topical Lecture 2; V. Molkov)
- Wall effects and first experimental work on condensation in the entrainment region (119)



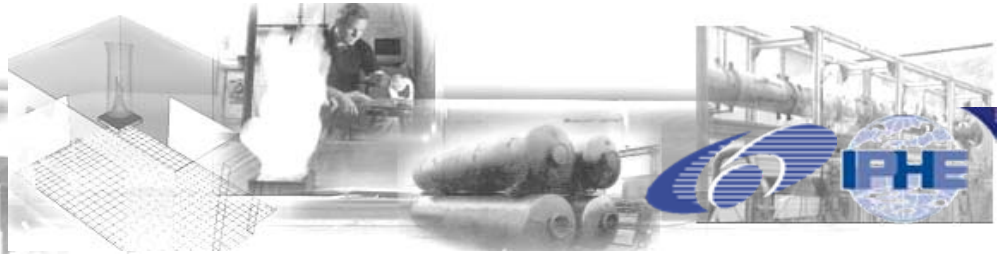
Release and mixing

Engineering models

- Simplified methods for distribution of H2 in confined spaces

LH2 spills

- Validation of LH2 spill modelling in CFD



Ignition, fire and explosion

Diffusion / spontaneous ignition

- CFD modelling and experimental work (216, 265)

New ignition modelling approaches

- Statistical (259) and numerically mechanistic

Combustion of inhomogeneous systems

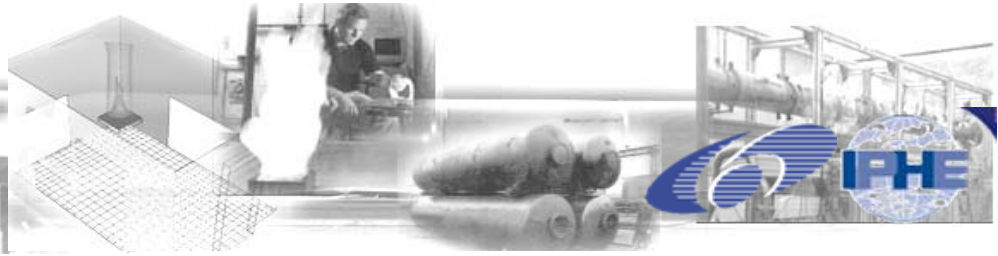
- FA and DDT in semi-open configurations with gradient layers

New mixtures

- Hythane

Limiting inventories

- For internal use and in the free field by large scale tests



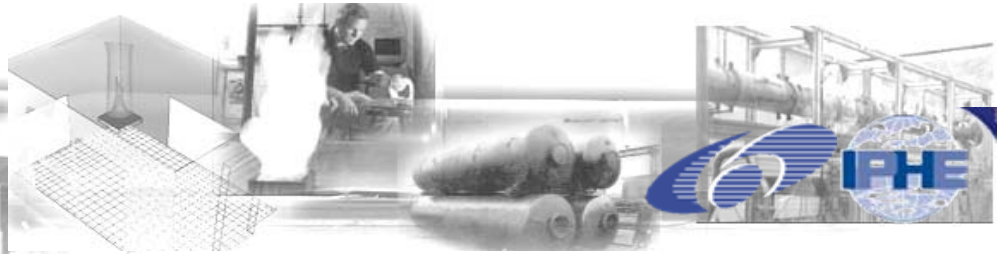
Others

Measurement

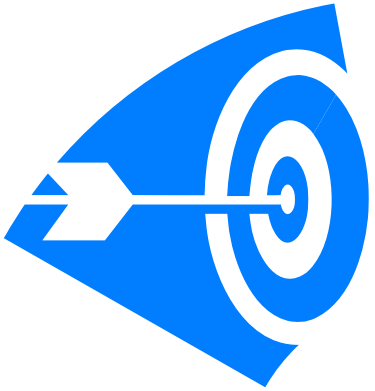
- New qualitative optical technologies
- New color changing indicators
- New optical sensors

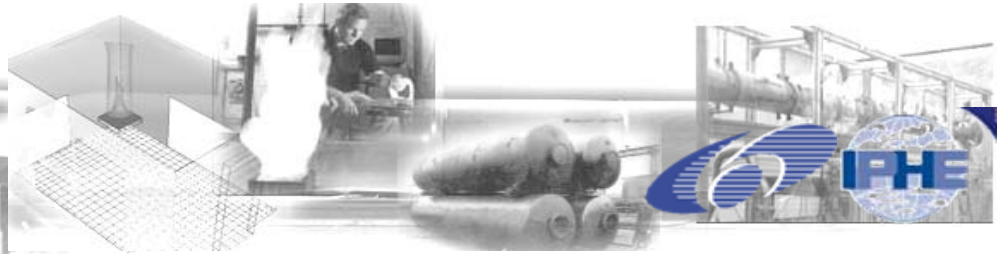
Risk Management

- strong CFD support in QRA



What remains, i.e. where is the target





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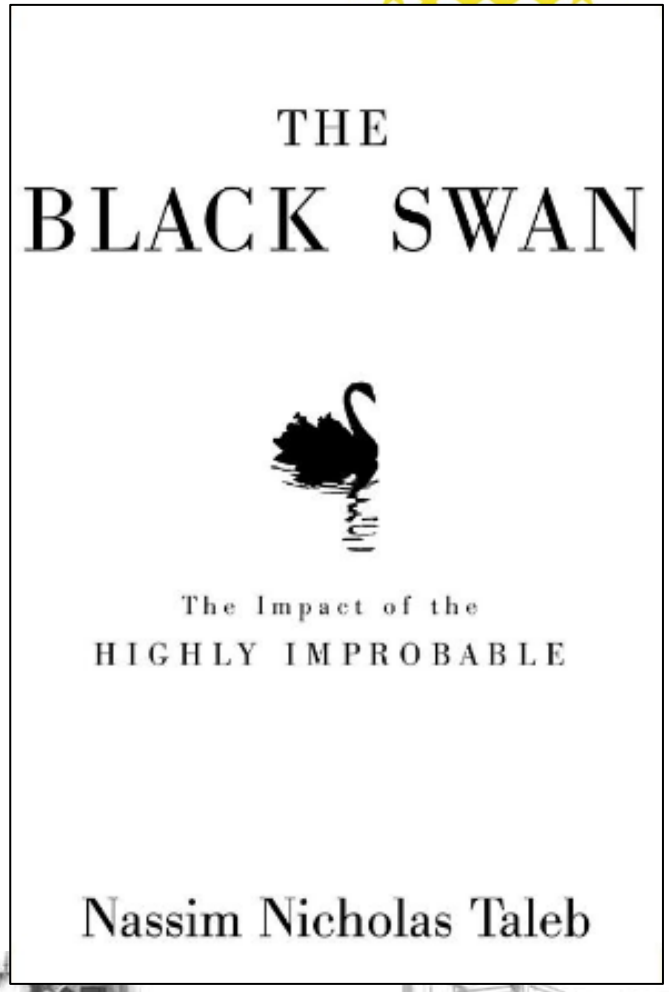
This was the know unknow !?

…

What about the unknown unknown ?? (165, J. LaChance)



We don‘t want to see the „Black Swan“ there→

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Konzerne einigen sich

Artikel-Services

Tankstellennetz für Brennstoffzellenautos geplant

Von Susanne Preuß, Stuttgart

Volltanken für 32,50 Euro? Dieter Zetsche glaubt an die Zukunft der Brennstoffzelle

11. September 2009 In Deutschland soll bis zum Jahr 2015 ein flächendeckendes Netz von Tankstellen existieren, an denen Wasserstoff getankt werden kann. Auf diese Weise soll die Brennstoffzelle als Antrieb für Personenwagen marktfähig gemacht werden. Dies ist der Inhalt einer Absichtserklärung, die in Berlin unterzeichnet wurde. Partner der Initiative mit dem Namen „H2 Mobility“ sind Daimler, der Gasespezialist Linde, die Energieversorger EnBW und Vattenfall, die Mineralölkonzerne OMV, Shell und Total, sowie die Nationale Organisation Wasserstoff- und Brennstoffzellentechnologie (NOW GmbH).

In einem ersten Schritt verpflichten sich die Konzerne, bis zum Jahr 2011 das Netz der aktuell 30 Wasserstoff-Tankstellen nahezu zu verdoppeln. Wenn sich das Projekt positiv entwickle, soll der Ausbau solcher Stationen großflächig fortgesetzt werden. Für die Abdeckung einer Großstadt gelten derzeit fünf bis zehn Tankstellen als ausreichend.