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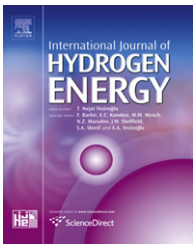

Integration of experimental facilities: A joint effort for establishing a common knowledge base in experimental work on hydrogen safety

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ABSTRACT

In the area of hydrogen safety, research facilities are essential for the experimental investigation of relevant phenomena, for testing devices and safety concepts, as well as for the generation of validation data for the various numerical codes and models. Within the framework of the European HySafe Network of Excellence (NoE), the 'Integration of Experimental Facilities (IEF)' activity has provided basic support for joint experimental work. Even beyond the funding period of the HySafe NoE in the 6th Framework Program, IEF represents a long-lasting effort for the sustainable integration of experimental research capacities and expertise of the partners from different research fields. In order to achieve a high standard in the quality of experimental data provided by the partners, emphasis was put on the know-how transfer between the partners. On the one hand, documentation on the experimental capacities was prepared and analyzed. On the other hand, a wiki-based

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communication platform was established, supported by biannual workshops covering topics ranging from measurement technologies to safety issues. Based on the partners' contributions, a working document was created on best practice including the joint experimental knowledge of all partners with regard to experimental set-ups and instrumentation. The paper gives an overview of the IEF partners and the network activities over the last five years.

1. Introduction

The introduction and commercialization of hydrogen as an energy carrier of the future makes great demands on all aspects of safety. Within the scope of the 6th European Framework Program, the HySafe Network of Excellence (NoE) aimed to integrate European research activities in the area of hydrogen safety and to disseminate the knowledge gained and achievements made. 24 partners from different fields, such as the automotive industry, nuclear safety research, and risk assessment consultancy, contributed to this effort [1].

All HySafe activities and projects were organized in four clusters: 'Basic Research', 'Risk Management', 'Dissemination', and 'Management'. Among these, the work of the 'Basic Research' cluster mainly consisted of knowledge consolidation, thus providing a well-structured hardware and software infrastructure for the network. In this way, the cluster supported internal projects such as InsHyde (releases in confined and partially confined spaces) and HyTunnel (safe tunnels for H_2 vehicles). The ability to adequately assess different accident scenarios was demonstrated in a set of numerical benchmark studies. For validation purposes, these numerical studies were based on high-quality experimental data, especially with regard to the increasing capabilities of high-resolution computational fluid dynamics (CFD) tools.

Consequently, the objectives of the activity known as the Integration of Experimental Facilities (IEF) were to enable the HySafe network to perform joint high-level experimental research by supporting the partners' development of excellence, broadening the fields of experience, and at the same time enhancing the communication and knowledge base.

At the beginning of HySafe, the IEF partners operated numerous test facilities in national and international projects for diverse research tasks ranging from materials research on a laboratory scale to full-scale explosion studies. Consequently, there was a need to identify the partners' expertise, potentially overlapping activities, and possible gaps. Furthermore, the exchange of expertise and know-how between the partners was regarded as one of the keys to providing high-quality experimental data.

2. The partners

The experimental activities in the field of hydrogen safety in Europe mainly originate from two areas. On the one hand, they have developed from safety investigations for natural gas applications. On the other hand, hydrogen has been a safety issue in 'severe accident' research in the field of nuclear technology for more than 20 years. Within the framework of IEF, fifteen partners from both research fields have contributed their specific expertise. Furthermore, the partners come from private and governmental research, industry and universities, and have certain historical differences in their methodologies and approaches addressing safety issues.

2.1. *Governmental research organizations*

The **Federal Institute for Materials Research and Testing (BAM, Germany)** [2] and its precursor bodies have worked on public safety and technical reliability since 1870 on the basis of legal tasks and independent application-oriented research. The fields of activity include testing and investigating classical (e.g. metals) and advanced (e.g. composites) materials, as well as the safe handling of flammable, explosive, or otherwise dangerous substances (gases, explosives) and the development of new test and investigation methods. BAM facilities and expertise are frequently used by external parties from industry and also as standards for comparative experiments.

The **Commissariat à l'Energie Atomique (CEA, France)** [3] has been involved in the field of hydrogen safety issues for more than ten years, initially within the framework of the so-called 'H_2 risk' for pressurized water nuclear reactor containments. In the past two years, CEA has also launched a program on H_2 technologies, which covers topics such as the production and storage of hydrogen, fuel cells and safety.

The **JRC's Institute of Energy (The Netherlands)** [4] is one of seven research institutes involved in the European Commission's Joint Research Center (JRC). It supports the European policy-making process and is a focal point for industry in the area of clean and sustainable energy in both nuclear and non-nuclear domains. Regarding the integration of experimental facilities, the JRC has a full-scale tank testing facility known as GasTeF for comparing and assessing the safety, performance and storage of hydrogen containers, and the SenTeF sensor testing facility. In GasTeF, high-pressure cycling and permeation measurements are carried out on compressed hydrogen storage systems for vehicles. In SenTeF, the performance of hydrogen-sensors is characterized under a wide range of environmental conditions with regard to safety.

The **Health & Safety Laboratory (HSL)** [5] is part of the UK regulatory authority, the Health & Safety Executive (HSE). HSL has developed an international reputation in combustion hazards, including dispersion, ignition, explosion assessment, prevention and protection, process safety and fire. HSL has extensive experimental and modeling facilities. Relevant current work includes the experimental study of ignited/