VIII.15 International Energy Agency Hydrogen Implementing Agreement Task 19 Hydrogen Safety

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Contract Number: Sandia National Laboratories P.O. 970632

Project Start Date: October 12, 2004
Project End Date: October 31, 2010

Fiscal Year (FY) 2011 Objectives

The goal of the Hydrogen Safety Task is to survey and analyze effective risk management techniques, testing methodologies, test data, contribute to development of fundamental knowledge on hydrogen related to hydrogen safety and develop targeted information products that will facilitate the accelerated adoption of hydrogen systems.

The specific objectives of this task are to:

- Survey risk assessment methodologies based on case studies provided by collaborative partners.
- Survey available test data, develop recommendations on modeling and testing methodologies, and share future test plans around which collaborative testing programs can be conducted thus avoiding duplication of work among collaborative partners.
- Collect information on the effects of component or system failures of hydrogen systems.
- Use the results obtained to develop targeted information packages for selected hydrogen energy stakeholder groups.

Technical Barriers

This project addresses the following technical barriers from the Hydrogen Safety section (3.8) of the Fuel Cell Technologies Program Multi-Year Research, Development and Demonstration Plan:

(A) Limited Historical Database
(B) Proprietary Data
(C) Validity of Historical Data
(D) Liability Issues
(E) Variation in Standard Practice of Safety Assessments for Components and Energy Systems
(F) Safety is not Always Treated as a Continuous Process
(G) Expense of Data Collection and Maintenance
(H) Lack of Hydrogen Knowledge by Authorities Having Jurisdiction

Contribution to Achievement of DOE Hydrogen Safety Milestones

This project will contribute to achievement of the following DOE milestones from the Hydrogen Safety section of the Fuel Cell Technologies Program Multi-Year Research, Development and Demonstration Plan:

- **Milestone 2**: Develop sensors meeting technical targets. (4Q, 2012)
- **Milestone 7**: Complete risk mitigation analysis for baseline transportation infrastructure systems. (1Q, 2012)
- **Milestone 8**: Complete investigation of safe refueling protocols for high pressure systems. (1Q, 2012)
- **Milestone 9**: Complete risk mitigation analysis fir advances transportation infrastructure system.s (1Q, 2012)
- **Milestone 12**: Complete research needed to fill data gaps on hydrogen properties and behaviors. (2Q, 2010)

FY 2011 Accomplishments

In 2010, the task continued to compare experimental data with risk analysis methods to validate the models and further close the knowledge gaps identified in earlier work. The subtask also completed the development of the Hydrogen Technical Experimental Database (HyTEx). Starting in late 2009, the populating of the data base with data from participating countries was begun. Technical progress on the development of risk informed approval criteria for hydrogen projects to provide a solid basis for risk informed codes and standards was completed.

- Established a list of relevant engineering models that had been used to evaluate the safety of hydrogen systems, categorized them, and performed a comparative analysis with actual testing data.

- Several dispersion models were further developed in 2009 by extending their capabilities to include surface and transient effects (November 2009).
- Developed a more detailed thermal radiation model.
- Completed development of HyTEx.
- Task participants presented many papers at technical conferences on subjects that dealt with the collaborative work.
- The International Energy Agency (IEA) Hydrogen Implementing Agreement co-organized the September 2009 Third International Conference on Hydrogen Safety and Task 19 members presented more than 10 technical papers.

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Introduction

Acceptability of new systems is traditionally measured against regulations, industry and company practices and the judgment of design and maintenance engineers, however contemporary practice also incorporates systematic methods to balance risk measurement and risk criteria with costs. Management decisions are increasingly relying on quantitative risk assessment (QRA) for managing the attainment of acceptable levels of safety, reliability and environmental protection in the most effective manner. QRA is being applied more frequently to individual projects and may be requested by regulators to assist in making acceptance and permitting decisions. This task was approved by the executive committee of the IEA Hydrogen Implementing Agreement (HIA) in October 2004. The Task is currently comprised of 11 participating countries.

Approach

This task, aimed at reducing the barriers to widespread adoption of hydrogen energy systems, is being accomplished within three subtasks:

Subtask A. Risk Management - To survey QRA methodologies and compare assessments of hydrogen systems with conventional fuels to develop recommendations for modeling and testing methodologies around which collaborative testing programs can be conducted. Subtask A Risk Management is concentrating on the following four activities:

- Develop uniform risk acceptance criteria and establish link with risk-informed codes and standards.
- Develop a list of appropriate engineering models and modeling tools. Develop simple but realistic physical effects models for all typical accident phenomena (i.e., jet fires, vapor cloud explosions, flash fires, boiling liquid expanding vapor explosions, pool fires, etc.) for education and training, design evaluation and simplified quantitative risk analysis purposes.
- Develop a methodology for consistent site risk assessment based on the HyQRA approach.
- Release updates to all published products: Risk assessment methodology survey, knowledge gaps white paper and Review and comparison of risk assessment studies.

Subtask B. Testing and Experimental Program - To conduct a collaborative testing program to evaluate the effects of equipment or system failures under a range of real life scenarios, environments and mitigation measures. This subtask will summarize and ultimately coordinate and guide the experimental programs being conducted within the 11 countries participating in the task. The approach is to identify such testing programs, the facilities being used, and to coordinate the activities to fill in the data and knowledge gaps for the development of risk informed codes and standards. Subtask B focuses on both testing and experimental data, i.e., testing data as collected by checking the performance of applications and equipment and experimental data as collected by experiments with hydrogen release, ignition, fire, explosions and preventive and protective measures.

Subtask C. Information Dissemination - To disseminate results of the task through targeted information packages for stakeholders. An important aspect of information dissemination is to ensure that the review and vetting of all work products for Task 19 are consistent with the requirements and procedures for producing, approving and distributing various types of IEA reports and other information products. A protocol has been adopted by Task 19 partners and is being applied appropriately for Task 19 work. It is expected that several of these Subtask C products will be updated and enhanced over the course of the period covering Task 19 through October, 2010.

Results

The IEA HIA Task 19 on Hydrogen Safety was approved in FY 2004 and the first task definition meeting was held in Washington, D.C. in June 2004. The Task 19 participants conducted their 11th and 12th meetings in FY 2011. FY 2011 task participation is comprised of experts as noted in Table 1.

The active work on Task 19 ended very early in FY 2010. A draft Final Technical Management Report was submitted to the IEA HIA Secretariat in May 2011. The HIA Secretariat is in the process of changing the format and enhancing the content of these reports and as a result the final report is waiting that information and will revise the report to comply as soon as it is available.

In 2010, the task continued to compare experimental data with risk analysis methods to validate the models and further close the knowledge gaps identified in earlier work. The subtask also completed the development of the HyTEx. Starting in late 2009, the populating of the data base with

TABLE 1. Task 19 Participants Attending the Karlsruhe Meeting

Name	Company/Institute	Country Represented
Hoagland, Bill	ELEMENT ONE	Operating Agent
Benard, Pierre	UQTR	Canada
Weiner, Steven C.	PNNL	USA
Tchouvelev, Andrei V.	AVT	Canada
Bernard-Michel, Gilles	CEA	France
Khalil, John	UTRC	USA
Venetsanos, Alex	NCSRD	Greece
Miyashita, Sam	ENAA	Japan
Koos, Ham	TNO	The Netherlands
Prankul, Middha,	GexCon	Norway
Kotchourko, Alexei	KIT – Campus Nord	Germany
Molkov, Vladimir	UU	UK
Bouet, Rémy	INERIS	France
Kessler, Armin	Fraunhofer ICT	Germany
Vagsaether, Knut	TELEMARK U.C:	Norway
Hoskin, Aaron	NRCan	Canada
Houf, Bill	Sandia	USA
Jordan, Thomas	KIT-Campus Nord	Germany
Carcassi, Marco	UNIPI	Italy
Buttner, Bill	NREL	USA
Ruban, Sidonie	AIR LIQUIDE	France
Baraldi, Daniele	JRC	EC

data from participating countries was begun. Technical progress on the development of risk informed approval criteria for hydrogen projects to provide a solid basis for risk informed codes and standards was completed.

Risk Management

Prior to 2010, the task had established a list of relevant engineering models that had been used to evaluate the safety of hydrogen systems and categorized them. In past year, they were compared to each other to assess their limitations and validity. Part of this effort was achieved through comparing the engineering models to actual testing data. Several dispersion models were further developed in 2009-2010 by extending their capabilities to include surface and transient effects. A more detailed thermal radiation model was also developed that would account for crosswinds.

A risk assessment methodologies survey was completed for existing risk assessment methodologies to identify their key elements, approaches, methodologies, methods of analysis, key results and recommendations, and post-study developments. Keeping this information in one document was useful to the ongoing evaluation to ascertain their differences and applicability. The survey also identified interesting findings when each was reviewed and compared. This gave insights to allow the identification of knowledge gaps. It was intended that this document be continually updates and new information was identified. This survey was followed by a comparative analysis of the available risk assessment studies.

A knowledge gaps report which was started at the beginning of the Task 19 was updated and wil continue to be updated in the new Task 31. The goal of this activity was to focus research and development resources on critical topics for which there was insufficient information to complete a detailed QRA new commercial systems. Improved safety comes from understanding the outcomes and probabilities of undesirable events that may occur with new technologies, and by mitigating any unacceptable risks posed by these new technologies. In this regard, while a lot is known about hydrogen combustion and its safe handling, it is important to realize that hazards with new hydrogen technologies that are unrecognized or not completely understood are difficult to mitigate. As a result, before appropriate mitigations can be developed, the underlying risks must be identified, quantified, and be well understood. In a white paper, the IEA Task 19 hydrogen experts tried to identify knowledge gaps and barriers for selected applications and to indicate how they can be overcome.

Testing and Experimental Program

An inventory of existing testing and experimental data is in progress and the participants have started sharing information during and beyond the Task 19 into Task 31 which was approved in October 2010. Ongoing work and future activities will start with a search by the partners for available data existing in their respective countries and around the world. In order to secure a continuing refinement of the survey, the data and/or references will be stored in HyTEx. The Subtask B databases HyTEx, Hydrogen Projects and Hydrogen Testing and Experimental Facilities will be used as a source of information for any missing data in relation to the knowledge gaps as defined by and resulting from the Subtask A activities. If data is not available this could give rise to recommendations on new testing and experimental programs. Several technical knowledge gaps were identified in Subtask A and described in the white paper ‘Knowledge Gaps in Hydrogen Safety’. Currently identified knowledge gaps are: spontaneous ignition, protective barriers and consequence modeling.

Development of Targeted Information Packages for Stakeholder Groups

The targeting of information packages for selected hydrogen energy stakeholder groups is central to the work and objectives of Task 19, currently focused on risk assessment methodologies and studies, testing and experimental programs, safety training and knowledge resources and hydrogen facility siting. Information packages can take a variety of forms: IEA publications, publicly available web-based tools, databases and documents for use by Task 19 partners.

Conclusions and Future Directions

The current task ended in October 2010 and a new task on hydrogen safety was approved to continue to build on the very effective collaboration of this six-year effort. A kick-off meeting for the new task was held in Karlsruhe, Germany in April 2011. It is anticipated that one of the major outcomes of this ongoing work will a technical and credible basis for the development of risk informed codes and standards that will not be unnecessarily restrictive. This will eliminate a major barrier to the widespread commercial adoption of hydrogen energy systems. Future work will support this goal by improving hydrogen risk assessment methodologies and quantitative risk analysis and closing knowledge gaps with regard to consequences of hydrogen related accidents and incidents, the effects of mitigation methods, and failure probabilities of system components.

FY 2011 Publications/Presentations

1. International Energy Agency Hydrogen Implementing Agreement Task 19, Hydrogen Safety Final Technical Management Report (Draft), June 4, 2011.