IX.11 International Energy Agency Hydrogen Implementing Agreement Task 19 Hydrogen Safety

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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; and
- 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 systems (1Q, 2012)
- Milestone 12: Complete research needed t fill data gaps on hydrogen properties and behaviors (2Q, 2010)

Accomplishments

In 2009, 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 (HyTEx) database. 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 the HyTEX database.
- 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.

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 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 hydrogen quantitative risk assessment (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

In 2009, 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 database. Starting in late 2009, the populating of the database 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.

Risk Management

Prior to 2009, 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 2009 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 by extending their capabilities to include surface and transient effects. A more detailed thermal radiation model was also developed that would account for crosswinds.

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 meetings. This has been extended (and will be in the future activities) by a search by the partners for any 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 the HyTEx database. The Subtask B databases HyTEx, HYPRO and HYTEF 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. The existing data can also be checked on its relevance and completeness. A first set of knowledge gaps has been 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 is scheduled to be completed in October 2010 and a new task on hydrogen safety is being developed to continue to build on the very effective collaboration of this six-year effort. 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 2010 Publications/Presentations

1. Houf, W.G., Evans, G.H., James, S.C., "Simulation of Hydrogen Releases from Fuel-Cell Vehicles in Tunnels," 18th World Hydrogen Energy Conference, Essen, Germany, May 16–21, 2010.

2. LaChance, J., Phillips, J., Houf, W., "Risk Associated with the Use of Barriers in Hydrogen Refueling Stations," 18th World Hydrogen Energy Conference, Essen, Germany, May 16–21, 2010.

3. Houf, W.G., Schefer, R.W., Keller, J., Blake, C., Hoagland, B., Pitts, W., Royle, M., Ruban, S., Jallais, S., Bengaouer, A., Shirvill, L., Gautier, T., Suzuki, J., Willoughby, D., "An Overview of IEA Annex 19, Subtask B: Experimental Data Bases Relevant to Hydrogen Safety Standards, Development, 18th World Hydrogen Energy Conference, Essen, Germany, May 16–21, 2010.