Lessons Learned:
U.S. Department of Energy Hydrogen Codes and Standards Program

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Goal of the Safety Codes and Standards Subprogram

To develop and implement the practices and procedures that will ensure safety in the operation, handling, and use of hydrogen and hydrogen systems for all DOE funded projects; to ***perform underlying research to enable codes and standards to be developed for the safe use of hydrogen in all applications; and to facilitate the development and harmonization of domestic and international codes and standards***.

Codes and standards development is a lengthy and ongoing process: a process that does not easily respond to the urgency of our energy issues.

Hydrogen Codes and Standards Program

- Program focuses on data required by the codes and standards process
- Facilitates communication
- Partially funds administrative costs of the SDO/CDO consensus process

- Significant progress has been made in the development of codes and standards through leveraging of limited resources
  - 9 active US Codes and Standards Organizations working on hydrogen
  - 22 C&S published, 10 of which are under revision
  - 28 draft C&S under preparation/review
  - 4 International C&S published, 13 under preparation/review
  - See www.fuelcellstandards.com

Federal Role

Because of the large number of interested parties in Codes and Standards activities – parties which represent competitive entities and which are both national and international – the Federal government is uniquely positioned to facilitate progress towards harmonized Codes & Standards and improved safety

- Lead Research
- Coordinate international participation
- Facilitate working relationships among cooperative and competing industries
- Publish and disseminate results
- Collaborate with multiple government agencies including Federal, State, and Local governments
- Educate codes and standards officials, first responders, and policy makers – in cooperation with DOE Hydrogen Education activity
- Critical DOT roles in hydrogen pipelines, vehicle safety, and international regulations

Facilitating Codes and Standards Development is a Communications Issue

SDO/CDO

Government Agencies

R&D Community

International

Communication

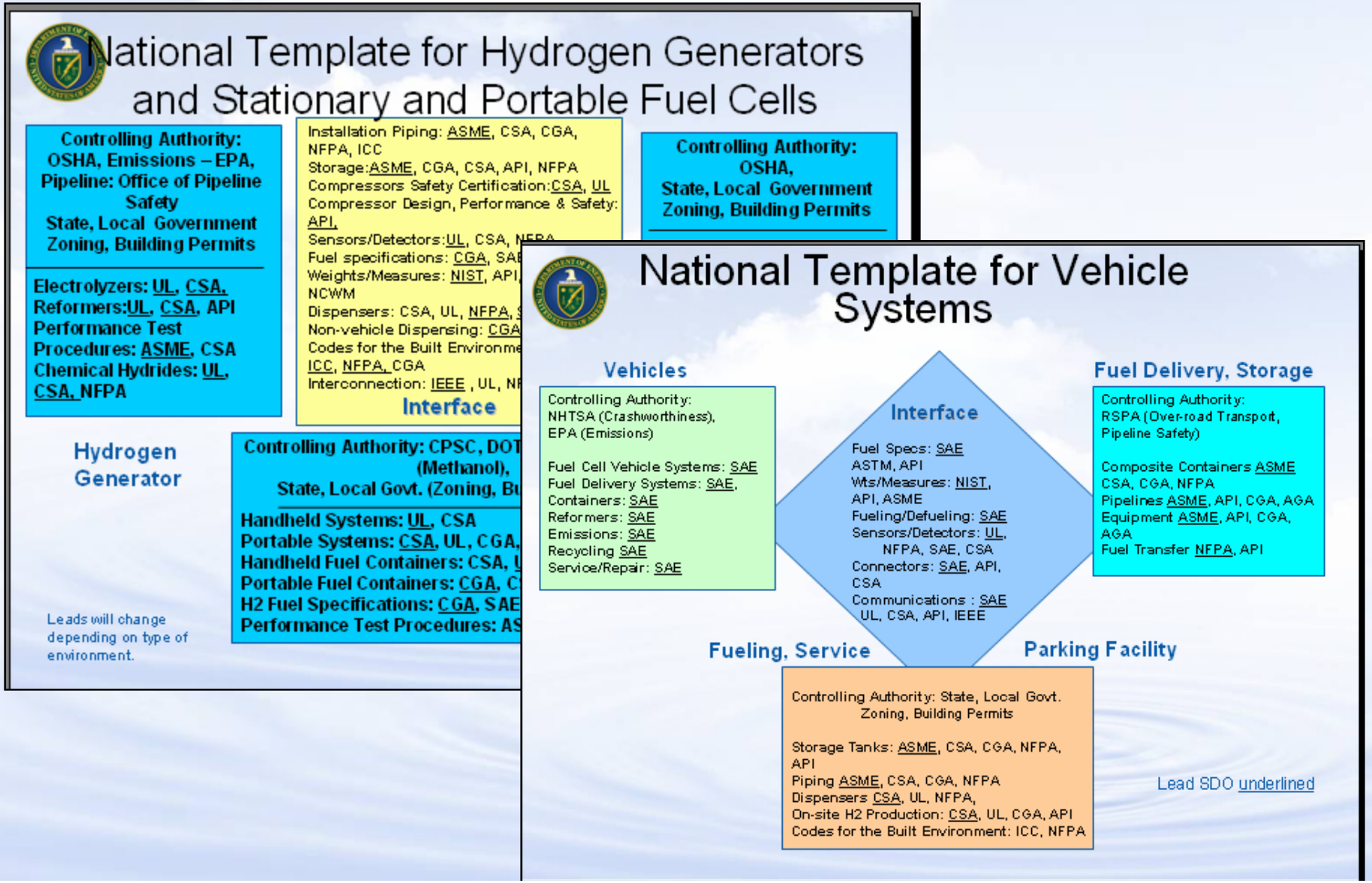
Stakeholders

First Responders

Code Officials

Public

"National Templates" for Hydrogen Codes and Standards



National Hydrogen and Fuel Cells Codes & Standards Coordinating Committee

Mission: *Working collaboratively to support and facilitate development of needed new hydrogen and fuel cell codes and standards and/or facilitate incorporation of safety requirements into existing codes and standards*

Includes representatives from:

- **SDOs and CDOs**
- **Hydrogen and energy industry**
- **Fuel cell industry**
- **OEMs producing products that use hydrogen and/or fuel cells**
- **National laboratories (NREL)**
- **Federal and state agencies (DOE, DOT, NIST)**
- **Other interested stakeholders (e.g., California Fuel Cell Partnership, etc.)**

For more Information:
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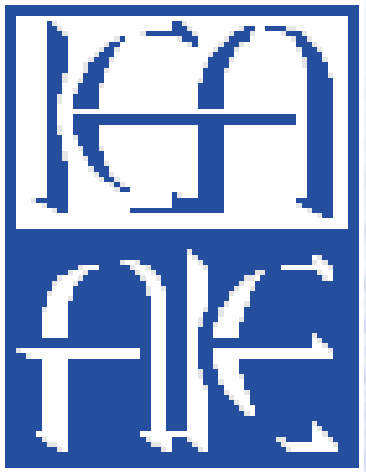
Other Collaboration

Critical to Success

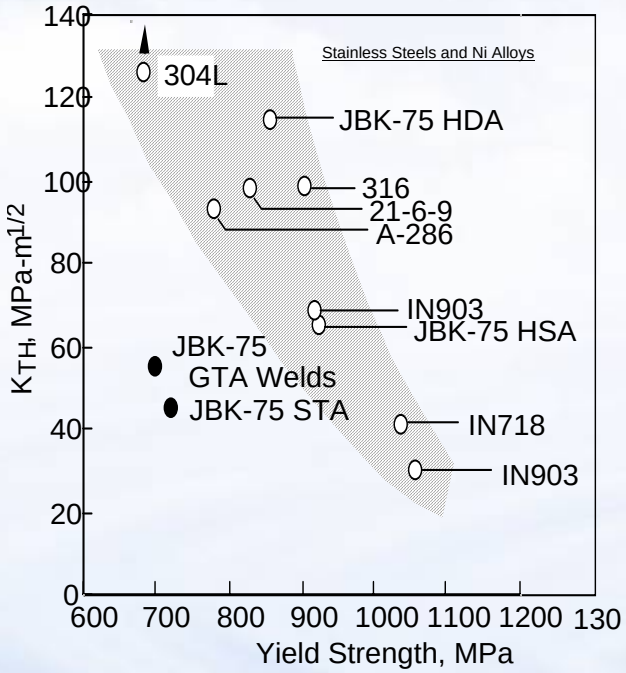


- **FreedomCAR and Fuel Partnership Codes and Standards Tech Team**
- **HIPOC (ICC/NFPA harmonization)**
- **International:**
  - **Sharing of data**
  - **Sharing of Lessons Learned**
  - **Harmonization of Codes and Standards**
- **Hydrogen Quality R&D**

V1.0 of *Technical Reference for H2 Compatibility of Materials* Complete

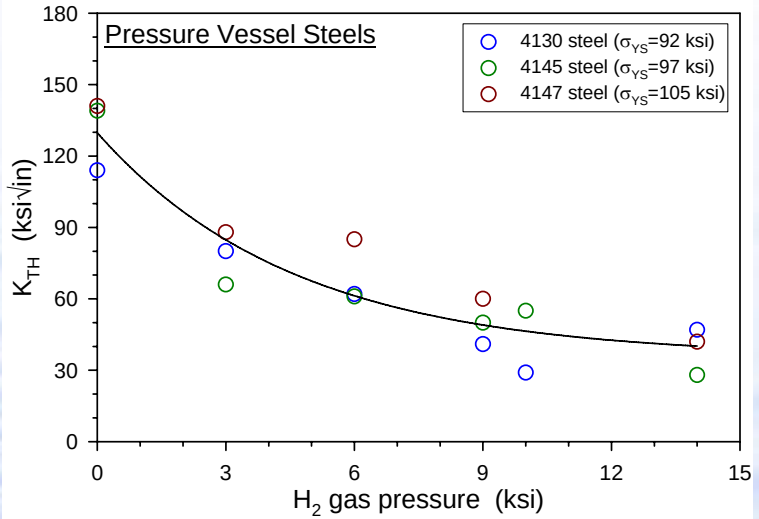
http://www.ca.sandia.gov/matlsTechRef/

Effect of Strength on Cracking in H_2



- Increased material strength lowers threshold for H_2-assisted crack growth

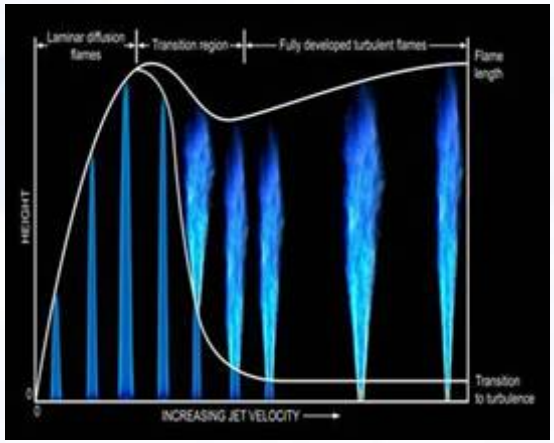
Effect of Pressure on Cracking in H2



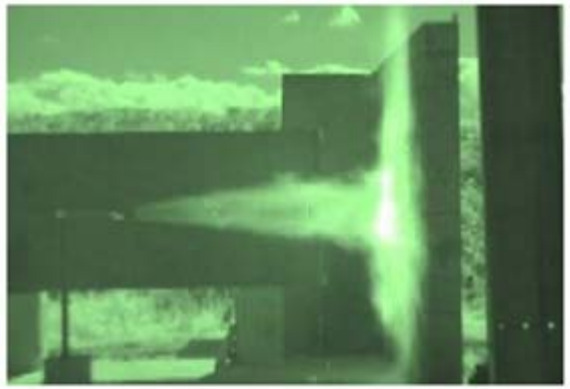
- Increased H_2 gas pressure lowers threshold for H_2-assisted crack growth

Data Published: Hydrogen Combustion and Release Scenarios

Flame Characterization

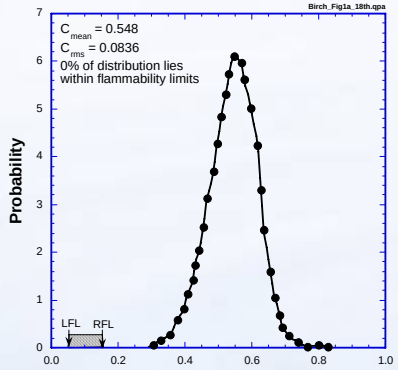


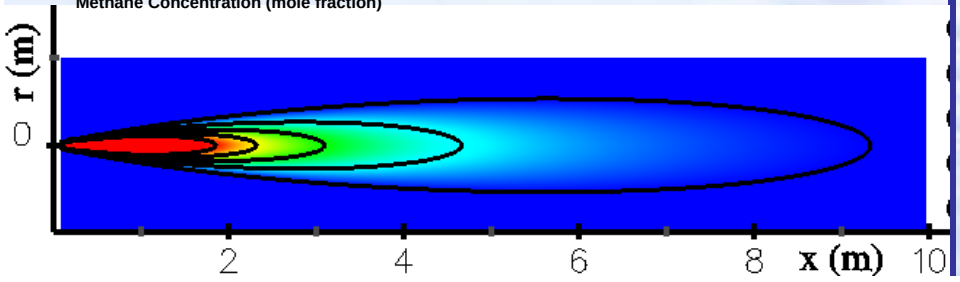
Experimentally Measure Heat Flux



Impinging jet, 10 ft impingement diameter

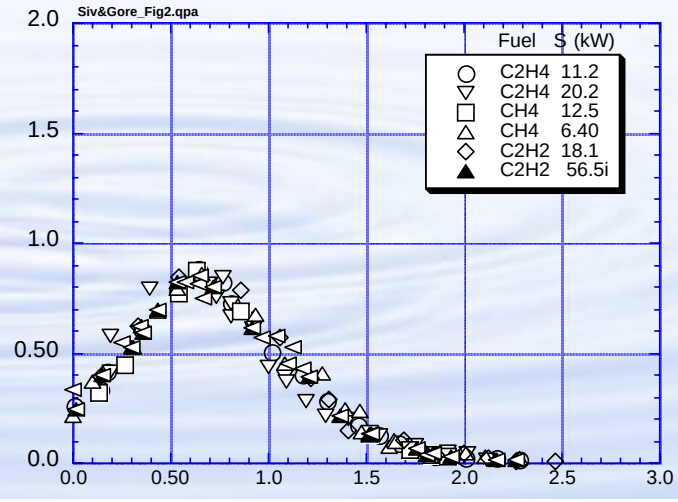
Flammability Limits & Ignition Probabilities





Thermal Radiation Models

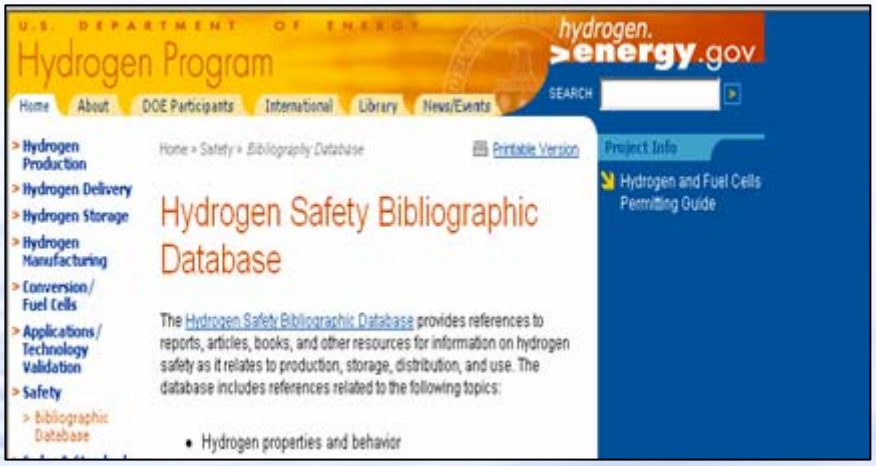
$$C^*(x/L) = 4 \pi R^2 q_{rad}(x/L) / S_{rad}$$



Safety Program Highlights – Web Resources

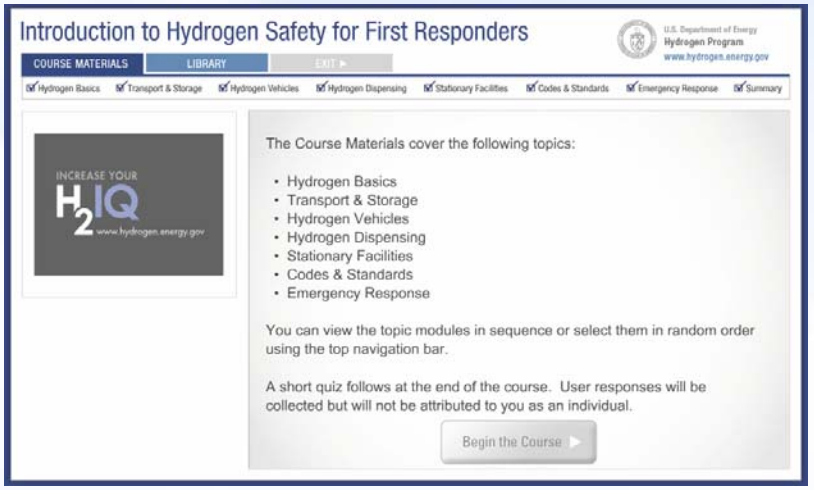
- **H2 Incidents Database**
  - Information on hydrogen incidents and lessons learned
  - 103 incidents documented as of February 2007
  - **www.h2incidents.org**

- **Bibliographic Database**
  - Contains approximately 400 publications related to hydrogen safety
  - **www.hydrogen.energy.gov**



Related Education Activities: First Responders

- **Introduction to Hydrogen Safety for First Responders**
  - 7-module, web-based basics course (includes quiz and video, animations, graphics for visual audience)
  - Print and CD versions available for free from DOE Information Center
  - Development included broad review involving hydrogen industry and emergency response community
  - Averaged 240-250 unique users/week since course launch in Jan 2007
  - Positive feedback from emergency response community – users include fire fighters, fire department training coordinators, fire marshals, fire plans inspectors/examiners, law enforcement personnel, industry, military, others

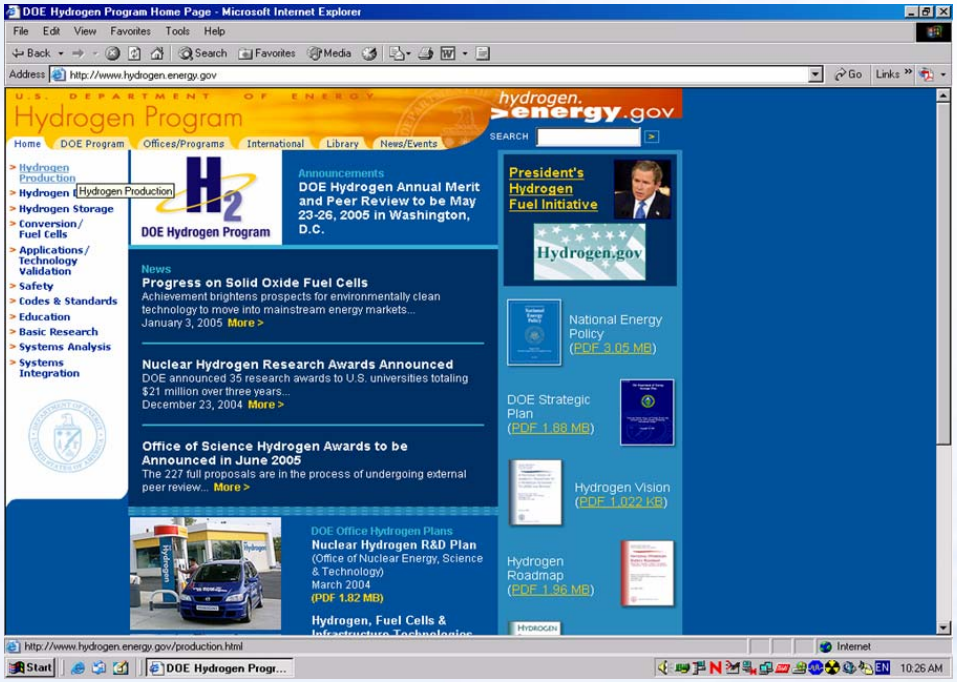


www.hydrogen.energy.gov/firstresponders

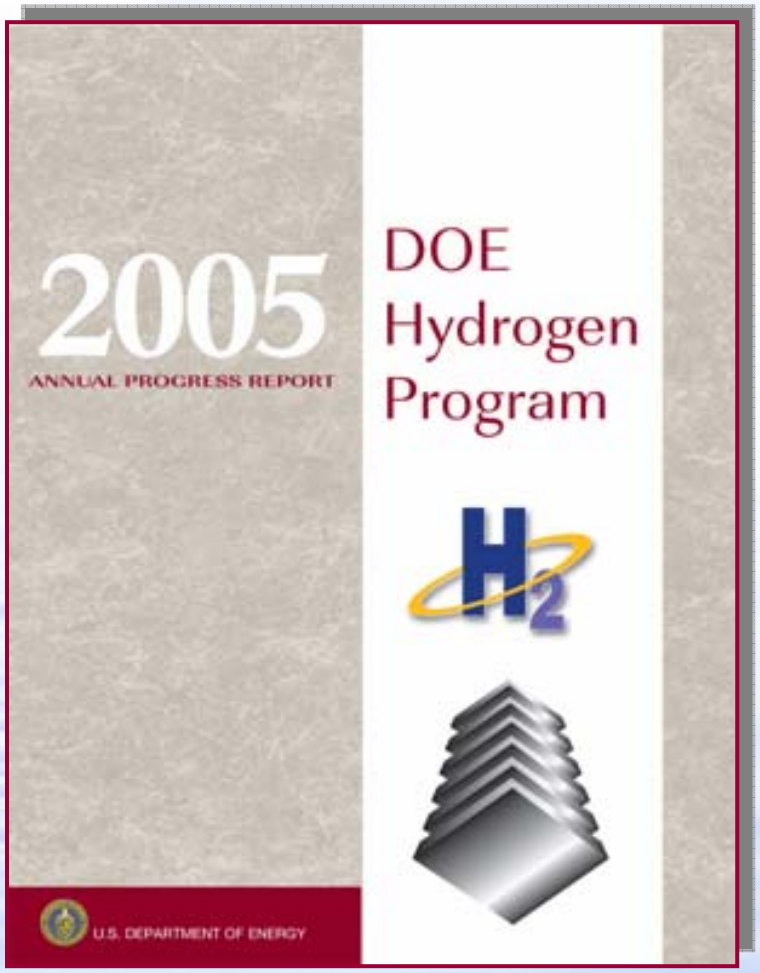
A “Cliffs Notes” poster is available for fire houses, free from the DOE Information Center

For More Information

Website: www.hydrogen.enery.gov



Annual Progress Report



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