Hydrogen Safety, Codes and Standards: Overview of US DOE Program

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Overall Objective

Support development of performance-based Codes and Standards that facilitates technology introduction but does not hinder technology innovation.

- R&D that support codes and standards development
  - Hydrogen Behavior (releases, combustion, etc)
- Testing that supports standards development (tanks, nozzles, components)
- Direct support of standards development organization (SDO) and model code development organization (CDO) activities
- International C&S activities that support harmonized global standards and regulations

Challenges/Barriers

- Insufficient technical data available to set codes, standards and regulations – yet non-hydrogen and industrial codes are often referenced
- Inadequate budget to execute R&D program
- Complex, consensus system of codes and standards and competition between SDOs and CDOs
- Approximately 44,000 independent local government jurisdictions in the U.S. with limited hydrogen experience and training
- International standards: challenge to secure, coordinate, and sustain adequate U.S. participation
- Harmonization of domestic and international standards

Key Activities

- Unified national agenda for codes and standards
  - DOE, USFCC, NHA created National H2-FC C&S Coordinating Committee as national focal point and consensus on key C&S issues and needs
  - ANSI hydrogen portal (www.hcsp.ansi.org)
    - incorporates C&S matrix and website (www.fuelcellstandards.org)
    - browse H_2-FC and download standards and model codes
- R&D to develop defensible standards for hydrogen systems
  - Codes and Standards Tech Team and R&D Roadmap implementation
    - hydrogen behavior
    - whole-system engineering research approach for hydrogen safety
    - R&D/test plan for hydrogen fuel quality
- Harmonize technical standards and global technical regulations
  - US Technical Advisory Group, ISO/TC197, Hydrogen Technologies
  - ISO and IEC Working Groups to prepare hydrogen and fuel cell standards
  - Participate in HyApproval, HyWays, HyPer, GRPE
  - Collaborate with HySafe

National Template: Vehicle Systems and Refueling Facilities

Vehicles

Controlling Authority:
DOT/NHTSA (Crashworthiness)
EPA (Emissions)

Standards Development:
General FC Vehicle Safety: SAE
Fuel Cell Vehicle Systems: SAE
Fuel System Components: CSA
Containers: SAE
Reformers: SAE
Emissions: SAE
Recycling SAE
Service/Repair: SAE

Interface

Fuel Specs: SAE
ASTM, API
Wts/Measures: NIST,
API, ASME
Fueling: SAE, CSA
Sensors/Detectors: UL,
NFPA, SAE, CSA
Connectors: SAE, CSA
Communications : SAE
UL, CSA, API, IEEE

Fuel Delivery, Storage

Controlling Authority:
DOT/PHMSA (Over-road
Transport**,** Pipeline Safety)

Standards Development:
Composite Containers ASME
CSA, CGA, NFPA
Pipelines ASME, API, CGA, AGA
Equipment ASME, API, CGA,
AGA
Fuel Transfer NFPA, API

Fueling, Service

Parking Facility

Controlling Authority: State, Local Govt.
Zoning, Building Permits

Standards Development:
Storage Tanks: ASME**,** CSA, CGA, NFPA,
API
Piping ASME**,** CSA, CGA, NFPA
Dispensers CSA, UL, NFPA**,**
On-site H2 Production: CSA, UL, CGA, API
Codes for the Environment: ICC, NFPA

Lead SDO underlined

National Template: Stationary and Portable Systems

Controlling Authority:
OSHA, Emissions – EPA
Pipeline: DOT/PHMSA
State, Local Government
Zoning, Building Permits

Standards Development:
Electrolyzers: UL, CSA
Reformers: UL, CSA, API
Performance Test Procedures: ASME, CSA
Chemical Hydrides: UL, CSA, NFPA

Hydrogen Generator

Installation Piping: ASME, CSA, CGA, NFPA, ICC
Storage: ASME, CGA, CSA, API, NFPA
Compressors Safety Certification: CSA, UL
Compressor Design, Performance & Safety: API
Sensors/Detectors: UL, CSA, NFPA
Fuel specifications: CGA, SAE, API, ASTM
Weights/Measures: NIST, API, ASME
Dispensers: NFPA, SAE, CSA, UL, API
Non-vehicle Dispensing: CGA
Codes for Built Environment: ICC, NFPA, CGA, ASHRAE
Interconnection: IEEE , UL, NFPA

Interface

Controlling Authority:
OSHA,
State, Local Government
Zoning, Building Permits

Standards Development:
H2 ICEs: UL, CSA
H2 Fueled Turbines: API, CSA, UL, ASME
FC Systems: CSA, ASME, UL
FC Installation: NFPA
FC Performance Test Procedures: ASME, CSA, NHA-GTI

Stationary Fuel Cells

Controlling Authority: CPSC, DOT/PHMSA, OSHA, EPA (Methanol),
State, Local Govt. (Zoning, Building Permits)

Standards Development:
Handheld Systems: UL, CSA
Portable Systems: CSA, UL, CGA
Handheld Fuel Containers: UL, CSA, CGA
Portable Fuel Containers: CGA, CSA, ASME
H2 Fuel Specifications: CGA, SAE
Performance Test Procedures: NHA-GTI, ASME, CSA

Portable Fuel Cells

Leads will change depending on type of environment.

Unified National Agenda for Codes and Standards

- Hydrogen and Fuel Cell Safety Report
  www.hydrogensafety.info (by National Hydrogen Association)
  - provides comprehensive information regarding published codes and standards, national and international codes and standards under development, and information for members of the national coordinating committee and other stakeholders
- Industry Panel on Hydrogen Codes (HIPOC) established
  - neutral forum to develop and submit hydrogen-related code provisions to International Code Council (ICC) and National Fire Protection Association (NFPA) and harmonize provisions in ICC and NFPA codes and standards

FreedomCAR-Fuels Partnership
Codes & Standards Technical Team

Energy Companies

BP

Chevron

ExxonMobil

Shell

ConocoPhillips

Auto Companies

DaimlerChrysler

Ford

GM

Government & Laboratories

Department of Energy

Department of Transportation

Los Alamos National Laboratory

National Renewable Energy Laboratory

Sandia National Laboratory

Mission

Enable and facilitate appropriate RD&D for development of:

- safe
- performance-based
- technical codes and standards

that support the 2015 technology readiness decision and are appropriate for later widespread consumer use of hydrogen and hydrogen-based technologies.

The Tech Team does not write codes or standards – we guide R&D that supports the existing codes and standards consensus process.

Key Goals

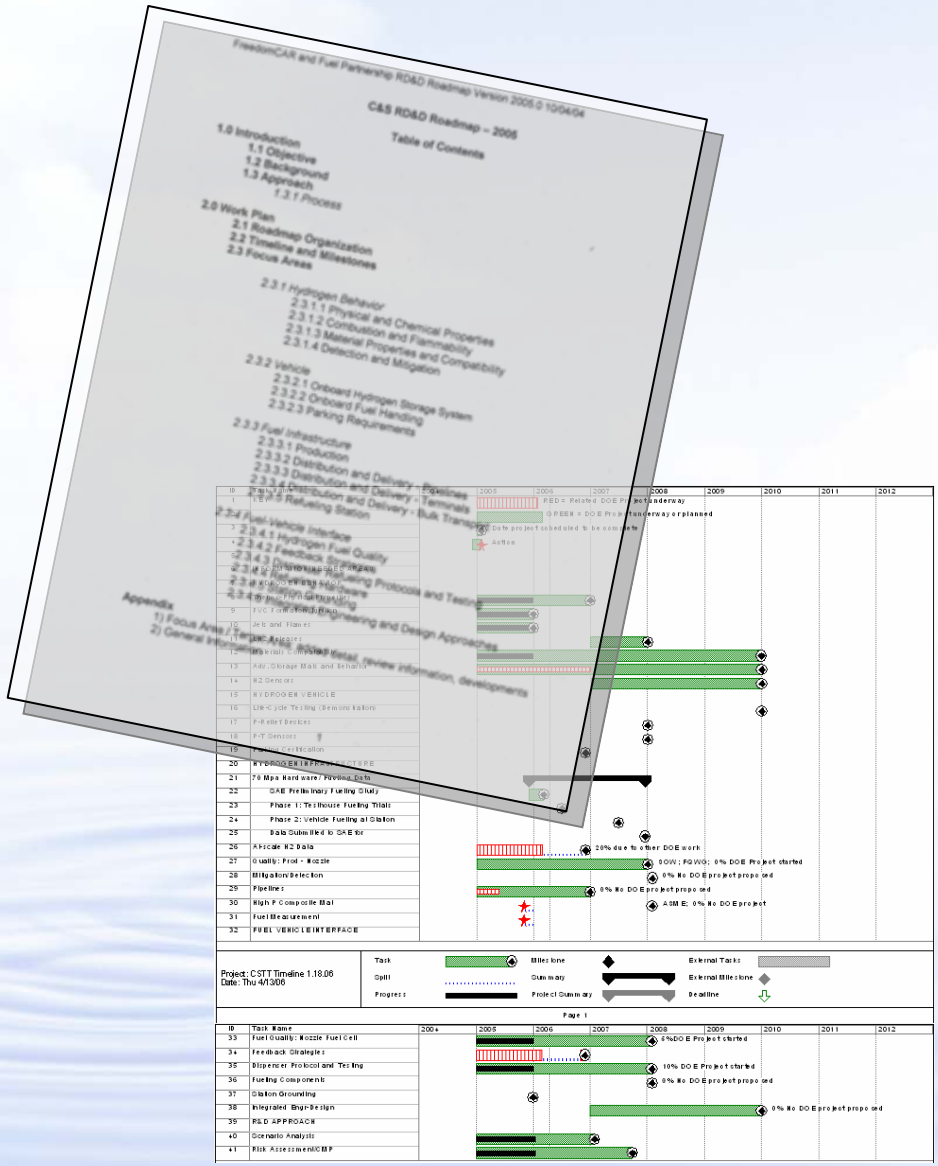
- Assess sufficiency of US and international hydrogen and fuel cell codes, standards, and regulations that are established and in the process of being established
- Identify areas where information is needed to advance codes and standards
- Implement RD&D program designed to fill information gaps related to codes and standards needed for a hydrogen/fuel cell economy
- Ensure that information and best practices developed under the FreedomCAR and Fuel Partnership are made available to responsible standards setting organizations as appropriate

Current Priorities

- Hydrogen Fuel Quality
  - R&D plan to assess fuel cell performance and fuel cost tradeoffs
  - SAE and ISO guidelines harmonized
- High Pressure Refueling
  - Initial experiments and validation tests conducted
- Hydrogen Sensor Technology
  - Work delayed due to budget constraints
- Component Testing
  - Testing of components to verify required performance and aid standards development process (i.e., tanks, valves)
- Hydrogen Behavior R&D
  - Materials compatibility handbook
  - High-pressure jet releases
  - Initiate low pressure release studies
- Risk Assessment
  - Collaboration with IEA Annex 19 (Hydrogen Safety)

Technology Roadmap

- First Version: Completed 2004
- Living document, annual updates planned
- Tech Team Update in September 2006
- Details Needs & Gaps in each Target Area



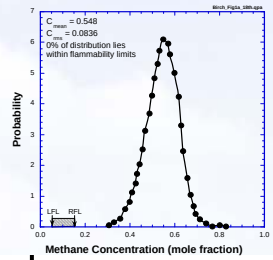
Roadmap – Target Research Areas

1. Hydrogen Behavior
   (physical/chemical, combustion/flammability, materials properties, sensing/mitigation)
2. Vehicles
   (fuel storage system, components, sensors, whole vehicle, failure modes)
3. Infrastructure
   (production, terminals/distribution/delivery, refueling stations)
4. Interface
   (fuel quality, feedback strategies, refueling components)

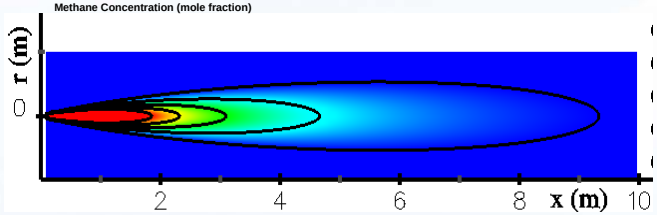
Roadmap details Information Needs or Gaps for each Target Area to ensure RD&D efforts are properly directed

Hydrogen Behavior

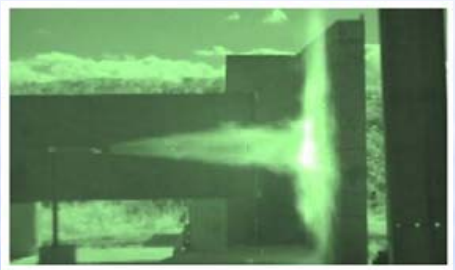
- Hydrogen Materials Compatibility: R&D and Handbook
- Hydrogen Combustion & Release Scenarios
- Turbulent Non-Premixed Flame Length
- Experimental Heat Flux Measurement
- Thermal Radiation Models
- Flammability Limits for Hydrogen
- Jet Ignition Probability
- Flame Impingement on a Wall
- Preliminary Comparisons of Natural Gas and Hydrogen



Flammability Limits & Ignition Probabilities

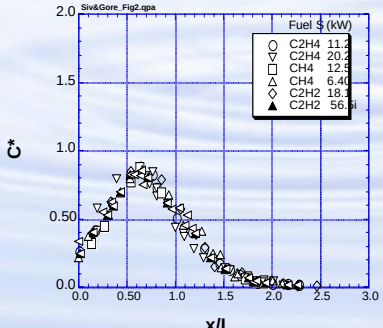


Experimentally Measure Heat Flux

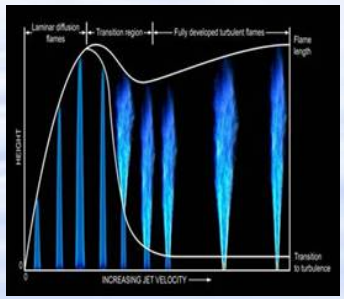


Impinging jet, 10 ft impingement diameter

Thermal Radiation Models



Flame Characterization



Vehicle-Fuel Interface: Fuel Quality

- Draft international guidelines for hydrogen fuel quality for PEM fuel cells in road vehicles (ISO DTS14687-2) prepared by ISO TC197 Working Group 12
  - submitted for balloting, vote due by December 2006
  - harmonized with SAE J2719
- R&D and testing to convert guidelines to international standard by 2010
  - consensus R&D/testing approach by Asia, EC, North America
    - formal participation by EC through FCTESTQA and JRC/EC
    - develop priorities, timetables, resources/costs, task “assignments”
  - fuel cell performance, mechanistic and material data involving effects of selected critical constituents (CO, S species, NH_3, He, CH_4, inerts, and PM)
  - engineering aspects of fuel quality (both production/purification and fuel cell stack/system operation), relative to impacts on fuel cost and performance under realistic operation of both fuel infrastructure and vehicles
  - critical analytical methods and procedures needed to verify recommended maximum levels of contaminants
- Good example of collaboration among EC, Asia, and North America
- DOE Hydrogen Quality Working Group established

Hydrogen Safety Program Goal

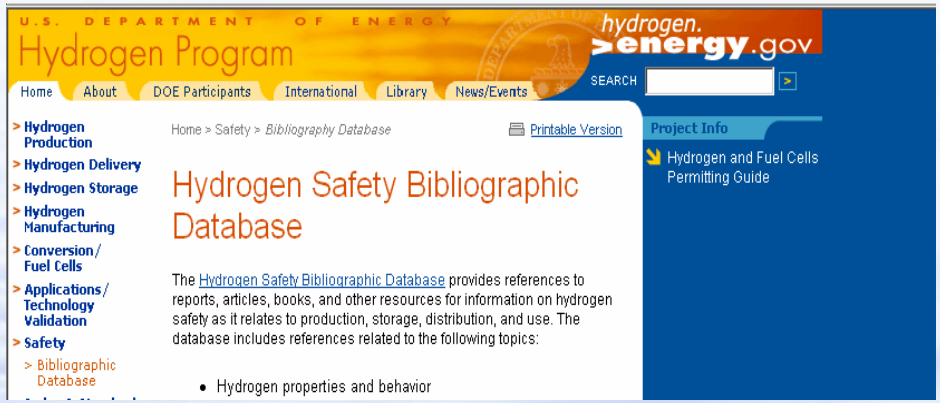
Develop and implement the practices and procedures that will ensure safety in the operation, handling, and use of hydrogen and hydrogen systems for all DOE projects and to utilize these practices and lessons learned to promote the safe use of hydrogen throughout the emerging hydrogen economy

Two Resources Established in 2006

New for 2006:

- Hydrogen Incidents Database: Information on hydrogen incidents and lessons learned
www.h2incidents.org

- Bibliographic database: Publications related to hydrogen safety
www.hydrogen.energy.gov



Thank you!

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www.hydrogen.energy.gov