DOE–DOT CNG–H₂ Workshop
Summary and Highlights
Antonio Ruiz

DOE Vehicular Tank Workshop
April 29, 2010 – Sandia National Laboratories, CA

Objectives of the Workshop:

1. Compare properties and behavior of CNG and hydrogen, including blends, and discuss R&D underway in each country for the safe use of these fuels
2. Discuss safety and testing of onboard and bulk storage tanks and identify research, regulations, codes and standards needed to ensure their safe use
3. Describe safety requirements and regulatory framework in each country and assess ways to harmonize domestic and international codes and standards
4. Collect data and information from demonstration activities and real-world applications in Brazil, China, India, and the United States
5. Conduct follow-up workshops, conduct collaborative R&D and testing, share hydrogen roadmaps and education/training plans and activities
Structure of Workshop

Overview of United States Hydrogen & Fuel Cell Activities (Sunita Satyapal, DOE)


Safety and Regulatory Structure for CNG, CNG-H₂ Vehicles and Fuels
  - India (Ambrish Mishra, Oil Industry Safety Directorate, Ministry of Petroleum and Natural Gas)
  - China (Jinyang Zheng, Zhejiang University)
  - United States (Barbara Hennessey, DOT/NHTSA)

Successful Adoption of CNG and Emerging CNG-H₂ Program in India (Narendra Pal, Univ. Nevada, Reno, and Indian Oil Corporation)

Lessons Learned from Practical Field Experience with High Pressure Gaseous Fuels (Doug Horne, Clean Vehicle Education Foundation)

CNG and Hydrogen Tank Safety, R&D, and Testing (Joe Wong, Powertech)

Overview of Indian Hydrogen Program and Key Safety Issues for Hydrogen Fuel (Dilip Chenoy, Society of Indian Automobile Manufacturers)

Hydrogen Vehicles and Fueling Infrastructure in China (Jinyang Zheng)

Hydrogen Vehicles and Fueling Infrastructure in India (Das, Indian Institute of Technology)

The Hydrogen Laboratory and The Brazilian Reference Center for Hydrogen Energy (Newton Pimenta, University of Campinas)

Controlled Hydrogen Fleet Infrastructure Demonstration and Validation Project (John Garbak, DOE)

Discussion, Action Items
Hydrogen Behavior – Myth Busting

Jay Keller,
Sandia National Laboratories

Topical Lecture
Progress in Hydrogen Safety: International Short Course Series

June 15-19, 2009
Hydrogen Myths

- Hydrogen Molecular Diffusivity is 3.8 times that of CH₄
  ➢ Therefore it diffuses rapidly and mitigates any hazard

- Hydrogen is 14.4 times lighter than air
  ➢ Therefore it rapidly moves upward and out of the way

- We do not know the flammability limits for H₂

- We just do not understand hydrogen combustion behavior
  ➢ Hydrogen release is different than other fuels
  ➢ Radiation is different than other fuels
**Hydrogen Myths**

- Hydrogen hazards can be compared favorably to experiences with other hydrocarbon fuels
  - Less dangerous than gasoline, methane ...
- Simply adding hydrogen to natural gas improves engine efficiency and lowers emissions.
- ICE’s are 33% less efficient than are Fuel Cells (@50% DOE / FreedomCar current goal)
- Hydrogen always ignites
  - Joule-Thomson heating, Static electric discharge, Shock heating ...
- Hydrogen is toxic and will cause environmental harm
  - “… We need to be indemnified against a hazardous toxic hydrogen spill …” – Generic Insurance Company
Oil Industry Safety Directorate (OISD)

Provide a Professional Technical body for hydrocarbon sector to:

1. Elaborate safety standards & procedures
2. Check implementation of safety regulations and analysis of incidents
3. Interface with regulators of industry

OISD – Duties

1. Development of standards
2. Institutionalized safety audits
3. Incident investigations, collation & analysis
4. Capacity building (training)
5. Safety performance evaluation
6. Collaboration with international organizations
7. Dissemination of information

Codes & Standards for CNG H₂ & CNG

- Motor Vehicles Acts / Rules:
  1. AIS 24: Safety & procedural requirement for type approval of CNG operated vehicles by ARAI
  2. AIS 28: Code of practice for use of CNG in ICE by ARAI
  3. ISO (BIS) specification for components

- Explosives Act:
  1. Gas cylinder rules
  2. OISD STD-179: Safety requirements on compression storage, handling and refueling of natural gas in the automotive sector by OISD
India: CNG-H2 Fueling Infrastructure

H-CNG Dispensing Station
Indian Oil Corporation Retail Outlet
Dwarka, New Delhi
India: CNG-H2 Fueling Infrastructure

H-CNG Dispensing Station
Indian Oil Corporation Retail Outlet
Dwarka, New Delhi

Layout

Electrolyser → H₂ Storage @ 400 bar → CNG/H₂ Blender → CNG/H₂

Natural Gas → CNG Storage @ 200 bar → CNG

Electricity

H₂ (Presently not allowed) → CNG/H₂

Bus

Truck
India: Codes and Standards

Codes and Standards For H:CNG+

-No Change in Vehicles system up to 20% Mix

Explosives Act :

- Need certain Changes in

OISD STD-179 : Safety requirements on compression storage, handling, and refueling of natural gas for use in automotive sector as regards inter-distances and specific safety requirements
India: Codes and Standards

Areas of Concern

- Quality monitoring of Natural Gas
- Tamper-proof Filling Nozzle
- Proper Fitment and Maintenance of CNG Systems and Vehicles
Initiatives on Transportation & Power Generation:

1. Green Initiative for Future Transportation (GIFT)
   - Develop & demonstrate hydrogen powered IC engines & fuel cell vehicles – deploy one million hydrogen vehicles by 2020
2. Green Initiative for Power Generation (GIP)
   - Developing and demonstrating hydrogen powered IC engine/turbine & fuel cell – setup 1,000MW hydrogen based power generation capacity

R&D, Infrastructure & Deployment

1. Fuel mixture strength requirement
2. Engine backfire (continues to be a major engine issue)
3. Hydrogen utilization with diesel engines
4. Deployment of Three-wheelers with the hydrogen-powered ICE
5. Develop pipelines & fueling stations
### National Standardization Bodies

1. SAC/TC 309 National Technical Committee 309 on Hydrogen Energy Standardization Administration of China (ISO/TC 197)
2. SAC/TC 262 National Technical Committee 262 on Boilers and Pressure Vessels of Standardization Administration of China (ISO/TC 11)
3. SAC/TC 31 National Technical Committee 31 on Gas Cylinders of Standardization Administration of China (ISO/TC 58)
4. SAC/TC 114 National Technical Committee 114 on Automotive Standardization (ISO/TC 22, 177)

### Major Issues, Needs:

1. **Tank regulation:** Types 1, 2 & 3 tanks are allowed, but Type 4 tanks are not allowed in China
2. **Additional proposed cooperation with international regulatory bodies**
3. **Standards for the design of hydrogen fueling stations**
Over the last five years, CNG vehicles have developed rapidly. The proportion of CNG taxis and buses in some key promotion cities has reached over 50%
China: CNG Vehicles

CNG vehicle development in China during past ten years
China: CNG Fueling Infrastructure

- 555 natural gas fueling stations in China
- 5 hydrogen fueling stations in China
CNG vehicle accidents in the last six years
China: CNG Vehicle Safety

CNG vehicle accidents

- explosion occurred during filled in station: 21 cases
- explosion occurred during driving: 7 cases
- explosion caused by stations leak: 4 cases
- explosion caused by traffic accidents: 3 cases
Published hydrogen standards and codes

- Industrial Hydrogen (GB3634)
- Pure hydrogen, High-Purity hydrogen and Ultrapure Hydrogen (GB/T7445)
- Technical Code on Safe Use of Hydrogen Gas (GB4962)
- Design Code on Hydrogen Gas Stations (GB50173)
- Technical Requirements on Water Electrolysis System for Hydrogen Production (GB/T 19774)
- Technical Requirements on Pressure Swing Adsorption System for Hydrogen Purification (GB/T 19773)
• Standards under development
  – Technical Code on Hydrogen Energy Automobile Refueling Stations (GB 50XX)
  – Hydrogen Energy Terminology (GB/T XXXX)
  – Fiber-reinforced high-pressure hydrogen cylinders with aluminum liner for land vehicle tanks
  – Stationary flat steel ribbon wound vessels for storage of high pressure hydrogen
  – Basic requirements for the safety of hydrogen systems
Collaborate under framework of energy cooperation between China and USA

• Seek opportunities to jointly apply for research funding from DOE, DOT, MOST, etc.
• Study of related standards and safety requirements, especially in the field of hydrogen embrittlement, fast filling, safety distance, etc.
• Develop International Standards, such as Hydrogen/CNG Stations, High Pressure Hydrogen Containers, High Pressure Hydrogen Supply Systems
• China is ready to be the Convener to develop an international standard on HCNG station and Pressure Swing Adsorption and would appreciate support by the USA and India
Brazil: Natural Gas Use

Natural Gas Supply: 25.9x10^3 toe
Natural Gas Consumption: 15.3x10^3 toe

Natural Gas Consumption (10^3 toe)
- Power; 4.286
- Residential; 233
- Industrial; 8.425
- Transport; 2.136
- Commercial + Public; 253
- Non-energy; 851

Dr. Newton Pimenta Neves, University of Campinas

States with CNG stations
States without CNG stations

Stations in Brazil: 1.750
Vehicles on CNG: ~1.5 million
The Brazilian Reference Center for Hydrogen Energy

• National effort to work on Hydrogen technology includes research institutions (State University of Campinas & the University of Sao Paulo) & government agencies (National Reference Center for Hydrogen Energy (CENEH))

• Hydrogen Lab at UNICAMP: Primary hydrogen research facility

LH2 Laboratory Projects:

1. Distributed Generation: Project Span from 2002 – 2008 which includes 5 kW of PEM fuel cells with hydrogen from natural gas

2. VEGA: UNICAMP fuel cell hybrid electric vehicle

3. LH2 & CENEH: Cooperative agreement with Itaipu (Brazilian / Paraguayan hydroelectric company) which includes supporting Itaipu hydrogen infrastructure, production & fuel cell application projects

4. LH2 & CENEH: Cooperative projects to foster CNG + H₂ development

Dr. Newton Pimenta Neves, University of Campinas
# Action-items: Info Sharing

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Information Resources:

- Agenda, workshop overview & presentations available on the DOE link below:
- http://www1.eere.energy.gov/hydrogenandfuelcells/wkshp_cng_and_h2.html

Additional Information
Thank You