Hydrogen Industrial Trucks

DOE Hydrogen Technical Advisory Committee
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Nurturing Products to the Market

- Fuel Cell and hydrogen generator development initiatives.
- Research studies to evaluate, predict possible impact of technology.
- Policy activities to coordinate support

Development

- Sponsored projects to prove technology in applications
- Research to troubleshoot roadblocks
- Industry advocacy to coordinate industry partners (standardize)

Demonstration

- Incentivized market to promote commercial sales
- Research to advance and ensure safety
- Industry groups assume responsibility for standards

Deployment
Meeting the Goals

2002 National Hydrogen Energy Roadmap Goal:

“Coordinate 4 industrial segments (Production, Delivery, Storage, Application) as one system”

Keys to Success:
- Captured Fleets
- Field Experience
- Simplified Infrastructure

What is the hydrogen industrial truck market?

Captured Fleets – 1 warehouse = 10’s – 100’s vehicles
Field Experience – High volume warehouses run 24/7
Simplified Infrastructure - Single storage feeds multiple refueling sites
Experience in Code and Standards

If codes and standards development relies on experience...
then industrial truck markets provide substantial experience.

**Automotive Hydrogen Use**
- 70-90 Million new cars/year
- 4-7 kg storage, 300 miles/fill, 1-2 fills/week...
- 8-10 kg per week per vehicle
- 0.5 - 1 kg/day
- **300-500 kg in 25 year life**
- Current US Vehicle Fleet: 300-400 vehicles

**Industrial Truck Hydrogen Use**
- 0.2 Million new industrial trucks/year
- 1-2 kg storage, 15-20 fills/week...
- 40 kg per week per vehicle
- 3-4 kg/day
- **4000 – 6000 kg in 10 year life**
- Current US Vehicle Fleet: 1000+ vehicles
‘Niche’ to ‘Broad’ Market Comparison

**Similarities**

*Engineering Development* - fuel cell/battery hybrid vehicle systems, high-pressure hydrogen storage, regenerative braking, “Fuel Cell Range Extenders”

*Safety* - storage vessel performance, leak detection strategies, impact detection strategies, refueling

*Codes and Standards Gaps* – end of life control, aftermarket, consumer product vs. industrial use

**Differences**

*Engineering Development* - weight, tank size and pressure, power requirements, vehicle integration, indoor fueling

*Safety* – driver training, regulatory agency

*Codes and Standards Gaps* – use type 1 tanks, indoor refueling standards
**Hydrogen Warehouse**

**Hydrogen meets the end-user’s goals:**
- Increase productivity
- Optimize floor space
- Optimize energy costs
- Improved corporate image

**Proven fuel cell advantages:**
- Refueling vs. Recharging
- Replace indoor battery charger with outdoor On-Site generation and storage
- On-Site Generation = on-demand generation
- “Green”, Retail brand names associated with national energy/security policies
Component Introduction

1. Onsite Hydrogen Generation
2. Outdoor Compression and High Pressure Storage
3. Indoor Dispensing
4. Battery replacement in existing electric forklifts
Current Status (Published Docs in bold)

**Industrial Vehicle**

Forklift
- NFPA 505
- UL 583
- UL 2267 (Integrated FC system)

**Fuel Cell Power System**
- UL 2267
  - Fuel Cell Power System (Battery Replacement)

**Fuel Cell System Components**
- Energy Storage – Batteries, Ultra-Caps
- Regenerative Braking Dissipation
- H2 Detectors/Proof of Ventilation
- Fuel Cell Stack and BOP

**Indoor Dispenser**

Dispenser
- NFPA 52
- HGV 4.3
- HPIT 2

**Dispenser Component Standards**
- Hose – HGV 4.2
- Breakaway – HGV 4.4
- Priority and Sequencing – HGV 4.5
- Manual Valves – HGV 4.6
- Automated Valves - HGV 4.7

**Indoor Refueling Guidelines**
- NFPA 52
- HPIT 2

**350 Bar Fueling Receptacle/Nozzle Pair**
- SAE J2600

**Hydrogen Pressure System**
- SAE J2919

**Hydrogen Pressure System Components**
- CSA HPIT 1
  - Cylinders, valves, fittings, tubing
Defining the Gaps

Overall Assumptions
- No one would want to put a steel tank on a vehicle
  - Forklifts use batteries as the counterweight
    - Therefore steel tanks are feasible
  - Steel tanks: low tech, low cost, fast fill w/o strict temp compensation
- Niche markets will not grow faster than automotive
  - Current deployments: 200 - Cars  1000 - Forklifts
- Refueling cycles are not a concern
  - Cars = 1800 cycles in 20 years  Forklift = 10,000 cycles in 10 years
- Refueling standards are sufficient for all markets
  - Indoor Fueling
  - Use of the same nozzle/receptacle
Defining the Gaps

Specific Gaps

- No available tank standard sufficient for the application
  - UL 2267 - 2006 – 4 tank standards referenced:
    - ASME BPVC Section VIII
    - DOT - subsequently interpreted as DOT 3AA
    - NGV2 – no HGV2 at publication
    - ISO 11119-1
    - Cycle fatigue phenomena and high cycle use application
- UL2267 – removable cylinders allowed
- UL 2267 - No link to component level or refueling standards
- HGV2 only applies to on-road vehicles
- NFPA 52/HGV 4.3 - Insufficient guidelines for safe dispenser function
Addressing the Gaps

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Consider, in 1 year...
- Testing programs at National Lab coordinated with Industry
- Changes affecting approximately ~15 documents
- Coordinating various entities to generate those documents:
  - Fuel Cell Companies
  - Industrial Truck OEMs
  - Industrial Gas Suppliers
  - Code Development Organizations
  - Department of Energy
  - National Laboratories

How did we get here...
- Identified Gaps through DOE sponsored pool of experts (HIPOC)
- Discussed in DOE sponsored monthly coordinating call (USFCCSC)
- Continued planning through USFCC as a DOE contractor (USFCC)
- Identified need for testing, supported by DOE (H2 Safety Panel)
- Test Planning (DOE, Sandia, Plug, Nuvera, Norris, CSA)
- Ongoing Standards development (UL2267, CSA–HPIT1, SAE J2919)
Open Technical Items

Counting Fill Cycles
- Cyclic fatigue concerns requires close monitoring of fill cycles on each tank

Decommissioning Tanks At End of Life
- Regulation and the aftermarket

Cylinder Handling
- Design and manufacture only as good as the installation

Escapee Scenario
- Use of SAE J2600 Nozzle/Receptacle for two separately regulated markets
- Forklift refueled at retail gas station
- Car refueled at warehouse or industrial truck fleet fueling station
Open Market Items

**Codes and Standards Harmony and Implementation**
- Harmony - UL 583, UL 2267 and NFPA 505
- Implementation – Comprehensive revision to UL2267 to reflect industry standards
- Implementation – Interpretation issues with “new” separation distance tables in NFPA

**Government Policy/ Codes and Standards Interaction**
- Regulatory Parent Agencies and Involvement
  - Industrial Trucks – OSHA – Dept of Labor
  - Automotive - FMVSS – Dept of Transportation

**Certification and Customer Confidence**
- Hurdle for small companies to pursue certification of not yet proven product
- Certification path not yet clearly defined
- Difficult for customers to trust uncertified products
- Less diverse customer base (not as many enthusiasts)
- Customers need gentle nudge to field new technology
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