

AIR
PRODUCTS



Indoor Refueling Experience and Code Compliance

2009 Fuel Cell Seminar – NHA Short Course
November 16, 2009
Dan Rabun

Hydrogen & Industrial Market

- Pipeline & tube trailers supply up to 2400 psig applications
- Liquid supplied systems to 130 psig
- 1000's of supply systems in service today supplying numerous applications
 - Small percentage to date are fuel stations
- Permitting for industrial market has been straightforward
 - NFPA 50A and 50 B evolved to NFPA 55 in recent years
 - International Fire Code
 - Chapters 30/35 and reference to NFPA 55



Horizontal bore of railroad



Development of Fueling Stations

- 1990's ushered in fuel stations
- Fuel dispensing
 - A new “application” for industrial market
- Exponential growth during 2000's
 - Initial growth was outdoors for cars and buses
- Indoor fueling applications have developed over last several years



Indoor Hydrogen Use in Industry

- Indoor Hydrogen Use is not new
- Most comparable sized industrial hydrogen systems serve indoor applications
 - Heat treating
 - Food hydrogenation
 - Electronics
 - Power Generation
 - Laboratories
 - Etc.
- Typically outdoor storage and supply systems
- Indoor piping distribution systems to end uses
- Flows
 - Frequently large
 - Batch use also
- Can compare to Outdoor Vehicle Fueling OR to Existing Indoor applications

Indoor Hydrogen Usage

- **Appropriate safeguards installed**
 - Outdoor shutoff for emergency stop
 - CGA 5.4 “Hydrogen Piping”
 - ASME B31.3
 - Gas/fire detection not required for these applications
 - Gas detection sometimes installed at point of use
 - Fire detection rarely installed
- **Addressed in NFPA 55 and I-Codes**
 - Example: Chapter 7 in Fuel Gas Code
- **Material Handling is a new application**
 - Follow and improve upon existing practice
 - Develop additional codes and standards where applicable
- **Natural Gas Indoors is good example**
 - Very common, even large mains
 - LFL’s comparable (5% vs 4%)
 - Limited means of shutoff, detection, etc.

Indoor Hydrogen Fueling

- Brings together:
 - Industrial Hydrogen Experience
 - Fuel Station Experience
 - Indoor Hydrogen Experience
- Why Indoor Fueling?
 - Required to serve material handling fleet
- Codes and Standards
 - Same as for other applications
 - Also develop new, specific Standards
 - Develop component standards for the particular applications

Indoor Hydrogen Fueling Experience

- Over 15 dispensers deployed
 - 8 more in process
- Usage is growing exponentially
 - Material handling alone
 - Almost 100,000 fills to date
 - February 2009: Almost 1000/week
 - April 2009: 1500/week estimated
 - December 2009: 3000/week estimated
- Excellent Operating History to date
 - Multiple Facilities On-line
 - Supports day to day operations
 - No longer just “demonstration”



Overall Fueling Approach

- **Outdoor Supply, Compression and Storage**
 - Leverage from existing industrial gas equipment
 - Refined for this market
 - Keep storage and equipment in safest areas...outdoors
 - Follow existing Codes and Standards and permitting practices
- **NFPA 55 is for Industrial Gas Supply Systems**
 - Chapter 10 for Gaseous Hydrogen
 - Chapter 11 for Liquid Hydrogen
- **NFPA 52 will not cover hydrogen supply systems to avoid overlap**

Historical Permitting - Early

- Limited Codes and Standards references for Indoor Hydrogen fueling
 - Used Industrial Experience and Codes
 - Used what was available in NFPA and I-Code
- Typical Codes
 - ASME Pressure Vessel Code/Piping Code
 - Law in most states
 - National Electrical Code
 - NFPA 50A – Gas, NFPA 50B – Liquid.
 - NFPA 52
 - International Codes (IFC, IFGC, etc)
- Successful with Above Approach
 - But led to additional time/effort for permitting

Permitting – AHJ Response

- **As expected with new technology:**
 - Difficult for AHJ to review and approve something about which they know little
- **Very high interest level**
 - Generally want to work to make things happen
 - Supportive of efforts
- **Insurance Companies are developing understanding**
- **Recognition that Indoor H2 dispensing is growing rapidly**
- **Growing Involvement with Codes and Standards specific to this market**
 - Support for activity
- **Recent efforts by some areas to develop local Codes can be a problem**
 - Inconsistencies can occur
 - Best to keep to national standards once developed

Recent System Example: DDSP

- **Defense Logistics Agency**
 - Desire to advance state of fuel cell technology by facilitating new markets
 - Obtain productivity savings for own facilities
 - 4 Projects to demonstrate fuel cell powered material handling equipment
 - Learn about h2 supply
 - Learn about real world use of technology
- **First deployed project at Defense Depot – Susquehanna PA, “DDSP”**

System Description - DDSP

- 40 Class 1 Lifts
 - 20 Plug Power
 - 20 East Penn/Nuvera
- Demonstrates LH2 Supply
- 9,000 gallon liquid hydrogen storage
- Dual CHC 6000/7000 pumps and vaporization
- Series 150 gas compressor
- Gaseous hydrogen storage – 120 kg
- Two indoor gaseous hydrogen dispensers
- Operating at about 300 fills/week since February 2009



Permitting Challenges - DDSF

- Concerns raised about the newness of technology and lack of existing experience
- Recognition that Codes and Standards were not clear
 - NFPA 52 had references to Indoor Fueling
 - Option for a special room
 - Option for when compression and storage is outdoors
 - I-Code has references to special rooms with some exceptions permitted
 - When do these options apply/not apply?
- Issues with traditional H2 installations
 - Lack of experience
 - Different occupancy

Permitting

- Engage Authorities early
 - Build trust and honest working relationship is critical
 - Discuss Code compliance
 - Which Codes and why
 - Understand specific concerns
 - Educate about Hydrogen as needed
 - Hydrogen safety training
 - Address any concerns
 - Involve with the station site design
- Provide information on inherent safety of system
 - Discuss Safety Reviews and safeguards
- Run dispersion models as required

Permitting Issue Resolution

- Numerous meetings with higher organizational levels
- Provided training on H2, fueling, and fueling systems
- Unified Facilities Criteria, DOD requirements
 - Required review by Fire Protection Engineer or PE
- Conducted Review by NREL Professional Engineer
 - Addressed concerns of permitting officials
 - Report Issued to document design considerations
- Once review complete, system was installed
 - About 9 month process in this case

Dispenser Safety Features

- Special attention on dispenser
 - End use application
 - Interface with personnel
 - Deviations will abort fill
- Multiple “Layers of Safety” to build redundancy
 - Pressure Protection
 - Transmitter, Regulator, Switch, Relief Valve
 - Release limited to piping
 - No storage inside



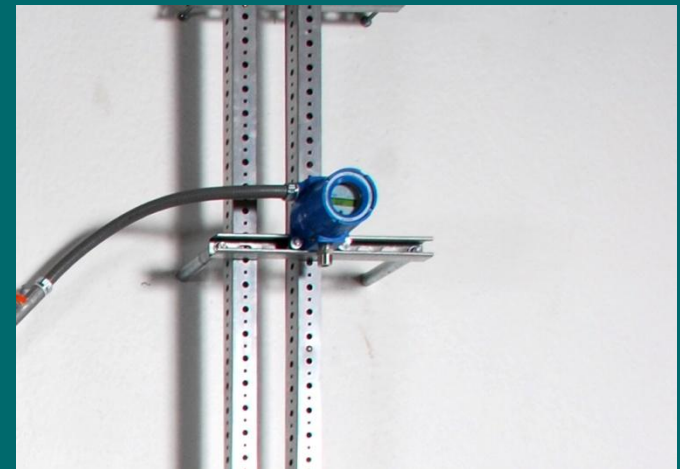
Dispenser Safety Features

- **Emergency Stop**
 - Shuts all valves
 - Cuts all power
- **Manual Shutoff Valve**
- **Automatic Shutoff Valves**
 - Triple redundancy
 - 2 outside
 - 1 inside
- **Redundant controllers**
 - 1 outside
 - 1 inside
- **Local Fire Extinguisher**



Dispenser Safeguards

- Secondary containment sleeve over fill hose & mechanical joints
 - No exposed joints
 - Sleeve routed to dispenser cabinet
- Gas Detection in cabinet
- Gas Detection in fueling area (NFPA 52 requirement)
- Flame Detection in fueling area (NFPA 52 requirement)
- All vents captured and routed outdoors, nothing inside
- All safeguards will stop fill



Dispenser Safeguards –Leak Protection in AP Dispenser

- Indoor piping pressure monitored continuously when system idle
- At start of fill, leak check of entire dispenser
- Instrumentation check
- Leak check after connection, prior to fill
- Hose break detection during fill
- Electronic Excess Flow protection



Dispenser Safety Features

- Vehicle and station electrically bonded through nozzle and hose
- Vehicle grounded through communication cable
- Non-interchangeable nozzles for pressure rating
- Special design nozzles compared to typical industrial fittings
 - Extensive testing, third party approvals
 - Double block and bleed, unlike industrial connections
 - Cannot be opened unless connected
- Self-sealing break away joints
 - For vehicle pull-away/accident

Dispenser Installation

- Sited per NFPA 52 and I-Code requirements
- All equipment within 15' to be classified
- Non-flammable construction in dispensing area
- Protected from impact damage
 - Bollards/railings
- Room area/volume very large
 - Comparable to outdoors
 - Ceiling height: approx 35'
 - Room size: 100's X 100's
 - Dispersion of worst case scenario completed

Dispenser Operation

- **Training**
 - Provide general hydrogen training
 - Provide specific operator training
 - Access restricted to trained personnel
- **No smoking or open flames in or around storage areas, piping, or dispensers**
- **No cell phones, cameras, or other potential ignition sources within 15 feet**
- **Emergency Response Plan**
 - Weave into existing facility plan

Applicable Codes and Standards for Systems and Siting

- **Hydrogen Supply Systems: NFPA and I-Code**
 - **NFPA**
 - **NFPA 55 for Industrial Gas Supply Systems**
 - Chapter 10 for Gaseous H₂
 - Chapter 11 for Liquid H₂
 - Siting Distances
 - **NFPA 52 for dispensing systems**
 - Derived from CNG experience
 - Tailored for H₂
 - Chapter 5 and 9 for gaseous dispensing
 - Significant recent changes from 2006 to 2010 with regard to indoor dispensing
 - Much greater direction provided

Applicable Codes and Standards for Systems and Siting

- I-Codes

- International Fire Code (IFC)

- Chapter 22 for motor fuel dispensing
 - Chapter 30 for industrial gases
 - Chapter 35 for flammable gases
 - Refers to NFPA documents as well

- International Fuel Gas Code (IFGC)

- Chapter 7 for hydrogen

- As applicable, references to International Building Code, Machinery Code, etc.

Indoor Fueling Summary

- Indoor Dispensing is growing rapidly
 - Fuel Cell technology is gaining acceptance
 - Fueling for this equipment is indoors
- Codes and Standards are in place for industrial systems, fueling stations, and hydrogen
 - Evolving to meet needs of this new market
- Installation and interface codes have shown good progress
 - NFPA 52 2010's greater definition and clarity
- Component standards are progressing
 - Needed for stations and fuel cell packs
 - Standards are preferred to be performance based.

Thank you

tell me more

www.airproducts.com