Controlled Hydrogen Fleet and Infrastructure Demonstration and Validation Project

TEAM: Chevron Technology Ventures, Hyundai-KIA Motor Company & UTC Power

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Dan Casey – Technical Director

Chevron Hydrogen

June 2010

Overview

Timeline

- Start: January 15, 2004
- End: December 31, 2009
- 100% complete

Budget

Total project funding	$94.5 mil
• DOE share	$38.1 mil
• Contractor share	$56.4 mil
Funding received in FY09	$ 2.9 mil
Funding remaining on award	$ 6.8 mil (est.)

Barriers

- Fuel cell vehicles data
- H_2 refueling infrastructure data

Team Members

- Hyundai-KIA Motor Companies
- UTC Power
- Hyundai-KIA America Technical Center
- Alameda-Contra Costa Transit
- Tank Automotive Research, Development and Engineering Center
- Southern California Edison

Relevance: Technology Validation Technical Plan *Barriers and Objectives*

- Fuel cell performance
  - *Public domain statistical data for vehicles*
    - **33 fuel cell vehicles collecting durability and range data on the road**
      - » *fuel cell durability*
      - » *vehicle range*
  - *Vehicle driveability in extreme environments*
    - **Operation in wide range of climates**
      - » *Low-temperature startup*
      - » *Hot climates*
- Refueling infrastructure performance
  - *Low availability of hydrogen production systems*
    - **Six separate new technologies deployed for this program**
  - *Safe and convenient refueling by drivers*
    - **24/7 safe fueling by trained drivers**

Approach - Vehicles

- 33 vehicles on the road
- Three maintenance facilities

Approach – Infrastructure

- Five stations
- Public/private partnership
- Onsite generation

Oakland, CA
Steam Methane Reformer
Open: December 1, 2005
Close: 3Q 2010

Chino, CA
Auto Thermal Reformer
Open: November 1, 2005
Transferred: 1Q 2010

Rosemead, CA
Electrolyzer
Open: March 6, 2007
Closed 1Q 2010

Selfridge, MI
Steam Methane Reformer
Open: April 4, 2007 Closed: 2Q 2010

Orlando, FL
Steam Methane Reformer
Open: January 31, 2007
Closed 1Q 2010

Goal: Infrastructure under real-world operating conditions

Collaborations – Partners

Within DOE Tech Val Program

Project Lead

Chevron hydrogen

Cost Share Provider

Light Duty Vehicle Technology Providers

HYUNDAI·KIA MOTORS

UTC Power
A United Technologies Company

Site Hosts and Vehicle Operators

SOUTHERN CALIFORNIA EDISON
An EDISON INTERNATIONAL Company

Hyundai KIA America Technical Center, Inc.

AC TRANSIT

Not Part of DOE Tech Val Program
Infrastructure data reported to NREL at no cost to DOE

Bus Technology and Funding

VANHOOL

ISE
Transportation recharged.

Site Host

Progress Energy

Vehicle Operators

ORLANDO INTERNATIONAL AIRPORT

SeaWorld ADVENTURE PARK Orlando

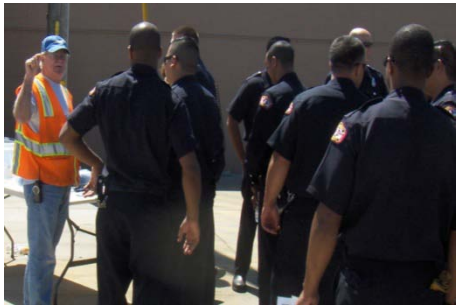
ORANGE COUNTY GOVERNMENT FLORIDA

Progress – Hydrogen Training

First Responder Training

- Station and vehicle safety
- Classroom and hands-on training
- Initial training on station opening
- Refresher training – offered yearly
  - Train new hire personnel
  - Train new transferred personnel
  - Prepare for response to incidents

  - Fire response drills

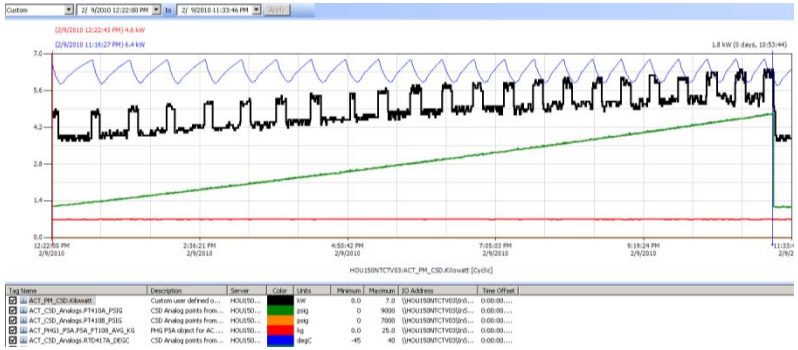


Progress – Hyundai Update

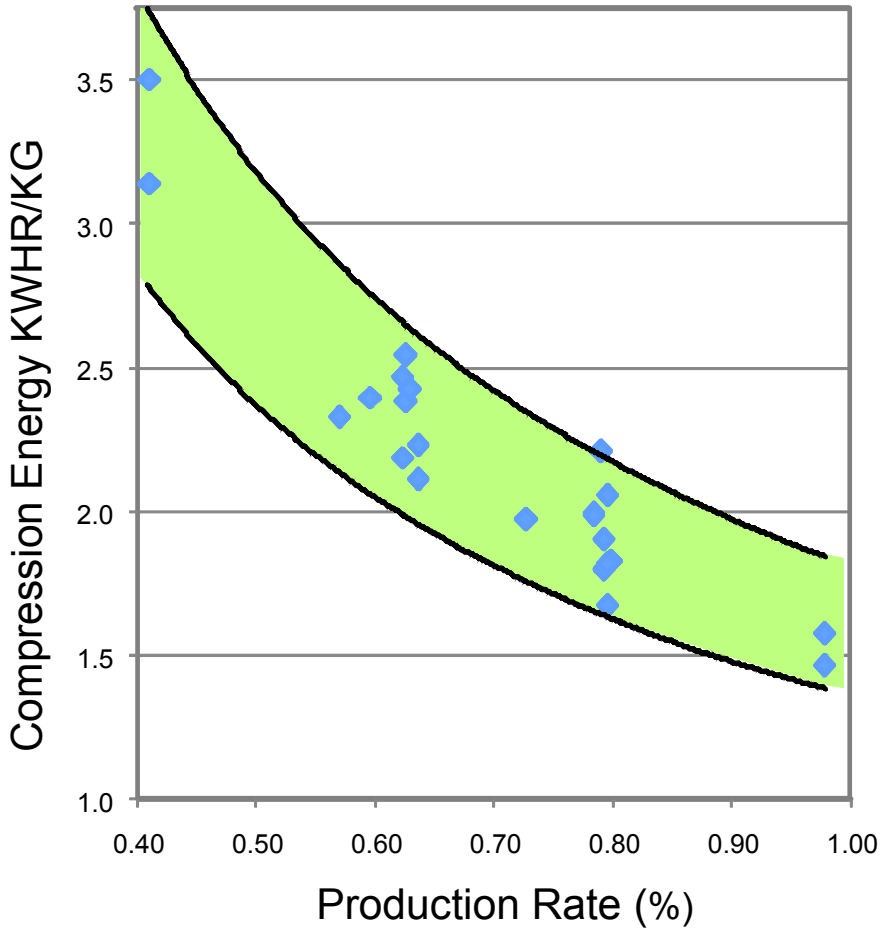
- Vehicle fleet
  - Fleet completed
  - Mileage accumulation
  - Status
    - DOE program vehicles
      - » 29 retired
      - » Four operating – internal fleet
    - Hyundai FCV
      - » Three vehicles
      - » More to be deployed in California
- Chino H_2 station
  - Transfer asset continue operation
    - Building
    - Dispenser
    - Compressor
    - Storage

Lesson Learned – Compression Efficiency

- Energy per kg compressed varies:
  - Production rate
  - Cooling fan load
  - Outlet pressure



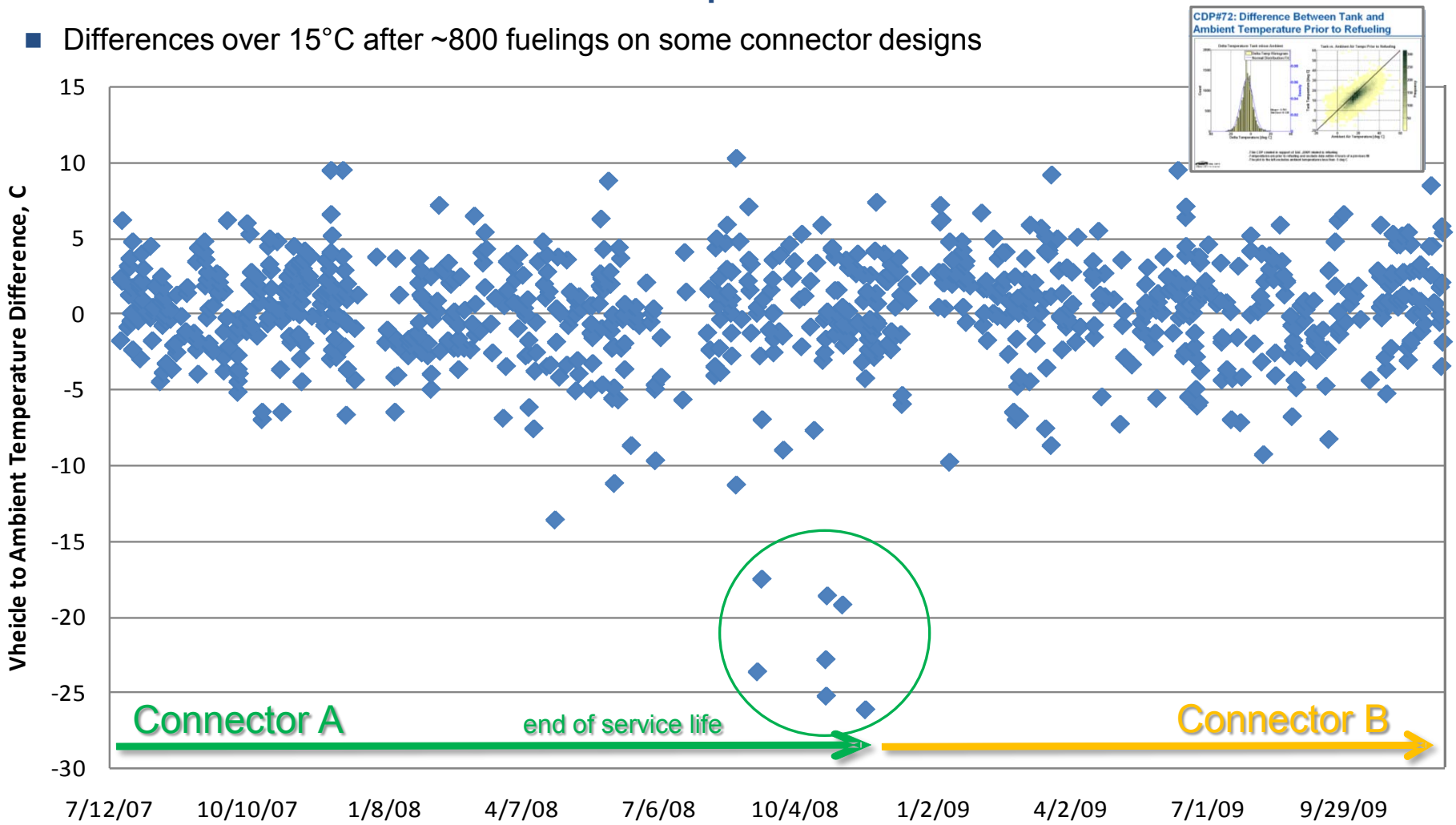
- Variable speed drive not currently available
  - Spillback design
  - Provides safety
  - Ensures no vacuum



Lesson Learned – Communications Cable Connector Service Life

Difference Between Tank and Ambient Temperature Increases With Connector Service Life

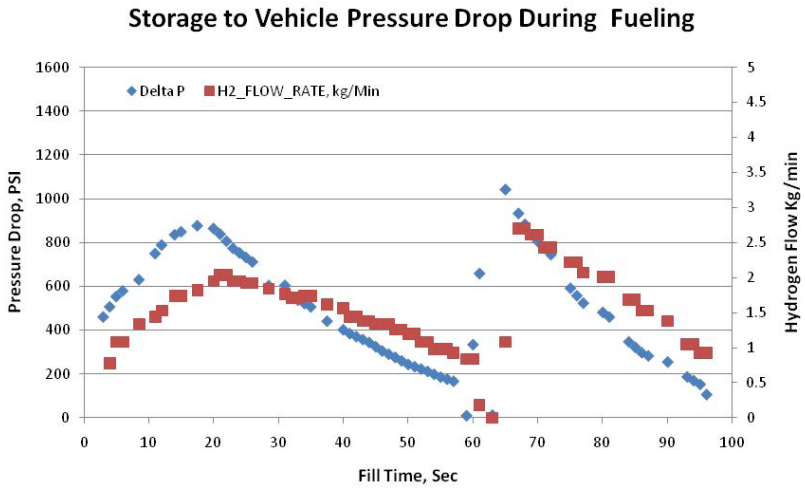
- Differences over 15°C after ~800 fuelings on some connector designs

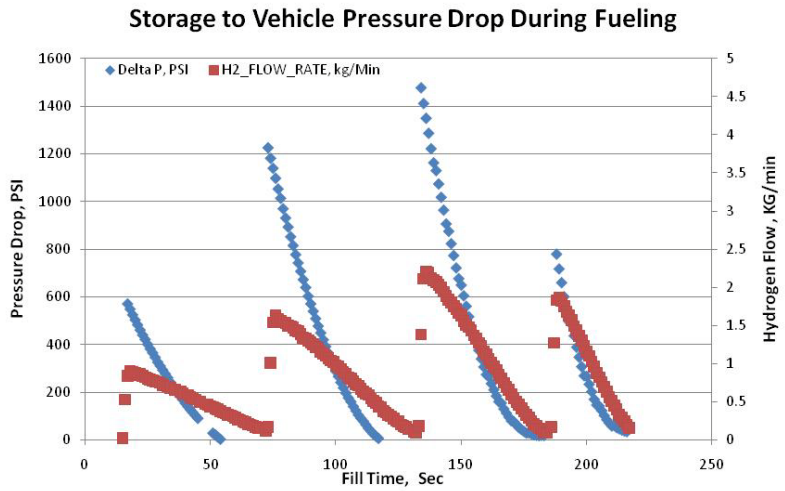


Lesson Learned – Pressure Drop

Pressure Drop From Storage to Vehicle

- Increases storage requirements
- Function of Darcy equation
  - Flowrate
  - Pipe diameter
  - Equivalent pipe length
- Varies by station design
  - Comparison
    - 2.5 kg vehicle fill
    - 152 liter tank

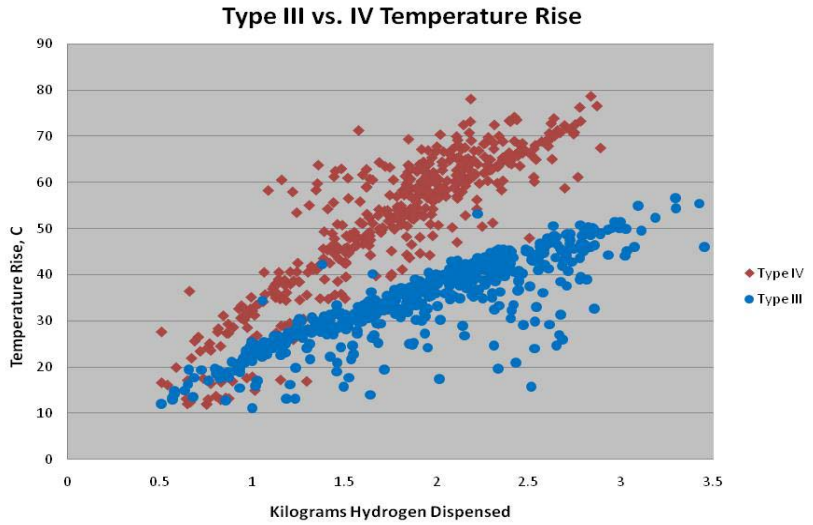


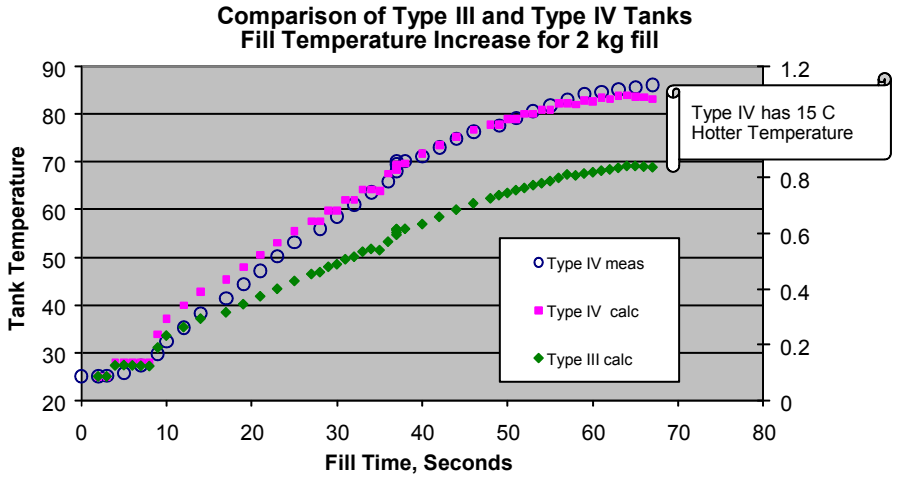


Technical Accomplishment – Type III vs. Type IV Tank Temperature Rise

Temperature Rise During Fueling

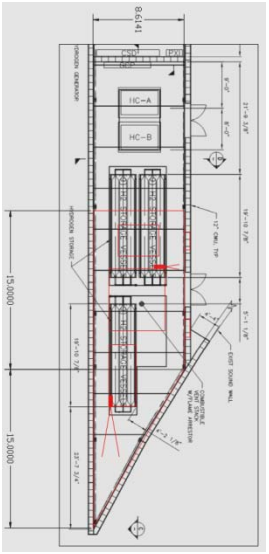
- Comparison 1,000 fueling events
  - Type IV 160 liter tank
  - Type III 152 liter tank
- Type IV composite
  - No aluminum liner
  - Proprietary materials of construction
  - Results can vary by manufacturer
  - Lower overall heat transfer coefficient
  - Less internal heat sink
- Temperature sensor
  - Accurate reading critical to safe fueling
- Higher internal temperatures during fueling
  - Fueling events can be temperature limited

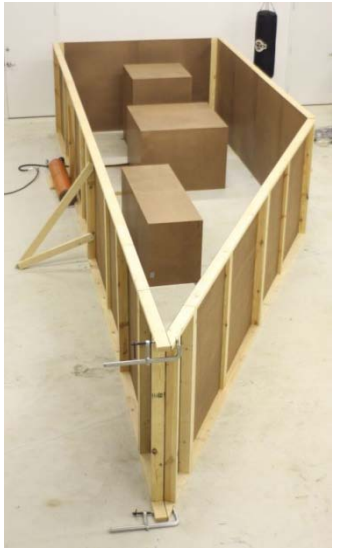


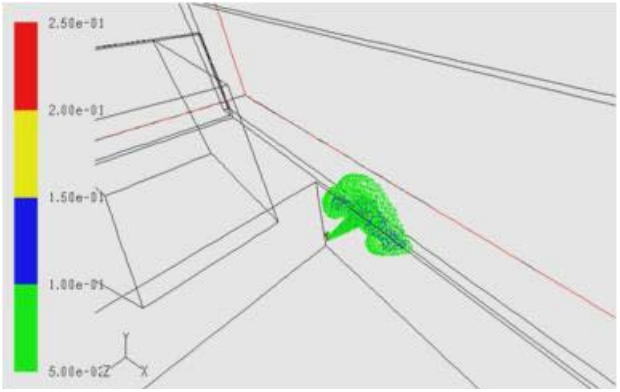


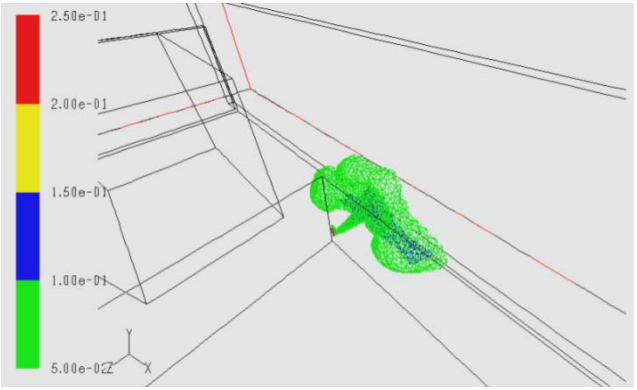
Collaboration – University of Miami Hydrogen Modeling

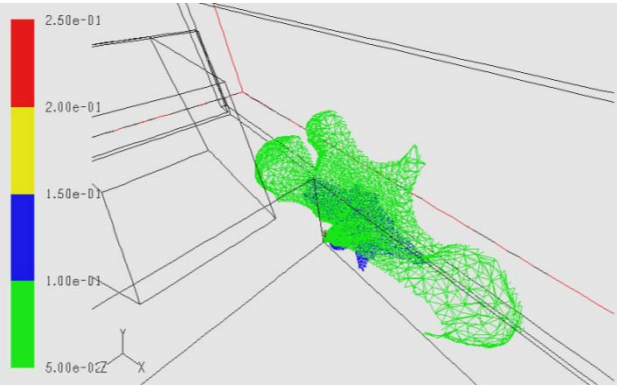
- CFD modeling of hydrogen storage leak
  - 575 SCFM leak
  - 0.05″ diameter orifice
  - Ground effect and wall effect included
  - Model compared to real-world helium leak
  - Extent of combustible cloud determined



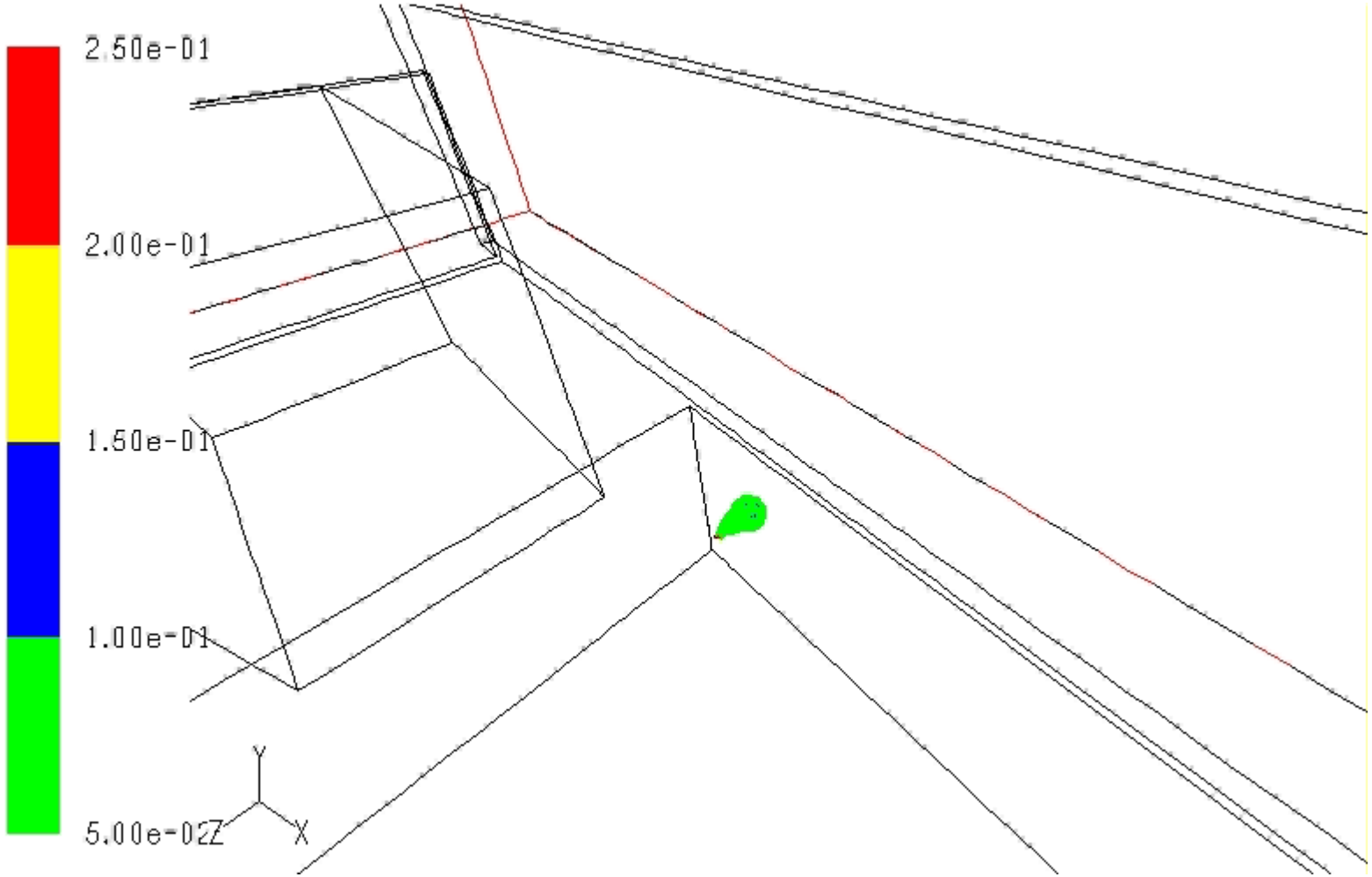






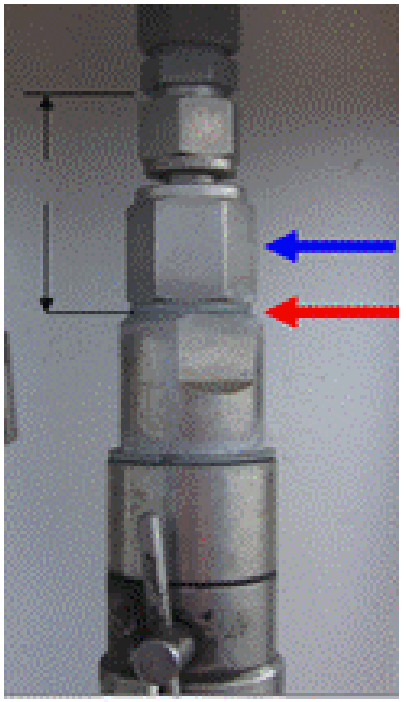


Collaboration – University of Miami Hydrogen Modeling Video



Lesson Learned – Design Rating of Breakaway Adapter

- Adapter is required to connect dispenser tubing to breakaway
- Fitting pressure ratings are not equal on *standard* fitting
  - Female fitting has lower pressure rating
    - Female adapter fitting 4,900 psig
    - Male G ½-in straight thread 7,700 psig
- Custom fittings are available
  - Can meet pressure rating
  - Require increased wall thickness
- Findings were submitted to H2Incidents.org



Future Plans – Hyundai-Kia New FCV vehicles

2nd Gen Fuel Cell SUVs: Deploy 34 in Korea

3rd Gen Fuel Cell SUVs: Deploy 100 in Korea

Deploy 50+ overseas including the USA

2nd Gen. Tucson/Sportage Hyundai 100 kW stack

3rd Gen. Borego/ Tucson ix SUV Hyundai 100+ kW stack

Fuel Cell Concept Vehicle

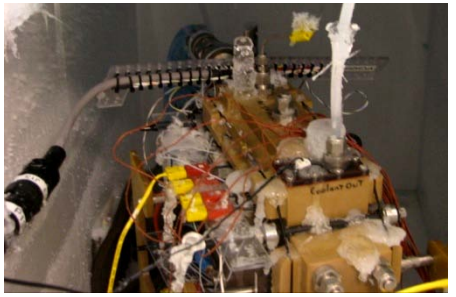
- Designed for fuel cell from ground up
- Uses future generation Hyundai fuel cell technology
- System: 100 kW stack power
- 70MPa compressed hydrogen
- Vehicle performance at 370-mile range

I-Blue

I-Blue Chassis

Future Work

- Publish final report
- Complete UTC Power technology development internally and with OEMs toward 2015 targets
  - Advancements in durability
  - Reduction in Pt loading
  - Improvement in power density
  - Cost reduction of stack components
  - Freeze capability
- Deploy 16 fuel cell buses in 2010
  - UTC Power Pure Motion® PM 120 power plants
  - 12 buses at AC Transit and local agencies
  - Four buses at CT Transit in Hartford, CT



Program Summary

- Relevance
  - Demonstrate safe, practical hydrogen technologies in real-world settings
- Approach
  - 33 fuel cell vehicles – Collect on-road data
  - Six onsite hydrogen generators – Introduce new distributed generation technology
- Technology transfer
  - Statistical data provided to NREL
- Technical accomplishments and progress
  - Cold start-up
  - Capability developed to meet 7% to 10% of a conventional gasoline station's daily fuel dispensing requirement using onsite hydrogen production
  - Safe fueling by drivers
- Proposed future work
  - Issue final report