# NHTSA Hydrogen Vehicle Fuel System Safety Research Program Update

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# Introduction

Hydrogen fuel for vehicles offers the promise of significantly reducing the amount of pollutants expelled into the environment

NHTSA understands that the properties of hydrogen fuel are different from the liquid fuels we know and may have unique safety concerns

NHTSA has undertaken the Hydrogen Vehicle Fuel System Safety Research Program to

- Assess safety performance of compressed hydrogen fuel cell vehicle fuel systems under crash conditions similar to those in the existing FMVSS
- Provide research to support enhancements for FMVSS, if needed, to address unique hazards and issues associated with these fuel systems
- Identify and assess any additional life-cycle safety hazards imposed by use of these unique fuel systems.

# Research Team

NHTSA is supported in this program by a research team, led by Battelle, including

- Powertech Labs Inc.
- Transportation Research Center (TRC)
- Engineering Mechanics Corporation of Columbus (Emc^2)
- Authorized Testing, Inc.
- Texas Transportation Institute

# Five Tasks Orders are in progress

***Task Order 1, Compressed Hydrogen Container Fueling Options for Crash Testing*** generating data on effects of fuel container pressure and orientation on performance during crash conditions

***Task Order 2, Cumulative Fuel System Life Cycle and Durability Testing*** generating data on potential life-cycle safety hazards of these fuel systems

***Task Order 3, Post-Crash Hydrogen Leakage Limits/Fire Safety Research*** generating data on potential ignition hazards of hydrogen in vehicles

***Task Order 4, Electrical Isolation Test Procedure Development and Verification*** generating data on post crash electrical isolation safety

***Task Order 5, Analysis of Published Hydrogen Vehicle Safety Research*** assessing recent relevant data in the literature

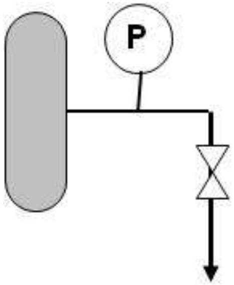
# Task Order 1, Compressed Hydrogen Container Fueling Options for Crash Testing

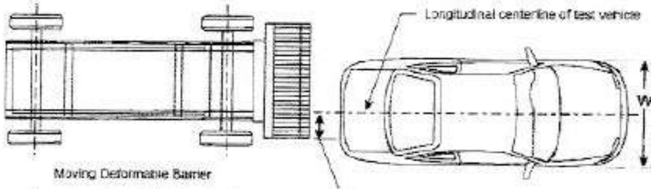
## Objective

- Assessing the fueling options for crash testing including fuel type and fuel pressure

## Approach

- Conduct severe impact testing of hydrogen fuel containers at high and low pressure to characterize effects of internal pressure, impact direction, container construction, and wall thickness on container integrity
- Conduct pressure drop rate vs. mass flow rate test of hydrogen at high and low pressure to determine equivalence of pressure drop and mass (energy) flow for hydrogen and helium
- Conduct forward, side, and rear crashes of vehicle equipped with hydrogen fuel systems vehicles to assess test procedures



# Task Order 1, Compressed Hydrogen Container Fueling Options for Crash Testing

## Status

- Severe impact testing completed
  - Suggests axial impact under full pressure may be most severe condition
- Pressure drop tests in progress
- Vehicles being prepared for crash test in Spring

# Task Order 2, Cumulative Fuel System Life Cycle and Durability Testing

## Objective

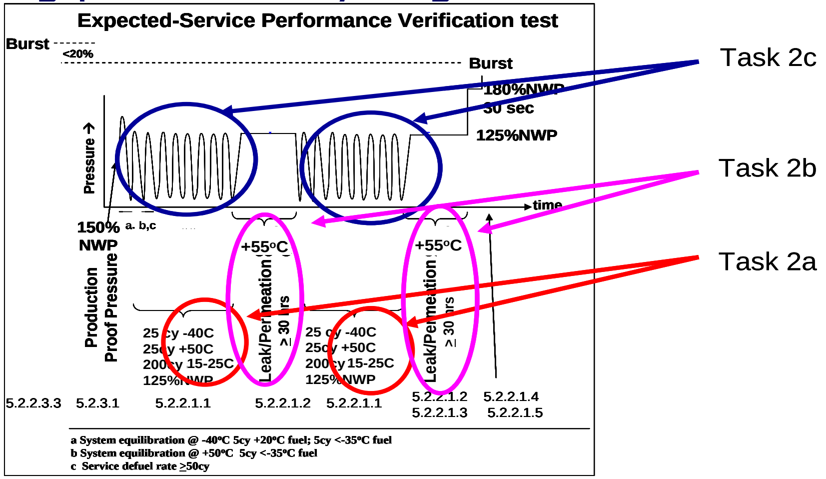
- Conduct cycle and durability testing to complement SAE TIR J2579 data to assess test conditions

## Approach

- Generate data to compare pneumatic cycle performance at different temperatures to assess the upper and lower test temperature
- Generate data to compare static pneumatic performance at different temperatures and hold periods to assess the test temperature for static parking performance
- Monitor degradation of containers during pneumatic cycling from 250 to 1833 cycles to assess the test cycle count

## Status

- Testing to begin in Spring



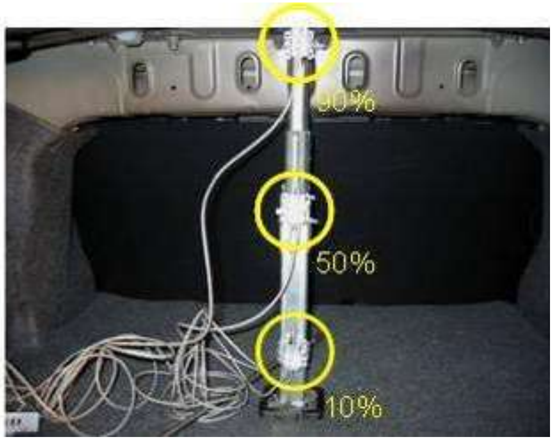
# Task Order 3, Post-Crash Hydrogen Leakage Limits/Fire Safety Research

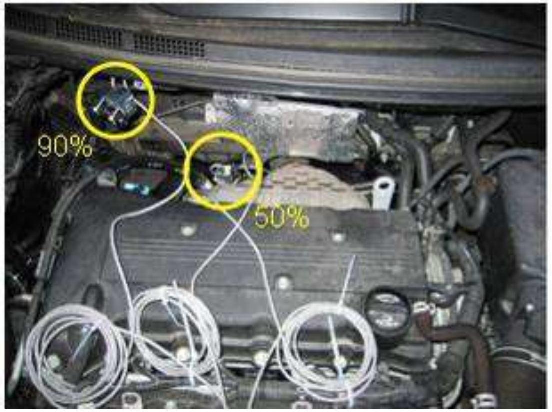
## Objective

- Conduct experimental research on the fire safety of potential Hydrogen leakage limits
- Correlate hydrogen fuel system leak rate to the accumulation of ignitable mixtures of H2 in engine, passenger, and trunk, compartments.

## Approach

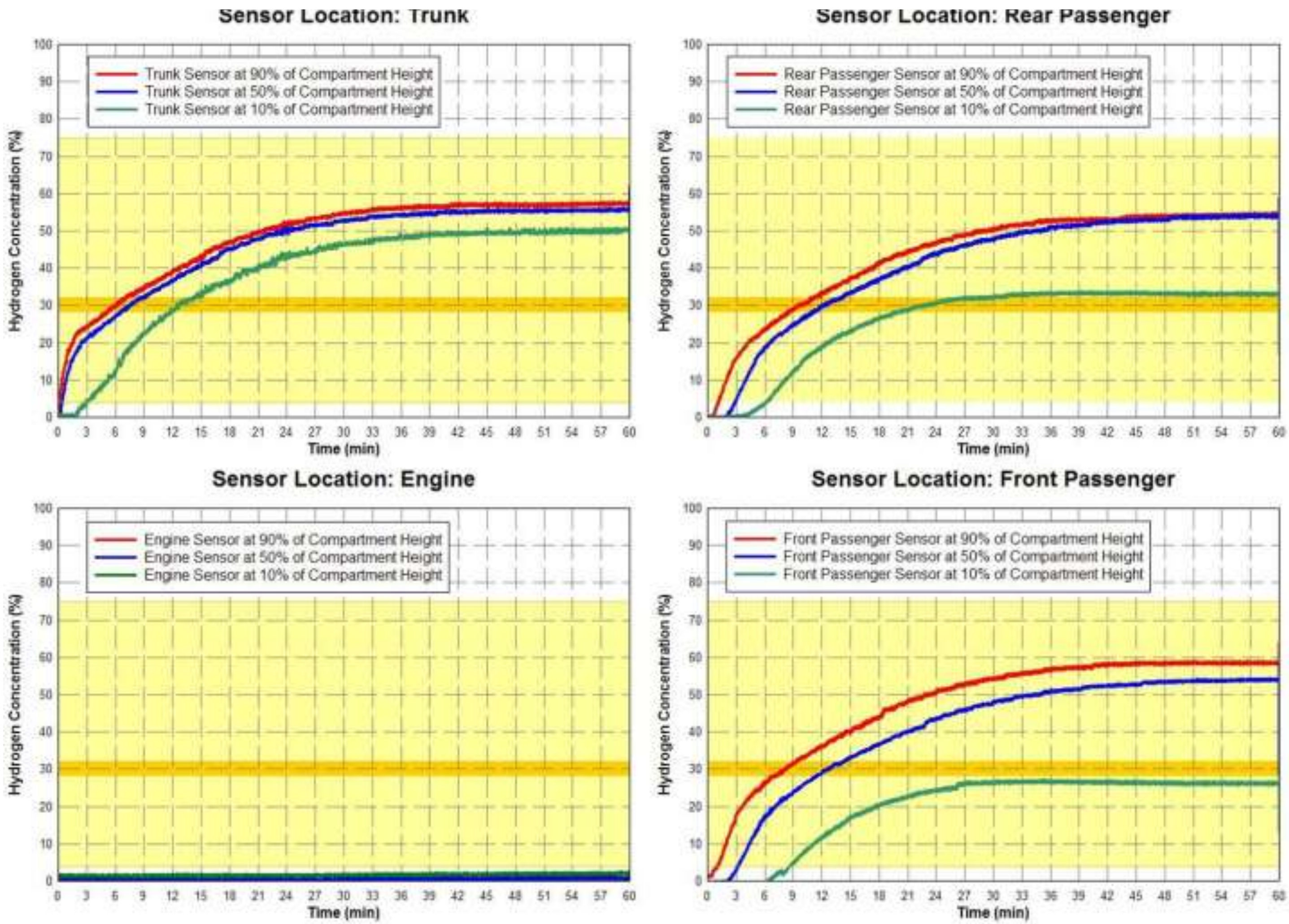
- Conduct analysis and experiments to characterize:
  - Hydrogen accumulation in engine, passenger, and trunk compartments as a function of leakage rate
  - Ignition of hydrogen at different concentration levels
  - Ignition of hydrogen in uncrashed and crashed vehicles.



# Task Order 3, Post-Crash Hydrogen Leakage Limits/Fire Safety Research

## Hydrogen Concentration Levels in an Intact Car



# Task Order 3, Post-Crash Hydrogen Leakage Limits/Fire Safety Research

## Test Observations

- Leaks located underneath the vehicle did not significantly increase the concentration of hydrogen in any vehicle compartment
- Leaks located directly into the trunk and passenger compartments achieved concentrations at the stoichiometric regime (~30%) for all the leakage rates tested
- Decreasing the flow rate to 58 lpm yielder longer dwell times in the stoichiometric regime
- Increasing the flow rate to 239 lpm yielded final steady-state values closer to 75%
- Low leak rates (<118 lpm) do not mix H2 well in air; H2 levels appeared random and unrepeatable
- High leak rates (>118 lpm) mix H2 more homogenously; H2 levels appeared more uniform and repeatable

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# Task Order 3, Post-Crash Hydrogen Leakage Limits/Fire Safety Research

## Ignition Test Completion expected in Spring


Mitsubishi Lancer


Mitsubishi Lancer


Mazda 6


Ford Taurus

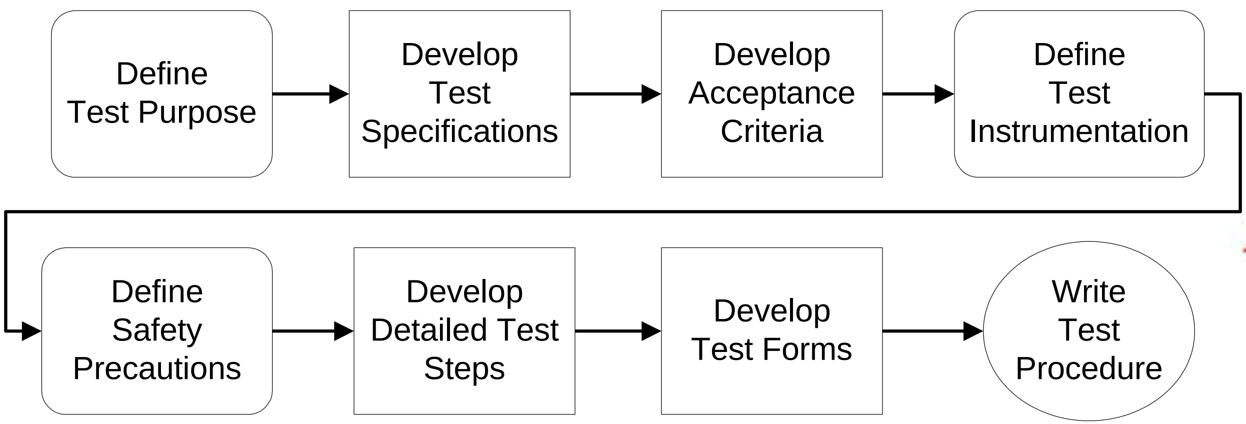
# Task Order 4, Electrical Isolation Test Procedure Development and Verification

## Objective

- Determine whether electrical isolation testing using a megohmmeter (megger) is feasible when crash testing HFCVs with high pressure helium yielding an inactive fuel cell
- Produce and validate an electrical isolation test procedure utilizing a megger that includes a test matrix, detailed steps, safety precautions, and test points.

## Approach

- Systematic Approach to Develop the Procedure




- Various existing standards and regulations were examined to create the test procedure and the acceptance parameter

# Task Order 4, Electrical Isolation Test Procedure Development and Verification

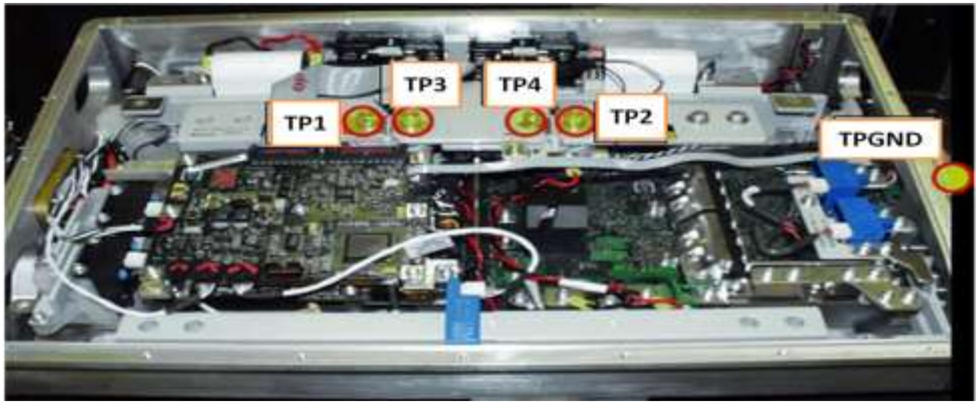
Procedure completed

Verifications were performed at GM and Ford on a Equinox and Focus.

Isolation failure was forced by inserting a resistor between the Fuel Cell and vehicle chassis

Results:

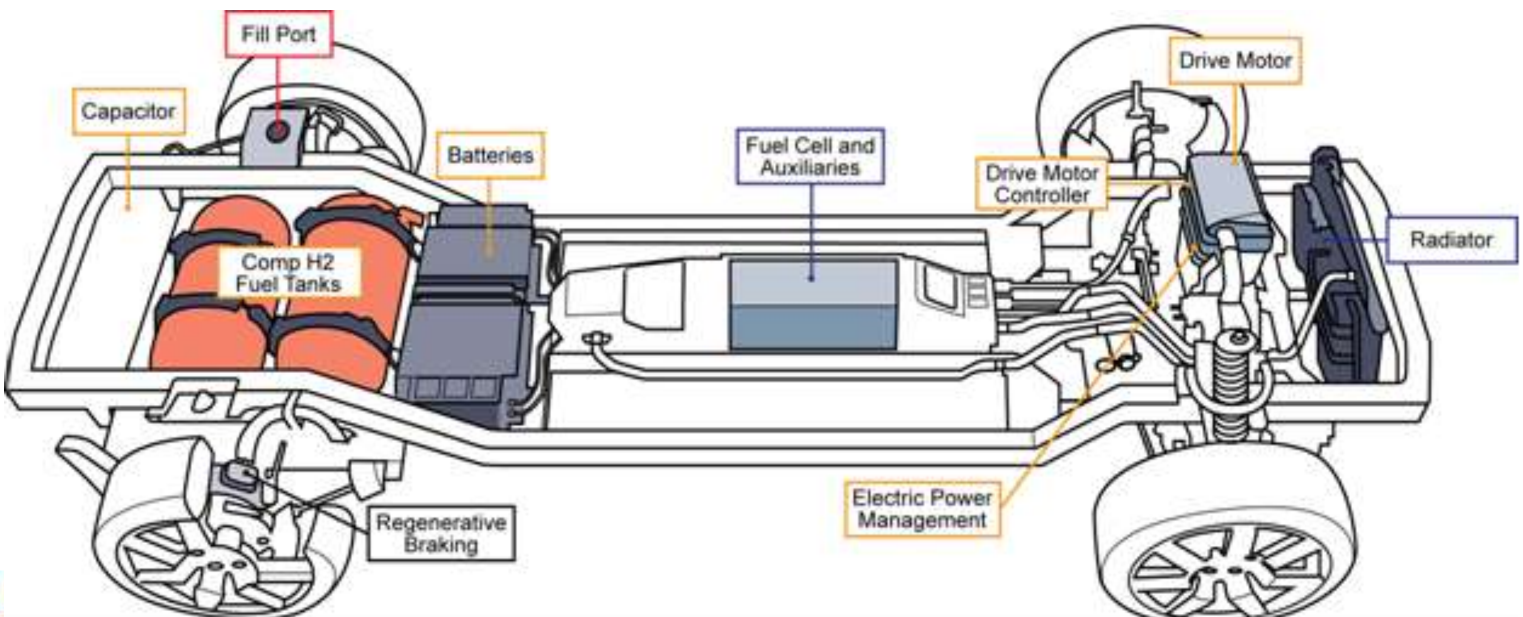
| | | Equinox | | Focus | |
|---|---|---|---|---|---|
| | | **Megohmmeter** | **Safety Tester** | **Megohmmeter*** | **Safety Tester** |
| **Pre-Crash** | Fuel Cell | 1073 ohms/volt | 1000 ohms/volt | 3158 ohms/volt | 3325 ohms/volt |
| | HV Bus | 437 ohms/volt | 371 ohms/volt | 629 ohms/volt | 625 ohms/volt |
| **Post-Crash** | Fuel Cell | 82 ohms/volt | 81 ohms/volt | 77 ohms/volt | 75 ohms/volt |
| | HV Bus | 440 ohms/volt | 410 ohms/volt | Not tested | Not tested |



# Task Order 5, Analysis of Published Hydrogen Vehicle Safety Research

The objective of this task was to identify outside sources of HFCV safety performance data and analyze their results.

This analysis provided useful information to NHTSA in support of drafting FMVSS for hydrogen vehicle fuel system integrity and in guiding international research planning while avoiding redundancy.



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